NSW North Coast Region Irrigation Profile

compiled by Meredith Hope
for the Water Use Efficiency Advisory Unit, Dubbo

The Water Use Efficiency Advisory Unit is a
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1. EXECUTIVE SUMMARY

The *NSW North Coast Region Irrigation Profile* was developed from a study to obtain regional and industry-based assessments of water use efficiency (WUE).

The Profile details (where possible, by water source and region) what is known about:

- the number of licences
- the number of enterprises that irrigate
- the entitled volume or area authorised for irrigation
- the area irrigated and water used in total and by crop type
- irrigation methods
- irrigated crop yields
- value of irrigated agriculture in the NSW North Coast region.

Irrigation data in the public domain were collected from State and Commonwealth sources, published research and industry reports and unpublished reports. These data were assigned a reliability rating using a system developed by the National Land and Water Resources Audit (1999).

This profile does not attempt to develop or analyse regional and industry-based estimates of WUE. This will be carried out in a subsequent report.

1.1 An overview of irrigation in the region

The North Coast region is a narrow coastal plain, 150 km wide and 500 km long, bordered by the Great Dividing Range in the west and the coast on the east. The region extends north from the top of the Manning catchment to the Queensland border and has a total area of 60,000 km^2. The Tweed, Brunswick, Bellinger, Richmond, Clarence, Macleay and Hastings–Camden Haven catchments are the main catchments in the region.

The total farm-gate value of agriculture in the region was estimated to be $672 million (1996–97) with irrigated agriculture accounting for $330 million (table1). In the same year, livestock products from irrigation produced $80 million followed by fruit and nuts (excluding grapes) ($50 million).

In the North Coast region, irrigation is necessary during spring and early summer and during drought. Annual rainfall varies from 820 mm and 3,000 mm and irrigation is necessary during these periods to ensure enterprise viability.

The region is characterised by a diversity of enterprises. There is a large dairy industry scattered through all catchments in the region except Brunswick.

Table 1. Summary of irrigation data for 1996–97

Data for the 1996–97 season provide an overview of the availability of irrigation data. Where there were no data, information from other seasons has been presented.

Water supply	Total irrigated area (ha)	Total water used by irrigated agriculture (ML)	Number of irrigation licences	Number of enterprises irrigating	Yield of major irrigated crop (t/ha)	Value of irrigation ($ /million)
NSW total	1,150,000	7,700,000	24,000	7,850	na	2,500
All sources of water	14,100	nd *Likely to range from 12,000 to 70,000*	3,087	991	nd *13–13.5 (perennial pasture) no year*	330
Regulated	nd *125 (1989–90)*	nd *1,000 (1999–2000)*	49	nd *1,450 (1993–94)*	nd	nd
Unregulated	31,700	nd *11,000-54,500 (1989–90 to 1994–95)*	2,976		nd	nd
Groundwater	nd *1,300 (1993–94)*	nd *2,530 (80)*	336	nd *340 (1993–94)*	nd	nd
Farm dams	nd *7,100 (1993–94)*	nd	na	nd *550 (1993–94)*	nd	nd
Reticulated water supply	nd *20 (1993–94)*	nd	na	nd *30 (1993–94)*	nd	nd

nd = no data and na= not applicable

The subtropical climate along the coast is also suited to a wide range of high-value tropical crops including avocados, bamboo, bush food (for example, lemon myrtle), citrus, coffee, custard apples, cut flowers, grapes, herbs, kiwi fruit, soybeans, olives, macadamias, pecan nuts, bananas, blueberries, low-chill stone fruit, tea-tree, lychees, vegetables and passionfruit (Creighton *et al.* 1999). Most of these crops are irrigated to a greater or lesser extent depending on the volume and frequency of rainfall received.

Of the total number of surface licences and groundwater licences for irrigation in the State, 13% or 3,087 exist in the North Coast region (Table 1). Licences on unregulated rivers far outnumber groundwater licences and licences using water from regulated supplies.

Of the total number of enterprises irrigating in NSW, 26% (or 2,026) are in the North Coast region.

In 1996–97, about 14,100 ha were irrigated in the North Coast region (Table 1) and of this area around 56% was pasture. The total volume of water used could not be determined but is likely to range from 12,000 and 70,000 ML/y, depending on climate.

The amount of land irrigated on individual broadarea and dairy farms in the North Coast region is small compared with the rest of the State. In 1996–97, these farms irrigated an average of 43 ha, compared with an average for the rest of the State of 189 ha. Horticultural farms have much smaller irrigated areas, on average between 5 and 10 ha. There are many enterprises irrigating a small area of land, especially during the low-flow months of spring and early summer. The impact of the industry on the environment relates not so much to the total amount of water it extracts but to the timing of the extraction.

The dominant method used to irrigate pasture and lucerne is spray irrigation. A range of methods including drip, micro sprinklers and hydroponics are used to irrigate horticultural crops.

1.2 Irrigation data issues

A number of data issues were raised in the *NSW North Coast Region Irrigation Profile*. Generally, these relate to the scarcity of data, the lack of data at useful scales and the reliability of available data.

Scarcity of data

Data have been collected for different purposes in the past to those currently needed. Data required for natural resource planning and for the planning and management of the irrigation industry are either scant or missing. Better data need to be collected to inform the water-sharing debate and to assist industry development.

Lack of data at useful scales

Point-scale data collected by the ABS and ABARE are confidential and have been reported at SLA, catchment or Agro-Ecological Region (AER) scales. These scales limit how useful these data are for on-ground users.

Reliability

Reliability of data varied with collection strategy and by water source. For example, the area irrigated from all sources as shown in Table 1 was half the area irrigated from unregulated supplies alone. These data were collected by different agencies and different methods and this may have affected reliability.

ABS estimates of the area irrigated and number of enterprises irrigating should be treated with caution. According to ABS data, areas irrigated have declined between 1993–94 and 1996–97 both in the North Coast region and across the State. Other data suggest the opposite is true.

1.3 Conclusion

A more comprehensive and consistent approach to the collection of irrigation statistics is needed. This would help to ensure that data are comparable across different water sources and industries. These improvements are needed:

- Data are needed at scales that are large enough to protect point-scale confidentiality but small enough to allow users to aggregate information to useful scales.
- Protocols for provision of data to users are needed. For example, information providers need to attach reliability ratings to data. This will help users make better decisions about the usefulness of the data.
- Two-way flow of information between agencies and irrigators needs to be fostered. Typically, data have been extracted from irrigators by agencies. These data need to flow back to irrigators in forms that might assist them make better water management decisions. This could in turn, over time, improve the reliability of information collected from irrigators.

Finally, such a comprehensive approach can only be developed with the full involvement of the many irrigators, agencies and community groups that require these data.

2. INTRODUCTION

During 1998, a desktop study was undertaken to develop a comprehensive database of NSW irrigation statistics. This was done to obtain regional and industry-based assessments of on-farm water use efficiency (WUE). From this study, Irrigation Profiles, or situation statements of irrigation, were developed for each of the major regions in NSW.

This Profile focuses on the North Coast region of NSW (Figure 1) and attempts to document what is known about the number of irrigators, the area irrigated and water used in total and by crop, irrigated production, irrigation methods and the value of irrigated agriculture. This Profile does not attempt to estimate or analyse regional and industry-based assessments of WUE. This will be carried out in a subsequent report.

2.1 Background

Irrigation statistics have been collected in NSW over the last 50 years.

1980s	The Water Resources Commission (WRC 1980) undertook an assessment of irrigation in NSW. The study highlighted a lack of data on crop areas irrigated, water used, irrigated yields and financial returns.
1980–89	A comprehensive report on crop areas irrigated, irrigated yields and the values of individual irrigated commodities between 1980 and 1989 was developed for NSW (DWC 1990).
1988–92	Sloane (1993) provided an overview of the number of farms and area irrigated for four broad agricultural regions in NSW between 1988 and 1992.
1986–current	The Australian Bureau of Statistics (ABS) has been collecting information on irrigation for various years since 1986 (ABS 1998).
1950s–current	The NSW Department of Land and Water Conservation (DLWC) has collected information over the last 50 years on the area irrigated and water used by the irrigation industry across NSW.
1996–97	The Australian Bureau of Agricultural Resource Economics (ABARE 2000) completed a survey of broadarea and dairy farms in each of the major catchments in NSW.

Despite the collection of apparently ample statistics in NSW over the last two decades, a basic description of the irrigation industry remains elusive. A review commissioned by the Murray-Darling Basin Commission, (Crabb 1997a; Crabb 1997b) highlighted a lack of data on the number of irrigators; the area of land irrigated; the location of irrigated land; and the volume of water used.

Four additional points could be added to the list: crop type, irrigated yields being obtained, irrigation methods being used and value of irrigated agriculture.

The importance of historical and current reliable information about the irrigation industry in NSW is increasing. The Council of Australian Governments (COAG), comprising all States, Territories and the Commonwealth, introduced reforms to improve the way water is managed in Australia. These reforms aim to introduce processes to enable better sharing between users and the environment, for trading water between users, for better defining a water right to users, and finally for recovering the real cost of storing and supplying water to users. A number of activities depend heavily on historical information and the future collection of reliable irrigation data.

- With the introduction of the new *Water Management Act* (2000), NSW community and agency groups have been developing Water Sharing Plans. These plans require accurate and reliable irrigation data to underpin their development and implementation. Water Sharing Plans are operational for 10 years with a review in year five. Monitoring the impact of these plans on the environment and other water users (for example, irrigators) has to be undertaken. Irrigation data will need to be collected as part of the Water Sharing Plan implementation phase.

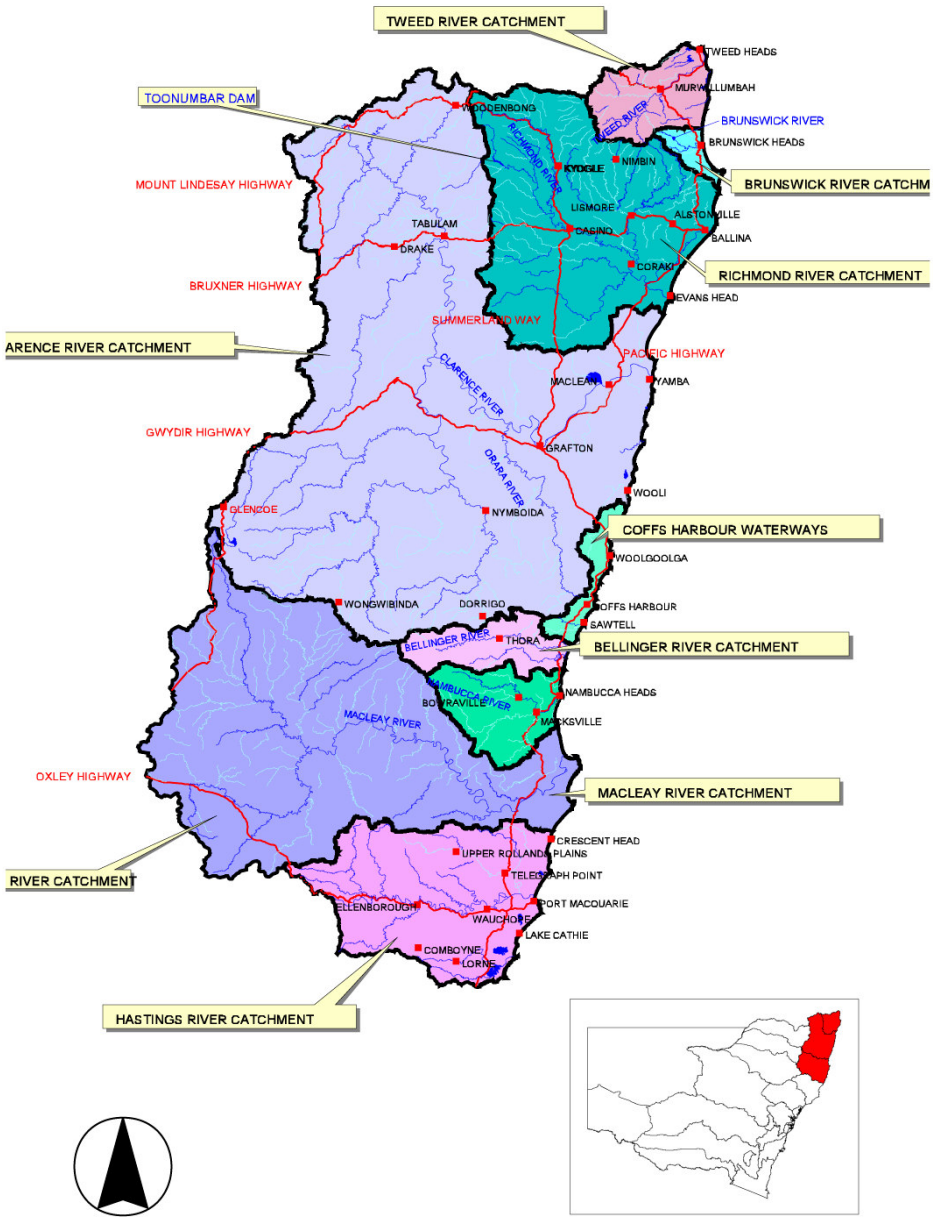
- Catchment Blueprints are being developed and finalised by Catchment Management Boards (CMB) in each major catchment/region in NSW. These plans are designed to improve the management of natural resources across the State and are operational for 10 years. These plans require data on irrigation to enable the impact of these plans to be assessed in the future;

- A structural adjustment package aims to assist irrigators adjust to new water management sharing arrangements jointly managed by NSW Agriculture, DLWC and the Rural Assistance Authority. In order to measure change as a result of this Scheme, historical and current irrigation data are needed to describe the base-line situation and the situation post-implementation.

In summary, there is a pressing need to obtain accurate and reliable irrigation data in order to help strategically focus efforts to improve WUE and IE. Reliable information are needed to assist irrigators find ways to help manage water more efficiently, to aid decision-making about sharing water in NSW and to help agencies and irrigators measure change as a result of Water Reform.

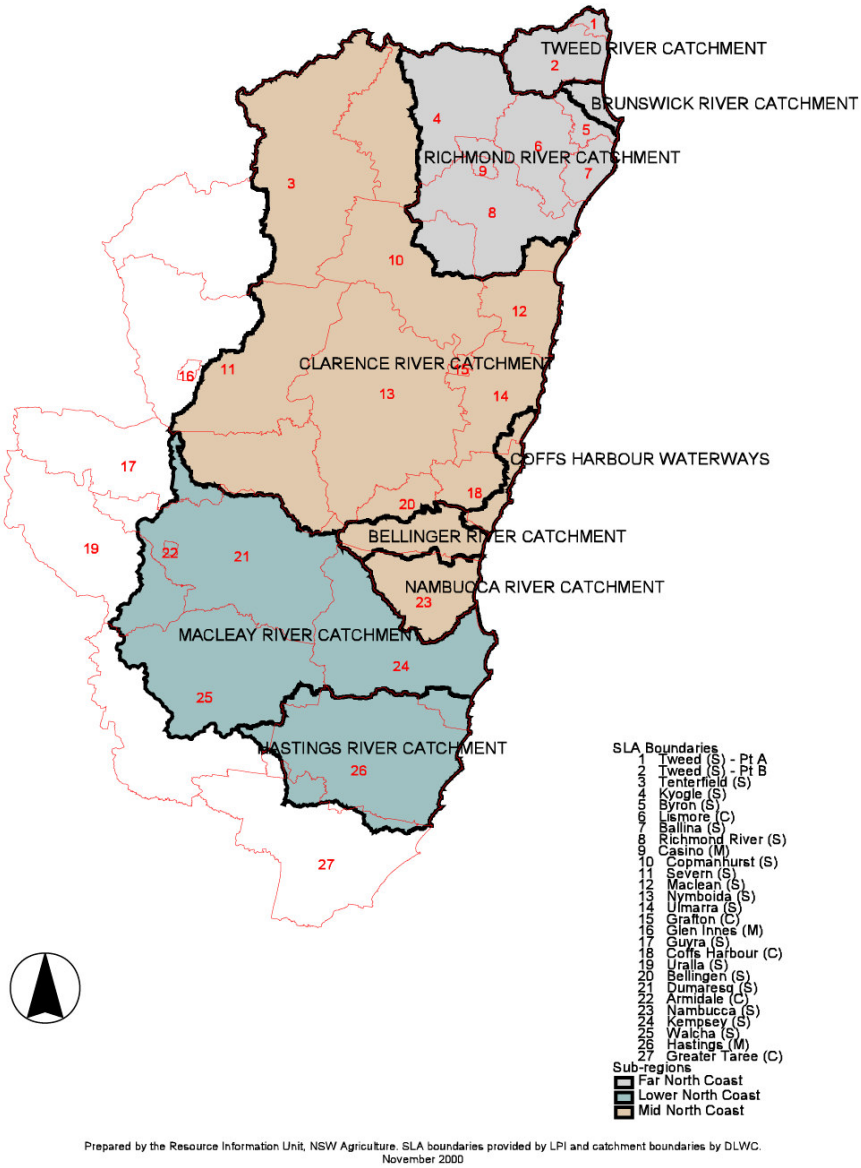
This report summarises both the availability and reliability of data on irrigated activities in the North Coast region.

Figure 1. The North Coast region



Prepared by the Resource Information Unit, NSW Agriculture.
Catchment boundaries from data provided by DLWC, topographic features from AUSLIG Topo 250K Geodata.
November 2000

Figure 2. The North Coast region, catchments and SLAs



3. METHODS

3.1 Summary of data collection

During 1998, a desktop study was undertaken to review readily accessible data from State sources including the DLWC and from Commonwealth sources including the ABARE and the ABS.

Electronic data collected include:

1. the ABS Irrigation Statistics Catalogue, AgStats (ABS 1998).

   The ABS collected information by Statistical Local Area (SLA) until 1996–97 (see Appendix 14.1 for a definition of a SLA) and in most instances these units can be aggregated into the North Coast region (Figure 2). Only SLAs that covered major areas of irrigation were used in this Profile. Between 1997–98 and 1999–2000, the ABS collected information by Agro-Ecological Region (AER). These regions span catchments and cannot be used to build catchment snapshots of irrigation. Since 2000–01, the ABS has returned to collecting information by SLA.

   A summary of the data collected by the ABS over the last 15 years is provided in Table 2 and Appendix 14.2.

Table 2. EVAOs used by the ABS to collect data about irrigation in NSW

Year	EVAO ($)	Collection Unit	Used in Profile
1986–87	20,000	SLA	✖
1989–90	20,000	SLA	✖
1990–91	20,000	SLA	✖
1991–92	22,500	SLA	✖
1992–93	22,500	SLA	✖
1993–94	5,000	SLA	✓
1994–95	5,000	SLA	✓
1995–96	5,000	SLA	✓
1996–97	5,000	SLA	✓
1997–98	22,500	AER	✖
1998–99	22,500	AER	✖
1999–00	22,500	AER	✖
2000–01	5,000	SLA	not available yet

In this Profile, only data collected between 1993–94 and 1996–97 were used. The reasons for this choice are as follows:

- The ABS has collected data based on different EVAOs during the last 15 years (Table 2), making comparisons between years difficult. The EVAO, or Estimated Value of Agricultural Operations, is the criterion for determining the population to be surveyed.[1]
- Prior to 1993–94, data were collected with different EVAOs, making comparisons between years difficult.
- Between 1997–98 and 1999–2000, the ABS collected information by using an EVAO of $22,500 and by AER (Table 2).

2. the 1996–97 ABARE Irrigated Farm Survey results obtained from the ABARE Survey of Primary Industry, Resources and Energy (ASPIRE) database (ABARE 2000). The North Coast region is the reporting unit for the ABARE survey and these data cannot be disaggregated, for example, into catchments or subcatchments.

2. a DLWC database of crop area and water use, designed for use by NSW Agriculture (DLWC 1998). Unlike ABS and ABARE information, these data can be aggregated to any scale, such as stream reach, subcatchment and catchment.

3. various spreadsheets provided by the Water Analysis and Audit Branch, Sustainable Water Management, DLWC, Parramatta (this branch is now located in Bridge Street, Sydney).

Data were also obtained from relevant research and industry reports. A situation statement of irrigated industries operating within the North Coast region was developed from this information. The profile was further developed in collaboration with NSW Agriculture staff in regional offices. As staff uncovered regional data (for example, unpublished reports), these were incorporated into the profiles.

3.2 Rating data reliability

The reliability of these data has been described using a rating system developed by the NLWRA (National Land and Water Resources Audit 1999). The system rates data against four classes:

1. **Class A** – data based on reliable recorded and surveyed information. Little or no extrapolation or interpolation required.

[1] The smallest unit collected by ABS is the SLA and the population to be surveyed is determined from the EVAO. The EVAO is estimated from a procedure that takes into account the value of the area of crops sown and the numbers of livestock on holdings at a point in time as well as the crops produced and the livestock turnoff during the year. The resultant aggregation of these commodity values is termed the EVAO.

2. **Class B** – data based on approximate analysis and limited surveys. Some measured data and some interpolation or extrapolation required to derive the data-set.
3. **Class C** – little measured data. Data based on reconnaissance survey.
4. **Class D** – data derived without investigation. Figures estimated from other data in nearby catchments or extrapolated or interpolated from any available data.

In this Profile, the reliability rating class has been indicated with the symbols:

- Class A: ①
- Class B: ②
- Class C: ③
- Class D: ④

So, for example, 'the number of irrigated enterprises in the North Coast region was 991 (ABS 1998, ②)'.

3.3 Structure of the Profile

The availability and reliability of data in the North Coast region have been summarised for five water sources: regulated rivers, unregulated rivers, groundwater, farm dam supply and reticulated supplies. This Profile has been prepared in contemplation of the full implementation of the *Water Management Act* 2000. The data have been presented in this way because availability and reliability of information vary markedly between sources. A description of these sources follows.

Regulated rivers[2] are those rivers that have been declared by the Minister, by order published in the *Gazette*, to be a regulated river (*Water Management Act 2000* (NSW)). Regulated rivers have their flows controlled by major government-owned dams. These capture water that is then released to users downstream when it is ordered (DLWC 1999d) or released for flood mitigation.

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[2] **Rivers:** A river is defined in the *Water Management Act 2000* as including:

a) any water course, whether perennial or intermittent and whether comprising a natural channel or a natural channel artificially improved, and
b) any tributary, branch or other water course into or from which a watercourse referred to in paragraph (a) flows, and
c) anything declared by the regulations to be a river,

but does not include anything declared by regulations not to be a river.
The 1912 Water Act describes rivers in Part 2, Section 5, Part 1a, b and c. Rivers are perennial or intermittent streams. They may be a natural channel, a natural channel artificially improved or an artificial channel that has changed the course of a stream. Rivers may also be an affluent, confluent, branch or other stream into or from which a stream flows (NSW Government 1998). Rivers are also defined as any stream or part of a stream for which the location is represented on any topographic maps listed in Schedule 3 of the Water Act (NSW Government 1999). They may be a third, fourth or higher order stream, or part of such a stream determined in accordance with the system set out in Schedule 4, or which maintains a permanent flow of water, being a visible flow which occurs on a continuous basis or which would so occur if there were no artificial abstractions of water or obstructions of flows upstream.

Unregulated rivers[2] are all other rivers that are not regulated rivers (*Water Management Act 2000* (NSW)). Many of these rivers may still have dams or weirs built on them by urban water suppliers (DLWC 1999d) to control water flows.

Groundwater is contained within an aquifer. An aquifer is a geological structure or formation, or an artificial landfill, that is permeated with water or is capable of being permeated with water (*Water Management Act 2000* (NSW)).

Farm dam water is water from dams containing water that is permitted to be captured under a Harvestable Right.

Reticulated water is water that has been reticulated for a town's or city's drinking water.

This report summarises the following, where possible, by water source and by SLA, subcatchment, catchment and region:

1. number of licences with the purpose of irrigation
2. number of enterprises irrigating
3. entitled volume or area authorised for irrigation
4. area irrigated and water used in total and by crop type
5. method of irrigation
6. yield of irrigated crops
7. value of irrigated production

Note that the Bellinger catchment comprises three smaller areas: the Coffs Harbour, Bellinger and Nambucca meso-catchments. Some documents (EPA 1997) separate these three small areas into individual catchments, while other documents aggregate them into one larger one (Bellinger) (WRC 1980). For this Profile, the Bellinger catchment will be reported as one large area, and the three smaller catchments as meso-catchments.

4. REGIONAL OVERVIEW

4.1 Region description

The North Coast region is a narrow coastal plain 150 km wide, bordered by the Great Dividing Range in the west and the Pacific coast on the east. The region has a total area of 60,000 km^2 beginning above the Manning catchment and extending 500 km north to the Queensland border.

Huge volumes of water, to 12,254,000 ML, discharge annually into the sea from these catchments: the Clarence catchment has the largest discharge (Table 3).

Table 3. Flow characteristics of the major North Coast rivers

Catchment	Tweed	Brunswick	Richmond	Clarence	Bellinger	Macleay	Hastings – Camden Haven
Area (km^2)	1,362	490	6,864	22,700	3,460	11,500	1,260
Mean ann. discharge from all streams (×1,000) ML[a]	418	246	1,920	4,920	1,150	2,150	1,450
Max. ann. discharge/ mean ann. discharge[a]	2.08	1.8	2.33	3.98	2.54	2.7	2.46
Min. ann. discharge/ mean ann. discharge[a]	0.16	0.2	0.15	0.16	0.08	0.09	0.16
Evaporation (mm) [a]	1,100 to 1,150	1,050 to 1,100	1,050 to 1,200	800 to 1,250	800 to 1,000	800 to 1,150	800 to 900
Ann. rainfall (mm) [a]	1,500 to 3,000	1,600 to 1,850	1,000 to 1,800	820 to 1,920	1,150 to 2,000	700 to 1,550	1,180 to 1,840
Av. run-off (mm) [a]	377	500	277	217	334	188	320
Total subcatchments[b]	**32**	**10**	**23**	**56**	**34**	**32**	**17**

[a](WRC 1980) [b](DLWC 1999e; DLWC 1999f; DLWC 1999g)

The seven main catchments in the region – Tweed, Brunswick, Bellinger, Richmond, Clarence, Macleay and Hastings–Camden Haven (Figure 1) – are described from north to south in the next section. North Coast rivers are characterised by significant variability between years: for example, the Clarence catchment can quadruple its average annual discharge (Table 3). Drought may reduce discharge to around 10% of the average annual discharge. Flows in some rivers may be six times greater in late summer than in spring (EPA 1997).

4.1.1 Tweed catchment

The Tweed catchment (Figure 1) has the second smallest annual discharge in the North Coast region (Table 3). The Tweed, Oxley and Rous rivers drain water from the slopes of Mt Warning and the McPherson Range. The Tweed River winds past the main townships of Murwillumbah and Tweed Heads before emptying into the sea at Point Danger (DLWC 1999g). The largest centre in the catchment is Tweed Heads (70,000). Other centres include Murwillumbah and Chillingham.

4.1.2 Brunswick catchment

The Brunswick catchment (Figure 1) is the smallest catchment in the North Coast region (Table 3). The eastern sections of the Brunswick catchment are undulating and dissected by moderate to steep ridges while the low-lying portions comprise wetlands and estuaries (DLWC 1999g). The area has the smallest average annual discharge of any catchment in the North Coast region (Table 3). The catchment has been affected by past clearing, agriculture, human settlement and recreational use. Sewage treatment works and high population density and an increasing number of rural dwellings are issues for the Brunswick catchment (DLWC 1999g). The main population centres are Byron Bay (10,000), Mullumbimby (4,000) and Brunswick Heads (1,700) (DLWC 1999g).

4.1.3 Richmond catchment

The Richmond catchment (Figure 1) has a large coastal plain stretching from south of Evans Head north almost to Cape Byron. The highest point of the catchment is heavily forested and has dedicated world heritage and national park areas. The Richmond River drains the heavily forested upland sections of the catchment into the ocean at Ballina. Below, the drier slopes support the beef cattle industry and expanding commercial timber plantations. The population is steadily increasing, placing pressure on regional land and water resources. Lismore is the largest centre in the area with a population of 44,000.

4.1.4 Clarence catchment

The Clarence catchment (Figure 1) is one of the largest catchments in the region (WRC 1980) (Table 3) and the largest river on the east coast of NSW (DLWC 1999e) (WRC 1980). The Clarence catchment has a great diversity of vegetation types and wildlife habitats, with many national parks and reserves with remnant rainforests. Approximately 66% is mountainous or hilly and the remainder is flat (less than 3%

slope) (WRC 1980). Beef cattle grazing is the major land use in the catchment and occurs on the dry slopes. This area is also expanding into commercial timber plantations, and sugarcane is grown intensively on the lower Clarence River downstream of Grafton.

4.1.5 Bellinger

The Bellinger catchment (Figure 1) is a long strip of coast extending from Nambucca Heads north to Lake Arragan. As noted in Section 3.3, the catchment comprises three distinct meso-catchments – Nambucca, Bellinger and Coffs Harbour.

The Coffs Harbour meso-catchment is formed by a series of smaller adjacent subcatchments, each with steep topography flattening out into creeks and estuaries that flow to the sea (DLWC 1999e). Most settlement has occurred on the flatter coastal plains. There are 54,000 people living in the urban areas in Coffs Harbour, Sawtell/Toormina and Woolgoolga and a further 7,000 to 9,000 people in rural and rural-residential areas. The forecast population for 2020 is 85,000 with planned urban expansion of Bonville, Boambee, West Coffs Harbour, Korora and Moonee (DLWC 1999e). Pressure for rural residential development in the valleys and on the slopes of the upper catchment is increasing.

The Bellinger meso-catchment is about 70 km long and 20 km wide (DLWC 1999e) and the Kalang and Bellinger rivers are the main watercourses draining it. The meso-catchment is mostly mountainous with limited areas of flat land that can be used for agriculture. Urban development is mainly limited to the small inland town of Bellingen and the coastal town of Urunga. Narrow floodplains have been cleared for grazing, cropping and other uses. Forestry is important, while mixed farming occupies the undulating and flat land, producing dairy products, beef, pork, maize, sorghum and vegetables.

The Nambucca meso-catchment has its headwaters in the Great Dividing Range and is bordered in the south by the Macleay catchment. The area's population is 19,000. Dominant agricultural industries include beef and dairy cattle, bananas, macadamias and vegetables. A wide range of winter and summer crops are grown in the Macksville area (Creighton *et al.* 1999).

4.1.6 Macleay catchment

The Macleay catchment (Figure 1) has extensive areas of sparsely populated tablelands (DLWC 1999f). It has the second largest average annual discharge of all catchments in the region, totalling 2,150,000 ML. East of these tablelands, the catchment has deep gorges of rainforests and wet sclerophyll[3] forests. The lower ridges give way to cleared pastureland and wetlands on floodplains that extend to the coast. Much of the tablelands has been cleared and is now covered in native and introduced pastures. Here, beef cattle grazing and sheep grazing for wool are dominant agricultural

[3] Sclerophyllic plants have sclerenchyma or large cells with thick woody walls that help reduce water loss.

practices – these enterprises are not irrigated. The eastern part of the catchment is almost entirely devoted to dairying and beef cattle grazing and growing fodder crops such as sorghum and maize. Major centres (including Armidale, Walcha, Guyra and Kempsey) total around 60,000 people (DLWC 1999f). Guyra sits on the border between the Macleay and Gwydir catchments.

4.1.7 Hastings–Camden Haven catchment

The Hastings–Camden Haven catchment (Figure 1) extends from the New England tablelands to the Pacific Ocean, encompassing 84 km of coastline. There are large areas of State and national parks in the steeper parts (greater than 15 degrees) of the catchment as well as on the coast. The alluvial soils of the middle parts of the Comboyne Plateau support the dairy and beef industries. In the lower parts, grazing, fishing oysters, grapes and tourism are important industries while the steeper areas have timber, grazing and tourism. Port Macquarie is the largest town in the area with a population of 57,000.

4.2 Climate

The North Coast experiences subtropical mild winters and warm to hot summers (Appendix 14.3). Temperatures vary considerably from frost-free subtropical coastal zones in the east to the western ranges where there can be snowfalls and heavy frosts. Typical annual falls range between 820 and 3,000 mm: the Tweed catchment is the wettest catchment and the Macleay catchment is the driest. Rainfall is strongly seasonal, falling mostly in late summer and early autumn (Appendix 14.3), and the region experiences large variations in river flows between and within seasons. In some catchments (for example, Bellinger), surface run-off is nearly double the average for coastal NSW and there is a risk of serious soil erosion (DLWC 1999e).

4.3 Demographics

The North Coast population is increasing, especially in Tweed, Brunswick and Richmond catchments (Appendix 14.4). Families who have lived in the region for generations have been joined by people moving to the region for lifestyle reasons (*pers. comm.* C. Rolfe). The North Coast region has a greater percentage of people aged between 55 and 64 than the rest of the State (DLWC 1999a; DLWC 1999c; DLWC 1999b), but also attracts younger people who relocate for lifestyle reasons and contribute to the large pool of unemployed people. In the Tweed, Brunswick and Richmond catchments, the unemployment rate is 7.8% against the State average of 5.2% (DLWC 1999a).

5. IRRIGATION FROM ALL SOURCES

5.1 Description of irrigation

As noted in section 4.2, the region has a diverse climate ranging from temperate in the west to subtropical in the east. This has allowed a wide range of crops and industries to flourish.

Dairy farms are the most significant irrigated industry and the largest water user in the region. Early European settlers developed dairy farms on alluvial soils. As the industry grew these farms spread to the hills where there were poorer soils (Kemp 1973). Clover, ryegrass and tropical grasses such as setaria, paspalum and kikuyu are irrigated during spring when rainfall is low (Fulkerson *et al.* 1983; Moore 1986a; Ashwood *et al.* 1993).

The subtropical climate along the coast is also suitable to a wide range of high value tropical crops including avocados, bamboo, bush food such as lemon myrtle, citrus, coffee, custard apples, cut flowers, grapes, herbs, kiwi fruit, soybeans, olives, macadamias, pecan nuts, bananas, blueberries, low-chill stone fruit, tea-tree, lychees, vegetables and passionfruit (Creighton *et al.* 1999). Most of these crops are irrigated to a greater or lesser extent depending on the volume and frequency of rainfall received.

Irrigation is conducted on a small scale in the North Coast region. For example, the average area irrigated by a dairy or broadarea enterprise in the region was only 43 ha compared with the state average of 189 ha (Relative Standard Error [RSE] = 7) (ABARE 2000) ③. Between 5 and 10 ha are irrigated on horticultural farms (*pers. comm.* G. Creighton).

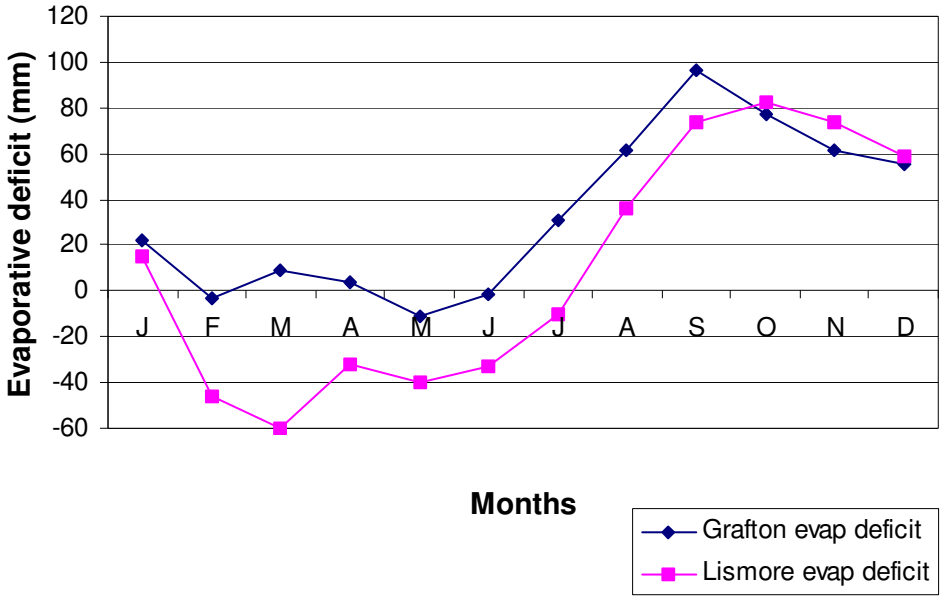
Irrigation is critical during drought periods (Moore 1986b; Moore 1996). At Coraki, 18 droughts have been recorded since 1896 , each lasting on average 18 months ± 6.9 months (Clewett *et al.* 1999).

Irrigation water is also needed during the low-flow months of spring and early summer months when there is an evaporative deficit (Figure 3).

During this low-flow period, a number of crops have heightened water requirements that correspond to critical phases of flower-set and yield formation. Lack of irrigation water during these times may cause lower yield. Such crops include bananas, olives, sweet corn, coffee, low-chill stone fruit, potatoes (spring crop), cabbage and sugar cane (Table 4). Crops that are less likely to be affected by water stress include maize, potatoes (crop 2), citrus, lucerne and pecans. For these crops, heightened water requirements occur outside spring and summer.

Figure 3. Evaporative deficit at Grafton and Lismore

Evaporative deficit = Monthly average reference evapotranspiration minus monthly average rainfall.



Note for figure 3: Reference evapotranspiration[4] was determined using the FAO 56 methodology (FAO 1998). Climatic data were obtained from the Bureau of Meteorology (2000).

There are conflicting reports regarding the effectiveness of irrigation. For example, Johns and Conchie (1994) suggest that tea-tree, bananas and macadamias were unaffected by irrigation in the North Coast region. Yield response factors (Doorenbos *et al.* 1986) suggest bananas are more prone to yield loss as a result of water stress than many other crops (Table 4).

Irrigation has been generally promoted as a tool to increase reliability and quality of subtropical products (Rolfe 1989a; Rolfe 1989b; Rolfe 1989c; Rolfe 1989d; Rolfe 1989e; Rolfe 1989f; Rolfe 1995; Rolfe 1989g; Rolfe 1989i; Rolfe 1989j; Rolfe 1989h; Bell 1985). Unpublished research suggests irrigation can help to increase yields by up to 30% for macadamias and 40% for coffee (*pers. comm.* C. Rolfe; Rolf 1988; Murtagh 1996; Trochoulias 1987; Trochoulias and Johns 1992) ④. Work is continuing on a range of crops to better understand the role irrigation plays in yield and quality.

The sections that follow provide an account of irrigation in each of the catchments in sequence from north to south.

[4] Reference evapotranspiration is the evapotranspiration from a reference grass crop.

Table 4. Crop response to water stress

Crop	Yield response factors[a]	Period of high water use
Banana	1.2 to 1.35	October to February
Bean	1.25	nd
Maize	1.25	January to February
Sugar	1.2	nd
Pea	1.15	nd
Wheat – spring	1.15	nd
Onion	1.1	nd
Pepper	1.1	nd
Potato	1.1	August to October (crop 1) then March to May (crop 2)
Citrus	0.8 to 1.1	December to February
Cabbage	0.95	nd
Sorghum	0.9	nd
Sunflower	0.9	nd
Alfalfa	0.1 to 1	October to March
Cotton	0.85	nd
Grape	0.7	nd
Groundnut	0.7	nd
Low-chill stone fruit	nd	October to November
Olive	nd	November to December
Pecan	nd	December to March
Sugar cane	nd	November to February
Tea-tree	nd	February to October
Sweet corn	nd	October to December
Coffee	nd	November to March

Source: (Doorenbos *et al.* 1986).

[a]A yield response factor is used to predict the reduction in crop yield when crop stress is

caused by a shortage of water.
nd = no data

5.1.1 Tweed catchment

In the Tweed catchment, sugar cane is grown on the alluvial estuarine flats. Dairying is carried out on the freshwater alluvial flats from Tyalgum to Murwillumbah and farms are mostly irrigated directly from the rivers.

A significant horticultural industry is located in the hills above the frost zone of the Tweed catchment. Crops include bananas, avocados, macadamias, stone fruit, mangoes and other tropical fruits. Many of the banana and macadamia crops are not irrigated. Other crops rely on small farm dams, bores and minor creeks for irrigation water.

There is a significant vegetable industry on the Cudgen Plateau adjacent to the coastline of the Tweed catchment (Seymour 1988). Part of the plateau is in the Brunswick catchment (see below). Here, large quantities of tomatoes, sweet potatoes and zucchinis are irrigated from farm dams and groundwater. The frost-free areas also support a large nursery industry (*pers. comm.* C. Rolfe). Bush foods such as aniseed myrtle, Davidson's plum and riberries are also in the catchment (Creighton *et al.* 1999).

5.1.2 Brunswick catchment

The warm subtropical climate has allowed agriculture to thrive in the Brunswick catchment. The catchment supports stone fruit, passionfruit, lychees, coffee, blueberries and macadamias on the slopes, with pecans on the low-lying areas. Vegetables including tomatoes, sweet potatoes and zucchinis are grown on the Cudgen Plateau. Dairy farms can be found along the Brunswick River. Irrigation is required during the spring and early summer. The amount of water needed by these industries varies from year to year depending on rainfall.

5.1.3 Richmond catchment

The Richmond catchment supports a large horticultural industry on the frost-free well-drained krasnozem soils of the Alstonville plateau and the slopes of the Nightcap Range between Nimbin and Bangalow. A recent horticultural expansion has replaced dairying in this plateau area.

The major horticultural crops are macadamias, avocados, stone fruit, custard apples, nurseries and blueberries. These crops are mainly irrigated from farm dams and bores with some growers relying on the more permanent streams.

A substantial dairy industry, supplying the local Norco Co-op at Lismore, is located along the alluvial flats of the Richmond River and Wilson River around Kyogle, Casino and Lismore. Most dairy farms rely on these rivers for irrigation.

In the upper regions of the tidal pools, dairying gives way to an expanding tea tree industry.

Sugar cane is the dominant agricultural crop along the estuarine flats between Ballina and Coraki. Very small areas of sugar cane are irrigated. There are many new expanding horticultural crops including coffee, pecan nuts, bamboo and bush foods (lemon and aniseed myrtle, Davidson's plum and riberries (*pers. comm.* C. Rolfe).

5.1.4 Clarence catchment

Potatoes, horticultural crops and dairies are located on the Dorrigo Plateau. Blueberries, citrus, macadamias, stone fruit, persimmons and grapes are grown on the Corinda plateau between Grafton and Woolgoolga. Crops are supplied with irrigation water from farm dams at Corinda and from farm dams and streams at Dorrigo. Some vegetable crops and dairy farms are irrigated in the upper northern arm of the Clarence River between Tabulam and Woodenbong where expanding olive and pecan industries are located (*pers. comm.* C. Rolfe).

5.1.5 Bellinger catchment

There is little irrigated agriculture in the Bellinger catchment. Many valleys in the Coffs Harbour meso-catchment are sown to bananas and it is estimated that around 10% of these enterprises irrigate (Johns 1993). As bananas become less profitable due to strong Qld markets, other crops such as avocados are replacing banana plantations. Small farm dams located in the steep gullies supply most of the irrigation. Agencies are investigating ways of diverting treated urban wastewater to high-value irrigated horticulture. There are also small areas of irrigation in the Bellinger meso-catchment along the Bellinger River including dairy, tea-tree, blueberries and avocados. Dairy farms and vegetable crops in the Nambucca meso-catchment are irrigated from the river.

5.1.6 Macleay catchment

In the drier inland regions in the north-western sections of the Macleay catchment, around Guyra, sorghum, sunflowers, soybeans, soybeans and maize are irrigated (Ringwood 1988; Patrick *et al.* 1988).

In the eastern sections of the catchment, irrigated agriculture consists of dairying, vegetables and nurseries. There is an intensive horticulture area around Yarrahapinni Mountain near the outlet of the Macleay River. Irrigation water is supplied from an extensive groundwater source. The main crops grown here are potatoes, avocados and macadamias.

5.1.7 Hastings–Camden Haven catchment

The krasnozem soils of the Comboyne Plateau support the dairy and horticulture industries. In the lower parts of the catchment, dairying is the dominant irrigated industry. Most farmers extract river water for irrigation.

5.2 Summary of irrigation data – all water sources

A summary of irrigation data available for all sources of water is provided in Table 5. Only the most reliable information is provided and where information was less reliable, it has been mentioned in the text. The table demonstrates the lack of data for irrigation from all sources of water in the North Coast region.

Table 5. Summary of irrigation data – all water sources

	Livestock products dep. on irrigation ($m) [c]	Value of irrigation ($m) [c]	Yield of pasture (t/ha)	Total water used on pasture (ML)	Total water used by irrig. ag. (ML)	Area of pasture irrig. (ha) [b]	Total area irrig. (ha)[b]	No. enterpr's irrigating	No. irrig. Lic's[a]
1988–89	-	-	-	-	-	-	-	-	-
1989–90	-	-	-	-	-	-	-	-	-
1990-91	-	-	-	-	-	-	-	-	-
1991–92	61	141	-	-	-	-	-	-	-
1992–93	64	147	-	-	-	-	-	-	-
1993–94	67	149	-	-	-	22480	29377	1432	-
1994–95	74	167	-	-	-	-	-	-	-
1995–96	80	198	-	-	-	-	11422	779	-
1996–97	80	188	-	-	-	7880	14088	991	-
1997–98	-	-	-	-	-	-	-	-	-
1998–99	-	-	-	-	-	-	-	-	3087
1999–2000	-	-	-	-	-	-	-	-	-
2000-01	-	-	-	-	-	-	-	-	-

[a] Information summed from DLWC 1999e; DLWC 1999f; DLWC 1999g, *pers. comm.* J. Morrison, DLWC 2000e ①; [b] (ABS 1998)② [c](Donovan 2000)③ (mainly dairy products).

5.3 Number of licences (all sources)

There are an estimated 3,087 licences with the purpose of irrigation (Table 6) ②. These data were determined by summing the number of irrigation licences from each water source.

Table 6. Number of licences for irrigation in the North Coast region

Water supply	No. of licences	Reference and reliability rating
Regulated	49	Pers. comm. J. Morrison. Data taken from DLWC (2000e) ①
Unregulated	2,702	DLWC 1999e; DLWC 1999f; DLWC 1999g ①.
Groundwater	336	Pers. comm. W. Hehir. Data taken from DLWC 2000e ①. This figure is for all purposes (irrigation, industrial, etc). However, it is believed that most licences are for the purpose of irrigation (pers. comm. W. Hehir)②.
Total	**3,087**	②

5.4 Number of enterprises using irrigation (all sources)

The total enterprises irrigating in the North Coast region in 1993–94 were estimated to be either 1,432 (ABS 1998)② or 2,026 (Creighton 1998)④ (Table 7).

Table 7. Enterprises and area irrigated in the North Coast region in 1993–94

Catchment	Number of enterprises		Area irrigated (ha)
	(ABS 1998)[a]	(Creighton 1998)	(ABS 1998) [a]
Tweed	154	190	1,810
Brunswick	88	90	787
Richmond	428	907	7,536
Clarence	358	345	10,149
Bellinger	171	301	2,454
Macleay	106	81	4,828
Hastings– Camden Haven	127	112	1,813
Total	**1,432**	**2,026**	**29,377**

[a] Data collected from enterprises with an EVAO of $5,000 or over.

The difference between the two figures may be the result of differing data collection strategies. The ABS (1998) collected information from every enterprise with an EVAO of $5,000 or greater. Creighton (1998) estimated the number of enterprises regardless of their EVAO. The biggest difference between the two sources occurs in the Richmond and Bellinger catchments (Table 7).

By 1996–97, the estimated number of enterprises irrigating appears to have dropped to 991 (ABS 1998) ②. Climatic factors such as rainfall cannot be used to explain this change. Total season rainfall was similar for the spring and summer months of 93–94, 94–95 and 96–97 and therefore access to water was similar for these seasons (Appendix 14.5). The apparent drop is represented statewide, occurring in many SLAs across NSW, and should be treated with caution.

Most enterprises that irrigated were in the SLAs of Tweed, Byron, Lismore, Ballina, Kyogle, Tenterfield, Coffs Harbour, Nambucca and Hastings (Appendix 14.6).

Of the total number of enterprises irrigating, the largest number was irrigating pasture. These enterprises were located mostly in the Kyogle and Hastings SLAs. Enterprises irrigating fruit (excluding grapes) were located mostly in Ballina, Lismore, Tweed, Nambucca and Coffs Harbour (Appendix 14.6).

5.5 Area irrigated and water used (all sources)

In 1993–94, the total area irrigated was 29,377 ha (ABS 1998) (Appendix 14.6) ②. Large areas of land were irrigated in the Richmond and Clarence catchment (Table 8) (Appendix 14.6). By 1996–97 the area irrigated had dropped to 14,088 ha (ABS 1998), (②), the reasons for which remain unknown. The largest falls occurred in the SLAs of Severn, Guyra, Walcha, Tenterfield, Dumaresq and Uralla (Appendix 14.6).

Pasture had the largest land area irrigated in the region, totalling about 22,480 ha (②) in 1993–94, representing approximately 77% of the total area irrigated. By 1996–97, the area irrigated had dropped to 7,880 ha ②, representing only 50% of the total area irrigated (ABS 1998) (Appendix 14.7). For the same year, ABARE (2000) estimated that 12,949 ha of pasture were irrigated in the North Coast region. The difference between the ABS and ABARE figures can be explained by the use of two different EVAOs. Where ABS used an EVAO of $5,000, ABARE used $22,500 (refer to footnote 1).

Dairy farms that irrigate occur in all catchments except for Brunswick (Table 8). ABS figures suggest that Kyogle, Hastings, Bellingen, Severn, Tenterfield, Uralla, Dumaresq and Walcha SLAs had the largest areas of pasture irrigated (Figure 4).

After pasture, fruit and nuts (excluding grapes) had the largest irrigated area. These enterprises were mostly concentrated in the SLAs of Ballina, Lismore and Coffs Harbour (Figure 5). Vegetables were concentrated in the SLAs of Tweed, Tenterfield and Nambucca (Appendix 14.7). A summary of the crops grown in each table is shown below in Table 8.

Volumes of water extracted by irrigation from all sources of water in the North Coast region in total and by crop type are not known. This is due to scarcity of information on extraction from individual water sources.

ABARE provides the closest estimate of the volume of water used in the region. It estimates that broadarea and dairy enterprises extracted 44,477 ML in 1996–97 (ABARE 2000)③. However, this figure does not include the water used by horticultural or vegetable enterprises.

Due to the lack of information on crop areas and crop water use, theoretical estimates of irrigation application rates must suffice (Table 9). Turf, sugar cane, tea-tree and perennial pasture have the highest requirements in the North Coast region while summer cereals and oilseeds have the lowest requirements. (For other estimates see Appendix 14.8.)

Table 8. Crop type as a percentage of area irrigated in each catchment

Crop industry	Tweed	Brunswick	Clarence	Bellinger	Richmond	Macleay	HCH
Avocados	5	12	-	3	10	-	-
Bananas	33	39	-	27	-	5	-
Blueberries	-	-	5	-	-	-	-
Citrus	-	-	3	-	-	1	2
Custard apples	2	5	-	-	3	-	-
Mangoes	2	-	-	2	-	-	-
Other tropical fruit	-	-	-	-	9	-	-
Passionfruit	2	4	-	-	-	-	-
Persimmons	-	-	2	-	-	-	-
Stone fruit	-	-	2	-	3	1	-
Other permanent hort. crops	-	-	-	6	-	19	-
Nurseries	3	15	1	2	2	3	1
Macadamias	-	-	2	10	16	-	-
Dairying	47	-	55	37	54	58	88
Sugar	-	-	3	-	-	-	-
Tea-tree	-	-	3	-	3	-	-
Turf	-	12	-	-	-	-	-
Vegetables	6	2	2	13	-	13	2
Not specified	-	-	-	-	-	-	7
Unspecified crops	-	11	22	-	-	-	-
Area irrigated[b] (96–97)	1,035	476	3,089	1,572	5,973	755	1,188

[a](*pers. comm.* C. Rolfe) [b](ABS 1998)

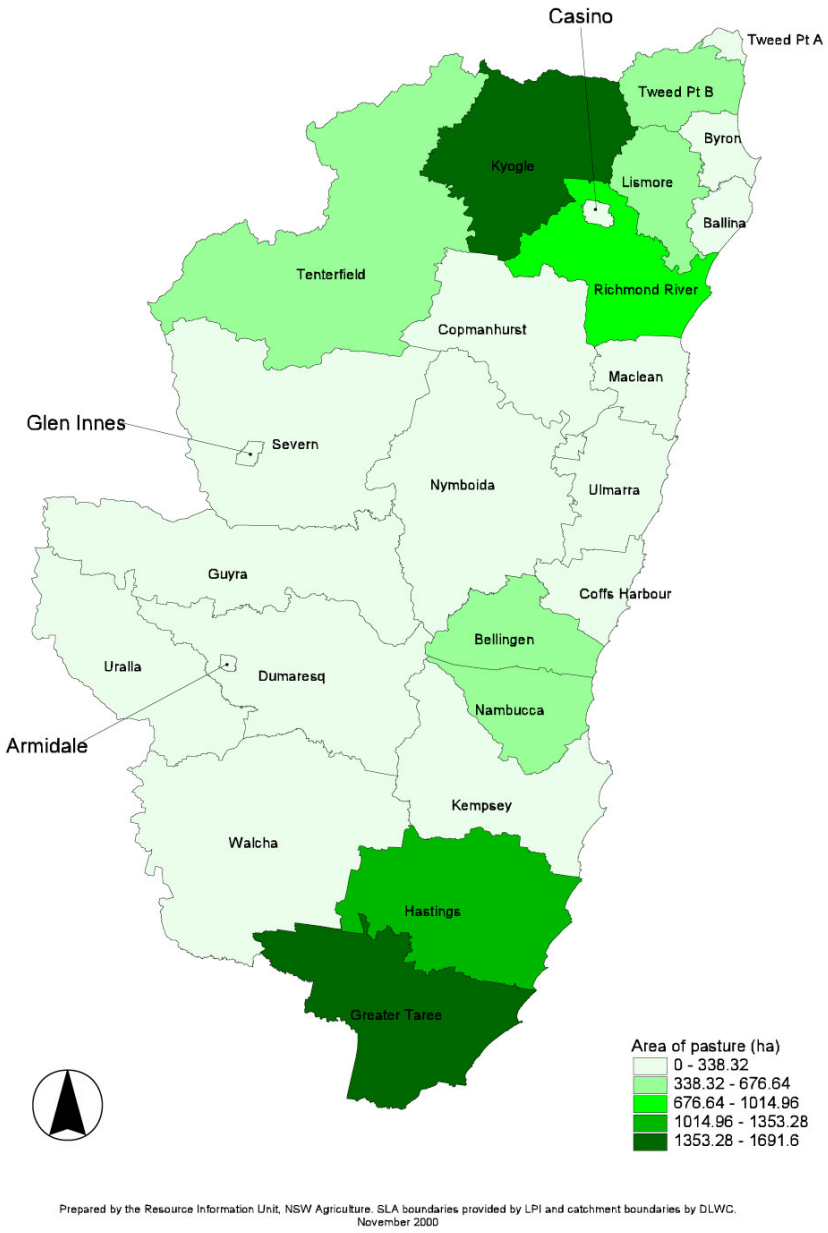
Table 9. Irrigation requirements[5] for crops in the North Coast region

Crop	Irrigation requirement (ML/ha)	
	Port Macquarie to Qld border	Taree to Port Macquarie
Turf	10	11
Sugar cane	8	-
Tea-tree	7	-
Perennial pasture – dairy	6.5	7
Coffee	6.5	-
Bananas	6.5	-
Vegies	6	6.5
Orchards	5.5	6.5
Nuts	5.5	6.5
Perennial pasture – non-dairy	4.5	5
Lucerne	4.5	5
Cut flowers	4.5	5
Pulses	4	4
Olives	4	-
Citrus	3.5	5
Winter oilseeds	3.5	-
Annual pasture	3	3
Winter cereals	2.5	2.5
Summer cereals	2	3
Summer oilseeds	2	3
Vines	1.5	-

Source: (DLWC 2000d) ②. These figures include an irrigation efficiency of 70%.

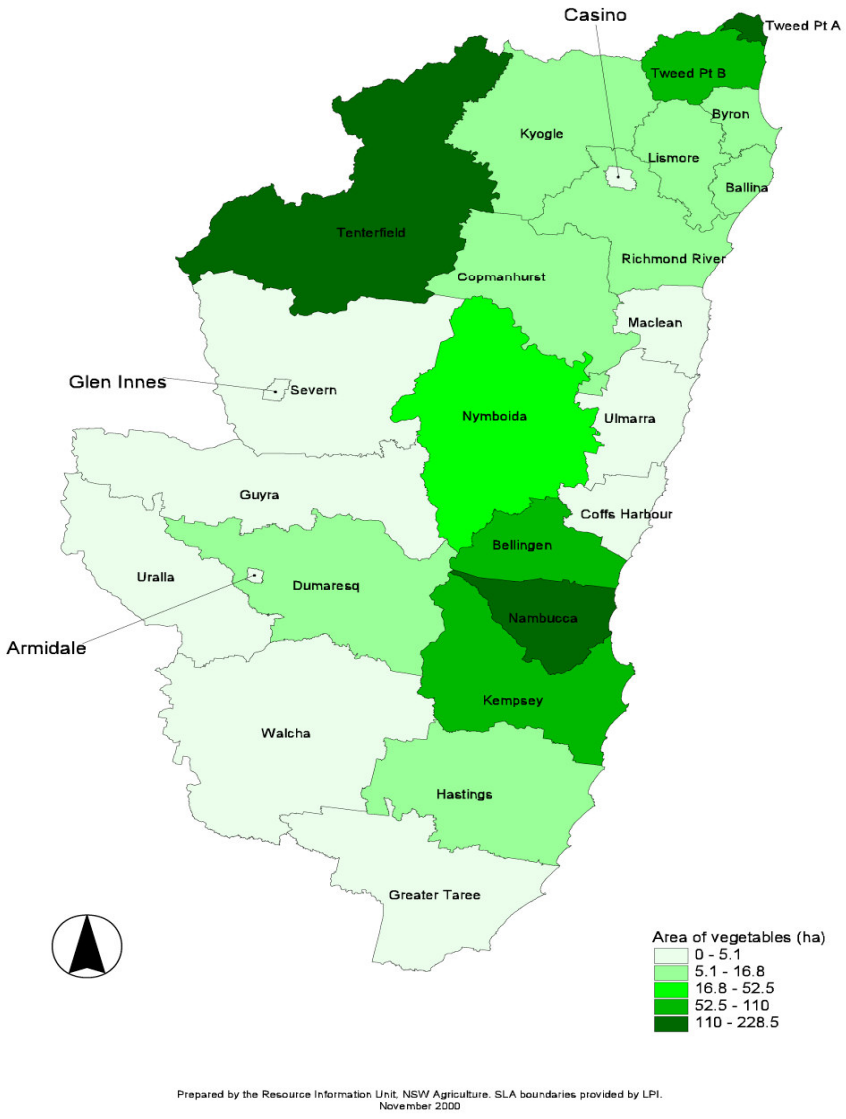
[5] Irrigation requirement is the volume of water required by a crop after rainfall has been taken into account.

Figure 4. Area (ha) of pasture irrigated in the North Coast region



Source: (ABS 1998) ②

Figure 5. Area (ha) of vegetables irrigated in the North Coast region



Source: (ABS 1998)②

5.6 Irrigation methods (all sources)

Data on the irrigation methods are shown in Table 10 and were compiled from NSW Agriculture staff and from referenced material.

Table 10. Irrigation methods used in the North Coast region

Crop	Irrigation methods	Reference and reliability rating
Irrigated pasture for dairy	Travelling irrigators and bike shift	(pers. comm. C. Rolfe), (pers. comm. K. Moore) ④
Avocados	Micro-sprinklers	(pers. comm. C. Rolfe) ④
Bamboo	Under-canopy sprinkler system	(pers. comm. C. Rolfe) ④
Bananas	Overhead, micro-sprinklers and drip	(pers. comm. C. Rolfe) (pers. comm. A. Akehurst) ④
Blueberries	Jet sprays and drip	(pers. comm. C. Rolfe) ④
Bush foods	Drip	(pers. comm. C. Rolfe) ④
Citrus	Micro-sprays and sprinklers	(pers. comm. C. Rolfe) ④
Coffee	Drip	(pers. comm. C. Rolfe) ④
Custard apples	Micro-sprinklers	(pers. comm. C. Rolfe) ④
Cut flowers	Solid-set, drip and hydroponics	(pers. comm. C. Rolfe) ④
Grapes	Drip	(pers. comm. C. Rolfe) ④
Herbs	Overhead solid-set, drip, travelling	(pers. comm. C. Rolfe) ④
Kiwi fruit	Micro-sprays	(pers. comm. C. Rolfe) ④
Lemon myrtle	Drip	(pers. comm. C. Rolfe) ④
Lychees	Micro-sprinklers and sprays	(pers. comm. C. Rolfe) ④
Macadamias	Inverted micro-sprinklers and drip	(pers. comm. C. Rolfe) ④
Maize	Travelling irrigators	(pers. comm. K. Moore) ④

Crop	Irrigation methods	Reference and reliability rating
Mangoes	Micro-sprinklers	(pers. comm. C. Rolfe)④
Nurseries	Overhead, drip, capillary watering	(pers. comm. C. Rolfe) ④
Olives	Micro-sprinklers	(pers. comm. C. Rolfe) ④
Passionfruit	Drip	(pers. comm. C. Rolfe) ④
Pecans	Micro-sprinklers & sub surface drip	(pers. comm. C. Rolfe) ④
Stone fruit	Micro-sprays and sprinklers	(pers. comm. C. Rolfe) ④
Sugar	Travelling irrigators and drip	(pers. comm. C. Rolfe) ④
Tea	Drip	(pers. comm. C. Rolfe) ④
Tea-tree	Flood, travelling irrigators and drip	(pers. comm. C. Rolfe) ④
Vegetables	Spraylines, solid-set and drip	(pers. comm. C. Rolfe) ④

Around 80% of the area irrigated was watered with travelling irrigators, with the rest irrigated using moveable spray systems (ABARE 1998).

Generally, dairy farms use either travelling irrigators and bike shift systems and horticultural farms use the more expensive systems of drip and under-tree mini-sprinklers (Table 10).

5.7 Irrigation yields (all sources)

Table 11. Irrigation yields of crops in the North Coast region

Crop	min to max	Average	Reliability rating	Reference
Perennial tropical	8-20	13	④	(*pers. comm.* K. Moore)
Pasture (perennial temperate)	9–18	13.5	④	(*pers. comm.* K. Moore)
Pasture (annual)	8–18	10-Dec	④	(*pers. comm.* K. Moore)
Bananas	10–35	*	④	(*pers. comm.* A.

Crop	min to max	Average	Reliability rating	Reference
				Akehurst)
Barley (a)	*	2.3	④	(ABARE 2000)
Hay/silage (b)	*	14.8	④	(ABARE 2000)
Oats (c)	*	0.7	④	(ABARE 2000)
Oilseeds (d)	*	2.6	④	(ABARE 2000)
Lucerne (e)	*	2.5	④	(ABARE 2000)
Echinacea	*	6.6	④	(Switala 1997)
Davidson Plum	*	21.6	④	(ARBA 1996a)
Riberries	*	8.3	④	(ARBA 1996b)
Warrigal greens	*	20	④	(*pers. comm.* C. Rolfe)
Lychees	*	3.7	④	(Hinton 1999)
Pecans	0.9-2.2	*	④	(Loeball 1997)
Tea tree (oil)	*	0.22	④	(Murtagh *et al.* 2000)
Macadamias	*	7	④	(*pers. comm.* C. Rolfe)
Avocados	20-25	*	④	(*pers. comm.* C. Rolfe)
Stone fruit	*	35	④	(*pers. comm.* C. Rolfe)
Coffee (f)	*	3.7	④	(*pers. comm.* C. Rolfe)
Blueberries	*	10	④	(*pers. comm.* C. Rolfe)
Bamboo	*	10	④	(*pers. comm.* C. Rolfe)

(a) **barley** yields = tonnes (RSE[6] 55) divided by area (RSE 39)
(b) **hay/silage** yields = tonnes (RSE 46) divided by area (RSE 30)
(c) **oat** yields – tonnes (RSE 107) divided by area (40)
(d) **oilseeds** = tonnes (RSE 35) divided by area (RSE 22)
(e) **lucerne** yields = tonnes (RSE 77) divided by area (RSE 83)
(f) These data arefrom a 5-year coffee trial, which began in 1998, funded by Rural Industries Research and Development Corporation (RIRDC) (No NPP 98-14) titled 'Developing Irrigation Strategies for Coffee Under Sub Tropical Conditions'.

[6] The Relative Standard Error or RSE is the standard error divided by the actual data value. The result is dimensionless. The RSE shows how big the standard error is as a proportion of the actual data value.

5.8 Value of irrigated production (all sources)

The total farm-gate value of irrigated agriculture in the North Coast region (see Figure 1) was estimated to be $330 million (*pers. comm.* C. Rolfe) ④. However, Donovan (2000) estimated that, for the North Coast region plus the Manning and Karuah catchments (which for this study was considered in the *NSW Mid-Coast Region Irrigation Profile*), irrigated agriculture was worth $188.6 million in 1996–97, or around 30% of the total value of agriculture. The second figure should be the larger, but there are discrepancies in the collection methods:

- The first figure was determined by adding data on the value of irrigated agriculture from a combination of industries (*pers. comm.* C. Rolfe) ④ (Appendix 14.9).
- The second figure was derived synthetically by Donovan (2000) ③ using ABS information [7].

The value of irrigated agriculture steadily increased from $141 million in 1991–92 to $197 million in 1995–96 (Appendix 14.10) and then fell slightly in 1996–97 to $189 million. Most crops maintained the same percentage of the total value, except grain and fruit (excluding grapes) (Appendix 14.10).

Livestock products had the highest irrigated value in the region and represented 42% of the total irrigated value ($72 million) (Appendix 14.10). Other information suggests that in the North Coast region the value of irrigated dairy alone was worth $130 million ④ (*pers. comm.* C. Rolfe).

The irrigated fruit and nuts industry was worth $50 million in 1996–97, or 26% of the total irrigated value (Donovan 2000). The industry has been steadily increasing in value.

In 1996–97, the total value of irrigated macadamias was $31 million, representing 85% of the total value of macadamias ($36 million) in NSW (Donovan 2000). Other information suggests that macadamias could be worth as much as $70 million in the North Coast region alone ④ (*pers. comm.* C. Rolfe).

[7] The individual irrigated commodity values for Australia were derived by estimating the percentage of the total commodity value that could be attributed to irrigation. The irrigated percentage was determined from agency reports and consultation with industry bodies (DWC 1990) (RR unknown). These individual commodity percentages were then applied to the total NSW commodity value data from the ABS for each SLA over the period between 1991 and 1997 (Donovan 2000) ②. These values were then summed to provide synthetically generated estimates of the total value of irrigated agriculture for each catchment. The reliability of the estimated percentage value for individual commodities may vary from crop to crop. For example, grapes values are more likely to be reliable than wheat values because grapes are usually irrigated with high security water that helps to ensure yields and areas remain reasonably static. Cereal areas and yields can by comparison vary markedly with climate and water availability. The overall RR for these data is ③.

The irrigated stone fruit industry produced a value of $7.2 million (Donovan 2000). Other information suggests that the value could be as much as $15 million (*pers. comm.* C. Rolfe). Seventy per cent of Australia's low-chill stone fruit is produced in the area (Creighton *et al.* 1999).

The value of irrigated bananas was estimated to be $5.3 million (Donovan 2000) ③, representing 10% of the total value of bananas produced in NSW. Due to the high capital and pumping costs necessary to irrigate elevated plantations (Johns 1993), only 10 to 15% of banana growers irrigate (Creighton *et al.* 1999; Donovan 2000; Johns 1993).

The avocado industry was valued at between $4.2 million (Creighton *et al.* 1999) and $5 million (Donovan 2000) ③.

The irrigated value of the citrus industry was estimated to be $1.1 million (Creighton et al. 1999; Donovan 2000). The citrus industry (limes, mandarins, tangors and oranges) is relatively small.

Approximately 80% of grapes were irrigated, with a value of $0.5 million (Donovan 2000) ③.

The lychees industry is small. There were estimated to be 13,366 trees producing 241 tonnes of fruit with a total value of $1.25 million (Creighton et al. 1999) (Appendix 14.9).

The blueberry industry was worth $19 million, with the industry expected to grow. The forecast production for 2002 was 1,900 tonnes (Creighton et al. 1999).

The North Coast region produced 35% of Australia's passionfruit, from 124 ha.

'Other crops'[8] represented 18% of the total value of production in the North Coast region, or $34.1 million. The most valuable crop in this category is likely to be the nursery industry. The nursery industry has a strong presence in the North Coast region especially in the Tweed, Brunswick and Richmond catchments. Of the 764 production/wholesale businesses in NSW worth $125 million (Atkinson nd), a quarter of these exist in the North Coast region (*pers. comm.* R. Stephens), ④ giving an estimated value of $31.2 million. Other information suggests that the value could be from $55 million–$140 million (*pers. comm.* C. Rolfe)④.

Vegetables represented 8% of the total value of agriculture in the region (Appendix 14.10) and most (90.8%) of the value could be attributed to irrigation.

Products such as coffee, lemon myrtle, olives, pecans and tea-tree oil are high-value 'sunrise' or new industries. The region is capable of producing high-value coffee, in a pest- and disease-free environment. The coffee industry has been valued at $2.6 million (Creighton *et al.* 1999) ④. There are expanding opportunities for medicinal and culinary herbs, bush foods and native flowers.

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[8] The ABS category 'other crops' includes cotton, sugar cane, field peas, chick peas, lupins, nursery production, canola, soybean, sunflowers, peanuts, tobacco and other. Note that because the North Coast region does not grow cotton, field peas, lupins, canola, soybeans, sunflowers, peanuts or tobacco, this category best approximates nursery production.

Table 12. Summary of irrigation data – regulated supply

	No. irrigation licences[a]	No. enterprises irrigating	Total area irrigated (ha)[b]	Area of pasture irrigated (ha)[b]	Total water use by irrigated agriculture (ML)[b]	Total water use on pasture (ML)	Yield of pasture (t/ha)	Value of irrigation ($/mill)	Value of livestock prods dependent on irrigation ($/mill)
1988–89	-	-	-	-	-	-	-	-	-
1989–90	-	-	125	125	270[b]	270[b]	-	-	-
1990–91	-	-	178	178	-	-	-	-	-
1991–92	-	-	-	-	-	-	-	-	-
1992–93	-	-	-	-	-	-	-	-	-
1993–94	-	-	-	-	-	-	-	-	-
1994–95	-	-	-	-	-	-	-	-	-
1995–96	-	-	-	-	-	-	-	-	-
1996–97	-	-	-	-	-	-	-	-	-
1997–98	-	-	-	-	-	-	-	-	-
1998–99	49	-	-	-	-	-	-	-	-
1999–00	-	-	-	-	1,000[a]	-	-	-	-
2000–01	-	-	-	-	-	-	-	-	-
Refer to	Sec. 6.3	Sec. 6.2	Sec. 6.5	Sec. 6.5	Sec. 6.5	Sec. 6.5	Sec. 6.7	Sec. 6.8	Sec. 6.8

[a] data obtained from (*pers. comm.* J. Morrison), (DLWC 2000e) (reliability unknown). [b] (DLWC 1998), area ②, water use ①

6. IRRIGATION FROM REGULATED RIVERS

6.1 Description of the regulated water supply

A very small percentage of irrigation in the North Coast region relies on regulated supplies.

Iron Pot Creek and Eden Creek in the upper Richmond catchment are the only regulated watercourses in the North Coast region. Iron Pot Creek joins Eden Creek before joining with the Richmond River above Casino. The creek is regulated by Toonumbar Dam, which has a storage capacity of 11,000 ML (EPA 1997).

Other dams and structures that regulate water in the catchment for town and industry include Rocky Creek and Emigrant Creek Dam, weirs at Casino, Mullumbimby Power Station on the upper Wilson River and numerous small barrages and floodgates on the coastal plains (DLWC 1999g).

A summary of irrigation data relating to regulated supplies appears below. The lack of data for this source of water is shown in Table 12.

6.2 Number of licences with the purpose of irrigation (regulated)

There are 49 licences (all of which have a volumetric allocation) in the North Coast region. Of these, 24 exist on Iron Pot Creek and 25 on Eden Creek (*pers. comm.* J. Morrison) (DLWC 2000e). The locations of these licences are shown in Figure 6.

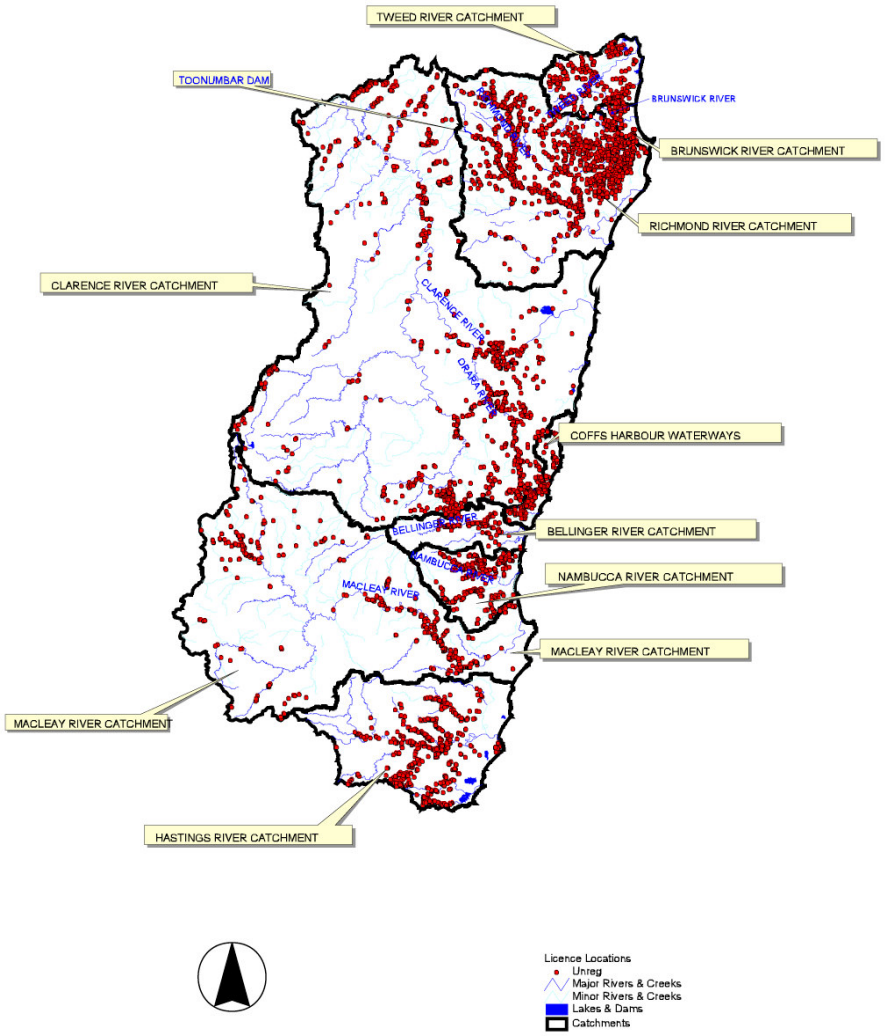
6.3 Number of enterprises using irrigation (regulated)

No data are available on the number of irrigation enterprises using water from regulated supplies in the North Coast region. The ABS collected information on all irrigation enterprises using water from surface supplies (Appendix 14.11). However, the ABS questionnaire combined rivers controlled by public and private dams in one question. Regulated rivers are in fact defined as those controlled by public dams (see Section 3.3), therefore irrigation data relating to regulated rivers cannot be separated. As a result, some enterprises on unregulated rivers reported irrigating using regulated supplies. In 1993–94, one respondent reported irrigating 8 ha of land in the Bellingen SLA using water supplied from a 'channel or pipe supply in an irrigation area or district'.

6.4 Volumetric entitlement to irrigation (regulated)

The volumetric allocation from Toonumbar Dam to irrigation is 4,500 ML (*pers. comm.* B. Edwards).

Figure 6. Location of regulated and unregulated licences with the purpose of irrigation in the North Coast region



Source: (DLWC 2000)

6.5 Area irrigated and water used (regulated)

Area irrigated – All the available water from the regulated portions of Iron Pot and Eden creeks was used to grow either winter or summer pasture (Table 13). During the two years for which records are available, between 125 and 178 ha of pasture were irrigated. Information on irrigated area, which was estimated by licence officers, attracts a reliability rating of ② .

Water use – In 1989–90, the total volume used was 270 ML ①. This figure was based on metered information. In 1999–2000 the volume had increased to approximately 1000 ML (*pers. comm.* B. Edwards) ④.

Table 13. Crop area and water use from the regulated portion of Iron Pot and Eden creeks

	1989–90		1990–91
	Area (ha)②	Water use (ML)①	Area (ha) ②
Summer pasture	82	264	63
Winter pasture	43	6	115
Total	125	270	178

Source: (DLWC 1998)

6.6 Irrigation methods (regulated)

There are no data on methods used to irrigate specifically from the regulated sections of Iron Pot and Eden creeks. Bike shift and travelling irrigators were the most prevalent methods of irrigating pasture from all sources of water (see section 5.6). These systems are likely to be used to irrigate from regulated supplies.

6.7 Irrigation yields (regulated)

There are no data on yields of crops irrigated from regulated supplies of Iron Pot and Eden creeks (see section 5.6 for details on yields from all sources).

6.8 Value of irrigated production (regulated)

There are no data on the value of irrigated agriculture solely from regulated rivers in the North Coast region.

7. IRRIGATION FROM UNREGULATED RIVERS

7.1 Description of the unregulated water supply

Unregulated rivers are the major source of water for the irrigation industry in the North Coast region. All rivers in the region except for the Iron Pot and Eden creeks in the Richmond catchment are unregulated. Water flow may still be controlled to an extent by private dams and weirs.

A series of developments has affected the access by irrigators to licences and water supplies.

- In 1995, an embargo was placed on the issue of new licences in the North Coast region. This move followed concern about declining river health and conflicts over water use in dry or low flow periods (DLWC 1998).
- Water management committees are developing water management plans for subcatchments in the North Coast region. Their work is being assigned priorities by the DLWC desktop analysis of subcatchment hydrological and environmental stress. For details of methods used to classify subcatchment stress see Appendix 14.12.
- In 2000, licences were converted from having an area-based limit to a volume-based limit. Rules for sharing the annual volume are being developed by Water Management Committees, which will define how much water can be taken from different flow events on a daily basis (DLWC 2000d).

Table 14 is a summary of the data that are available on irrigation from unregulated water supplies.

7.2 Number of licences and area authorised (unregulated)

There is an estimated 4,000 licences for all purposes[9] on unregulated water sources in the North Coast region. This figure comprised 3,100 surface water licences already known to the DLWC and a further 900 applications for licences through amnesty. The amnesty process began in 1998 when landholders were given the opportunity to come forward and register any unlicensed use of water or water storages. The Government guaranteed that those who registered under the amnesty, and complied with any subsequent requirements, would not be prosecuted for their past activities.

[9] All purposes includes domestic, horticultural, industrial, irrigation, recreation, stock and town water supply uses.

Table 14. Summary of irrigation data – unregulated water supply

	Number irrigation licences[a]	Number enterprises irrigating	Total area irrigated (ha)[b]	Area of pasture irrigated (ha)[b]	Total water used by irrigated agriculture (ML)[c]	Total water used on pasture (ML)	Yield of pasture (t/ha)	Value of irrigation ($m)[C]	Value of livestock products dependent on irrigation ($m)[c]
1988–89	-	-	-	-	-	-	-	-	-
1989–90	-	-	8,668[b]	4,501[b]	20,032[b]	-	-	-	-
1990–91	-	-	8,119[b]	4.544[b]	12,612[b]	-	-	-	-
1991–92	-	-	8,631[b]	5,445[b]	14,668[b]	-	-	-	-
1992–93	-	-	6,021[b]	3.737[b]	54,491[b]	-	-	-	-
1993–94	-	-	12,300[b] 24,442[c]	7,947[b] 9,991[c]	11,271[b]	-	-	-	-
1994–95	-	-	12,720[b] 25,508[c]	4.038[b] 10,690[c]	12,601	-	-	-	-
1995–96	-	-	30,769[c]	10,957[c]	-	-	-	-	-
1996–97	-	-	31,678[c]	10,987[c]	-	-	-	-	-
1997–98	-	-	31,417[c]	10,492[c]	-	-	-	-	-
1998–99	2,702	-	32,611[c]	9,126c	-	-	-	-	-
1999–00	-	-	[c]	10,374[c]	-	-	-	-	-
00–01	-	-	-	-	-	-	-	-	-
Refer to	Sec 7.2	Sec 7.3	Sec 7.4	Sec 7.4	Sec 7.4	Sec 7.4	Sec 7.6	Sec 7.7	Sec 7.7

[a] sum of data from DLWC 1999g, 1999e and 1999f, [b]. (DLWC 1998) ④, [c] (DLWC 2000c)②

The number of licences for irrigation was estimated to be 2,702 (Table 15). Their location is shown in Figure 6. The total number of licences was determined by summing information from several reports (DLWC 1999e; DLWC 1999f; DLWC 1999g). Note that this figure does not include applications for irrigation licences though amnesty. Many of these licences exist in the Far North Coast area, which includes the Brunswick, Tweed and Richmond catchments.

The area authorised for irrigation was estimated to be 33,506 ha ① (Table 15).

Table 15. Number of licences in the North Coast region

Catchments	Number of irrigation licences	Area authorised for irrigation	Reference
Far North Coast[a]	1,321	15,783	(DLWC 1999g)
Mid North Coast[b]	937	13,568	(DLWC 1999e)
Lower North Coast[c]	444	4,155	(DLWC 1999f)
Total	2,702	33,506	

[a] Brunswick, Tweed and Richmond catchments, [b] Bellinger, Clarence, Macleay and Bellinger catchments and Coffs Harbour meso-catchments, [c] Hastings–Camden Haven catchment, Nambucca meso-catchment

7.3 Number of enterprises using irrigation (unregulated)

The number of enterprises irrigating was estimated to be 1,408 (ABS 1998)③. This figure was determined by subtracting the number of licences with a volumetric entitlement (49) ① from the total number of enterprises using water from surface (regulated and unregulated) supplies (1,457) (ABS 1998) ②.

7.4 Area irrigated and water used (unregulated)

Area irrigated: In 1993–94, estimates of the area irrigated from unregulated streams varied from 24,442 ha (DLWC 2000c)② to 36,862 ha (ABS 1998) ③.

- The first figure was collected from all irrigators using water from unregulated streams.
- The second figure was determined by summing the area irrigated in each SLA then subtracting the estimated area irrigated from regulated streams (152 ha) (DLWC 1998) ③. The estimate is assigned a lower reliability rating accordingly.

Note that the second figure is more than the area authorised for irrigation (see previous section) and is more than the total area irrigated from all sources of water (see section 5.5).

The area irrigated increased by 33% between 1993–94 and 1996–97. Large increases were seen in nurseries, winter oilseeds and tea-tree. There were decreases in the irrigated area of sugar cane and perennial and annual pasture (Table 16).

Water used: Information on the total volume of water extracted from unregulated streams is scarce and outdated. Data on total water use was collected from licence holders by survey return cards between 1989–90 and 1994–95. However, data on crop water use alone was not collected (Appendix 14.13). Due to the poor response rate from irrigators, the usefulness of these data is limited. The information shows that between 11,000 ML and 54,500 ML were irrigated between 1989–90 and 1994–95

(DLWC 1998) ④ (Appendix 14.13). This Profile has not attempted to adjust the volume to include those who did not return survey cards to the DLWC. With the conversion of licences from area basis to volume basis (DLWC 2000d), licences will be metered. This will eventually yield better and more current data on crop water use and extraction patterns. Until then, theoretical estimates of the volume required by crops (Table 9) or estimates must suffice (Appendix 14.8).

7.5 Irrigation methods (unregulated)

There are no data on the methods used to irrigate crops from unregulated supplies. See section 5.6 for methods used to irrigate from all sources.

7.6 Irrigation yields (unregulated)

There are no data on yields from crops irrigated from unregulated supplies. See Table 11 for details on yields obtained from crops irrigated from all sources.

7.7 Value of irrigated production (unregulated)

No data were available on the value of crops irrigated solely from unregulated stream in the North Coast region alone.

Table 16. Change in irrigated area by crop type

Area irrigated (ha)

Crop type	1993–94	1994–95	1995–96	1996–97	1997–98	1998–99	Diff. between 93–94 & 98–99
Sugar cane	157	128	153	91	105	56	-101
Perennial pasture	5,948	6,246	6,497	6,407	6,118	5,353	-595
Fodder	247	247	263	259	299	227	-20
Annual pasture	3,382	3,752	3,700	3,885	3,684	3,123	-259
Lucerne	662	692	760	695	690	651	-11
Nuts	1,180	1,150	1,160	1,158	1,177	1,177	-3
Vegetables	1,048	1,007	963	1,055	985	1,047	-1
Bananas	352	366	361	361	372	356	4
Trees – orchards	1,404	1,456	1,507	1,558	1,506	1,540	136

Crop type	1993–94	1994–95	1995–96	1996–97	1997–98	1998–99	Diff. between 93–94 & 98–99
wine grapes	41	41	41	44	45	46	5
Summer cereal	525	505	523	593	688	648	123
Turf	154	171	194	184	196	196	42
Citrus	76	83	89	95	95	97	21
Rice	11	11	11	12	14	14	3
Pulses	36	32	59	68	58	50	14
Other	653	684	760	944	899	936	283
Trees – other	538	583	625	634	619	794	256
Summer oilseeds	260	326	376	547	602	390	130
Winter cereal	390	542	625	840	910	633	243
Nurseries	7,186	7,189	11,605	11,626	11,644	14,550	7364
Cut flowers	5	5	13	12	12	14	9
Tea-trees	182	284	363	541	560	645	463
Vines – table grapes	0	0	0	0	0	1	1
Winter oilseeds	4	4	102	44	106	28	24
Coffee	4	4	19	22	22	30	26
Cotton	1	1	1	1	11	11	10
Olives	0	0	1	2	3	1	1
Total	24,442	25,508	30,769	31,678	31,417	32,611	8169

Source: (DLWC 2000c) ②

8. IRRIGATION FROM GROUNDWATER SUPPLIES

8.1 Description of groundwater supplies

The North Coast region has 33,120,000 ML of groundwater, most of which occurs in fractured or porous rocks. In 1980, only 2% was considered usable and of this only 17% was being used by irrigation (Table 17). It was estimated that only 5% of the total area irrigated in the North Coast region used groundwater, mostly in the Tweed catchment on the Cudgen Plateau. This water is used to grow tomatoes, sweet potato and zucchinis. Avocados and potatoes are irrigated from groundwater around Mt Yarrahapinni near Stuarts Point in the Macleay catchment.

8.2 Number of licences with the purpose of irrigation (groundwater)

There were 336 licences in the region (see footnote 9), most of which were likely to be for the purpose of irrigation (*pers. comm.* W. Hehir).

8.3 Number of enterprises using irrigation (groundwater)

There were 114 enterprises irrigating crops with groundwater (ABS 1998)② and most of these were in the SLAs of Ballina (22%), Hastings (13%), and Kempsey (11%) (Appendix 14.13).

8.4 Volumetric entitlements (groundwater)

No data was available on the volume of water allocated through entitlement.

8.5 Area irrigated and water used (groundwater)

Area irrigated – The total area irrigated from groundwater supplies in 1993–94 was 1,336 ha (ABS 1998). Most of this land is in the SLAs of Ballina (17%), Hastings (15%), and Kempsey (16%). More recent information is not available, nor is information on crops irrigated using groundwater.

Water used – Groundwater licences with the purpose of irrigating are not monitored and therefore total usage cannot be determined directly. In the 1980s, the Water Resources Commission (WRC) estimated that 2,530 ML was being used by irrigated agriculture in the North Coast region (WRC 1980). Approximately 63% of this was in the Richmond catchment (Table 17). Data on the volume of water used by crop type were unavailable.

8.6 Irrigation methods (groundwater)

Data on the methods used to irrigate crops with groundwater in the region were unavailable (see section 5.6 for details on methods from all sources).

8.7 Irrigated yields (groundwater)

Data on yields from crops irrigated using groundwater were unavailable (see section 5.7 for details on yields from all sources).

8.8 Value of irrigated production (groundwater)

There are no data on the value of agriculture irrigated using groundwater in the North Coast region. However, the total value is likely to be small.

Table 18 provides a summary of the data related to irrigation from groundwater supplies and demonstrates the paucity of data.

Table 17. Groundwater resources and usage in the North Coast region

				Present annual usage (× 1,000) (ML)				
Catchment	**Area of aquifer (km^2)**	**Volume in storage (× 1,000) (ML)**	**Possible exploitable yield (× 1,000) (ML)**	**Urban**	**Irrigation**	**Other[a]**	**Total**	**% total extraction of possible exploitable yield (× 1,000 ML)**
Tweed	1,830	1,390	44	0	0.08	0.06	0.14	0.23
Brunswick	490	400	55	0	0.05	0.06	0.11	0.18
Richmond	12,090	13,770	173	1	1.6	6.1	8.7	5.03
Clarence	23,970	14,240	214	0	0.5	0.08	0.58	0.28
Bellinger	3,470	890	125	0	0.1	0.04	0.14	0.08
Macleay	11,210	2,060	108	4	0.1	0.1	4.2	3.89
Hastings–Camden Haven	4,530	370	46	0	0.1	0.7	0.8	1.74
TOTAL	57,590	33,120	765	5	2.53	7.14	14.67	1.91
	Volume used as a % of total extracted volume			34%	17%	49%		

Source: (WRC 1980). [a] 'Other' refers to stock and domestic and industrial supplies. Reliability unknown

Table 18. Summary of irrigation data (groundwater)

	Number irrigation licences[a]	Number enterprises irrigating [b]	Total area irrigated (ha)[b]	Area of major crop irrigated (ha)	Total water used by irrigated agriculture (ML)	Total water used on major crop (ML)	Yield of major crop (t/ha)	Value of irrigation ($m)	Value of major crop ($m)
1988–89	-	-	-	-	-	-	-	-	-
1989–90	-	-	-	-		-	-	-	-
1990–91	-	-	-	-		-	-	-	-
1991–92	-	-	-	-		-	-	-	-
1992–93	-	-	-	-		-	-	-	-
1993–94	-	114	1,336	-		-	-	-	-
1994–95	-	-	-	-	-	-	-	-	-
1995–96	-	-	-	-	-	-	-	-	-
1996–97	-	-	-	-	-	-	-	-	-
1997–98	-	-	-	-	-	-	-	-	-
1998–99	-	-	-	-	-	-	-	-	-
1999–00	336	-	-	-	-	-	-	-	-
2000–01	-	-	-	-	-	-	-	-	-
Refer to	Sec. 8.2	Sec. 8.3	Sec. 8.5	Sec. 8.5	Sec. 8.5	Sec. 8.5	Sec. 8.7	Sec. 8.8	Sec. 8.8

[a] (*pers. comm.* W. Hehir) Number of licences refers to all purposes: irrigation, reticulated water supply, industrial purposes ① [b](ABS 1998)②

9. IRRIGATION FROM FARM DAMS

9.1 Description of farm dam water supplies

Irrigation of crops from farm dams is widespread in the North Coast region. Approximately 24% of the area irrigated from all sources could be attributed to farm dams in 1993–94 (ABS 1998)②.

Farm dams were used to irrigate:

- bananas, macadamias, tomatoes, sweet potatoes and zucchinis in the Tweed catchment (*pers. comm.* C. Rolfe)
- avocados, blueberries, custard apples, macadamias, nurseries and stone fruit in the Richmond catchment (*pers. comm.* C. Rolfe)
- blueberries, citrus, grapes, macadamias, persimmons and stone fruit on the Corinda plateau in the Clarence catchment (*pers. comm.* C. Rolfe)
- most crops in the Bellinger catchment (*pers. comm.* C. Rolfe)

Farm dams are used to provide security during drought and low-flow periods in spring. However, some areas of the North Coast have krasnozem soils that have high permeability and are not suitable for dams.

In the past, a dam of up to 7 ML could be built without needing to be licensed, providing the water was used for non-commercial purposes. There was no allowance for the size of the property or for climatic variation, nor were there restrictions on the number of dams that could be built on a property. Part 10 of the Water Act 1912, which came into operation on 1 January 1999, created a Harvestable Right. This gives landholders the right to capture and use for any purpose 10% of the average regional yearly rainfall run-off for their property, regardless of the dam's purpose (DLWC 1999d). Harvestable rights are now addressed in Chapter 3, Division 2 of the *Water Management Act 2000*.

Dams that collect more than 10% of the run-off require a licence.

Table 19 summarises irrigation data relating to farm dams water supplies. As the table shows, information was only available for 1993–94, and then only pertaining to the number of enterprises irrigating and the area irrigated. Other data were not available.

Table 19. Summary of irrigation data for farm dams in the North Coast region

	Number irrigation licences	No. enterprises irrigating[a]	Total area irrigated (ha) [a]	Area of major crop irrigated (ha)	Total water used by irrigation agriculture (ML)	Total water used on major crop (ML)	Yield of major crop (t/ha)	Value of irrigation ($/mill)	Value of major crop ($/mill)
1988–89	-	-	-	-	-	-	-	-	-
1989–90	-	-	-	-	-	-	-	-	-
1990–91	-	-	-	-	-	-	-	-	-
1991–92	-	-	-	-	-	-	-	-	-
1992–93	-	-	-	-	-	-	-	-	-
1993–94	-	547	7,103	-	-	-	-	-	-
1994–95	-	-	-	-	-	-	-	-	-
1995–96	-	-	-	-	-	-	-	-	-
1996–97	-	-	-	-	-	-	-	-	-
1997–98	-	-	-	-	-	-	-	-	-
1998–99	-	-	-	-	-	-	-	-	-
1999–00	-	-	-	-	-	-	-	-	-
2000–01	-	-	-	-	-	-	-	-	-
Refer to	Sec 9.2	Sec. 9.2	Sec. 9.4	Sec. 9.4	Sec. 9.4	Sec. 9.4	Sec. 9.6	Sec. 9.7	Sec. 9.7

[a](ABS 1998)

9.2 Number of licences with the purpose of irrigation (farm dams)

The number of licences for irrigation from farm dams is not known. Irrigators using water from this supply are currently being licensed.

9.3 Number of enterprises using irrigation (farm dams)

An estimated 547 enterprises were using water from farm dams to irrigate crops in the North Coast region (ABS 1998) ② in 1993–94. These were in Lismore, Tweed, Nambucca and Coffs Harbour SLAs.

9.4 Area irrigated and water used (farm dams)

Area irrigated – In 1993–94, 7,103 ha were irrigated using water from farm dams (ABS 1998) ②.

Data on the crops irrigated with this water were unavailable.

Water use – Data on the water used in total and by crop type were unavailable.

9.5 Irrigation methods (farm dams)

There are no data on methods used to irrigate from farm dam supplies (see section 5.6 for details on methods used for all sources).

9.6 Irrigation yields (farm dams)

There are no data on yields from crops irrigated using farm dam supplies (see section 5.7 for details on yields obtained using all sources of water).

9.7 Value of irrigated production (farm dams)

There are no data on the value of irrigated production from farm dams in the region.

10. IRRIGATION FROM RETICULATED WATER SUPPLIES

10.1 Description of reticulated water supplies

The irrigation of crops from reticulated supplies is very limited in the North Coast region. Less than 0.1% of the total area irrigated could be attributed to water from reticulated supplies (ABS 1998). Agricultural use of reticulated water is limited to high-value, small-area industries such as the nursery industry (*pers. comm.* C. Rolfe). According to Rous Water, which supplies water to areas such as Murwillumbah, Ballina and Lismore, the cost per ML is $700.

Very little data are available for irrigation from reticulated supplies. Table 20 summarises what is known about irrigation dependent on this source.

10.2 Number of irrigation licences (reticulated)

There are no data on the number of irrigation licences using water from reticulated supplies.

10.3 Number of enterprises using irrigation (reticulated)

There were 26 enterprises using water from reticulated water supplies (ABS 1998) ②. Most were located in the Tweed and Hastings SLAs (Appendix 14.6). There are no

10.4 Area irrigated and water used (reticulated)

Area irrigated – Approximately 20 ha were irrigated using water from reticulated water supplies (ABS 1998) ② and most of this land was in the Tweed SLA. Each enterprise was on average 1.8 ha (ABS 1998).

Water use – There were no data on water use in total or by crop type from reticulated water supplies.

10.5 Irrigation methods (reticulated)

Nurseries are generally irrigated using overhead, drip and capillary watering (see Table 10).

10.6 Irrigation yields (reticulated)

There were no data on yields from crops irrigated using water from reticulated supplies (see Table 11 for details on yields from crops irrigated using all sources).

Table 20. Summary of irrigation data for reticulated water supplies in the North Coast region

	Number irrigation licences	Number enterprises irrigating[a]	Total area irrigated (ha) [a]	Area of major crop irrigated (ha)	Total water use by irrigated agriculture (ML)	Total water use on major crop (ML)	Yield of major crop (t/ha)	Value of irrigation ($m)	Value of major crop ($m)
1988–89	-	-	-	-	-	-	-	-	-
1989–90	-	-	-	-	-	-	-	-	-
1990–91	-	-	-	-	-	-	-	-	-
1991–92	-	-	-	-	-	-	-	-	-
1992–93	-	-	-	-	-	-	-	-	-
1993–94	-	26	20	-	-	-	-	-	-
1994–95	-	-	-	-	-	-	-	-	-
1995–96	-	-	-	-	-	-	-	-	-
1996–97	-	-	-	-	-	-	-	-	-
1997–98	-	-	-	-	-	-	-	-	-
1998–99	-	-	-	-	-	-	-	-	-
1999–00	-	-	-	-	-	-	-	-	-
2000–01	-	-	-	-	-	-	-	-	-
Refer to	Sec.10.2	Sec.10.3	Sec.10.4	Sec.10.4	Sec.10.4	Sec.10.4	Sec.10.6	Sec. 10.7	Sec. 10.7

[a] (ABS 1998)②

10.7 Value of irrigated production (reticulated)

It has been estimated that the value of the nursery industry is between $55 million and $140 million (Appendix 14.9). The proportion of the industry reliant on reticulated water supplies is not known.

11. OPPORTUNITIES AND ISSUES

11.1 Opportunities for the North Coast region

11.1.1 Improving irrigation data

- **Metering of water use on unregulated rivers will improve knowledge.** Volumetric conversion of area-based licences will lead to better information regarding usage of water from unregulated streams. Water use will be metered and recorded by the DLWC for billing purposes, leading to a greater understanding of the impact of irrigation on unregulated streams and thus better decision-making.
- **Developing better data-sharing partnerships between government and irrigators.** Data collected from irrigators for purposes such as billing, operational and reporting are seldom returned to their source. This creates suspicion among irrigators, which in turn may affect the reliability of data. The opportunity exists to return data to irrigators in a useful format with the potential to help improve farm water management. This would also improve the quality of irrigation data collected by agencies.
- **Reporting data at more useful scales.** The opportunity exists to provide agencies and communities with data that can be aggregated to useful scales through use of Geographic Information System applications. The challenge would be to continue to maintain data confidentiality (that is, licence and enterprises information) while maximising data usefulness to resource managers.

11.1.2 Opportunities for irrigated agriculture

- **Deregulation may free water in the dairying areas of the North Coast region by forcing marginal irrigation operators into dryland farming.** As trading of water licences continues, licence values will increase. As a result of dairy deregulation farms may cease irrigating, which could potentially free water in the system. The opportunity may exist for growing other high-value crops such as coffee, tropical fruits, vegetables and nuts.
- **Restricted access to water will force irrigators to build farm dams.** Restricting the extraction of water from unregulated rivers during low-flow periods will become an issue for many subcatchments in the North Coast region. The opportunity exists to extract high flow water for storage in dams. This water could be used to irrigate crops during other times of the year when water volumes in rivers are low. NSW Agriculture is compiling an education package on development of storage facilities in the region.
- **Expanding opportunities for high value crops.** The nursery, turf, cut flowers and agro-forestry industries in the North Coast region may expand, especially in the far north where there are rapid population increases. As the

population continues to rise, there is likely to be more storm water run-off from bitumen and building-covered surfaces and more tertiary-treated effluent water. Non-edible and edible irrigated crops may become a sink for this water. For example, irrigation of bananas with treated effluent water is already being tested around Coffs Harbour (Johns 1993).

- **Improving water use efficiency.** Investigations of irrigation practices in Kyogle revealed large pumping inefficiencies and poor knowledge of the amount of water being applied to paddocks (Rolfe 1988). The opportunity exists to improve efficiencies in order to adjust to market deregulation and water reforms.

11.2 Issues for irrigation in the North Coast region

11.2.1 Data issues

- **Information about irrigation in general is scarce.** Since the implementation of water reforms and the development of water-sharing plans, a greater range of irrigation data is needed than is currently available (for example, data on crop areas, water use, yield, value of production and irrigation methods). In the past, agency and community data needs were fewer and therefore fewer data were collected. For example, the DLWC billed people on their authorised area rather than the area they actually irrigated. There were no requirements to record information such as crop area and water use, yield, irrigation method or value. As a result, these data tend to be scarce.
- **There is a scarcity of data at useful scales.** Natural resource managers involved in developing water-sharing plans require data at scales such as river-reach or subcatchment. Data at, or less than, these scales are scant, particularly with respect to yield, irrigation method and value of production. These data are typically collected by or determined from either the ABARE or the ABS. There are several difficulties with these data-sets:
  - ABARE collected data at the North Coast region scale during a survey in 1996-97. This presentation is much larger than that required by, for example, Water Management Committees. This survey contains potentially useful information about yields of irrigated crops, methods of irrigation and financial data, but the reporting scale limits its usefulness.
  - The ABS has been collecting data on irrigation by SLAs for a number of years. The difficulty with these data is that they do not align well with catchment and subcatchment boundaries. Consequently, the area irrigated may be underestimated or overestimated depending on the SLA composition and its relationship with catchment boundaries.
  - The ABS stopped collecting data by SLAs in 1996–97 and began collecting information by Agro-Ecological Regions (AER). These AERs often span many catchments and cannot be disaggregated into smaller units. This reduces the usefulness of data on the number of enterprises irrigating and the value of irrigation.

- **Data about irrigators and irrigation enterprises are limited –** Information at licence level is available from the DLWC and is relatively easy to access. However, data about irrigators and irrigation enterprises are far more difficult to obtain. The ABS provides the only source of information on enterprises that irrigate. Often one licence may be held by many irrigators, as for Surface Authorities for Joint Water Supplies[10] (SA) or, alternatively, many single licences[11] (SL) may be held by one irrigator. In order to determine, for example, the area irrigated or volume use by an irrigator, the user must:
  - amalgamate licences held by one owner using available contact details. This approach flounders where family members in an irrigation enterprise each own a licence or where licences are listed under different contact addresses.
  - approach managers of SA licences to access private information about irrigators operating within a scheme. Access depends on the development of trust between the user and provider and on the extent to which these data have been collected and recorded.
- **Data reliability ratings are needed.** The Land and Water Audit provides reliability ratings and metadata (data about the data). Similar protocols are needed for the provision of data to public by State agencies and private authorities.
- **Collection strategies have limited data usefulness.** The ABS has collected irrigation data using three different EVAOs or survey cut-off points over the past 13 years. This makes it difficult to show trends in the area irrigated or enterprise numbers. For example, apparent changes in the area irrigated between 1992–93 and 1993–94 may be due to the different EVAOs used rather than real change in the area irrigated. Only data between 1993–94 and 1996–97 were compared in this Profile.
- **There is some irrigator resistance to agency collection of data *eg*. crop areas irrigated, water used and irrigation yields.** Resistance has increased with the implementation of water reforms and the development of new water sharing plans that include the environment as a 'new' user. This resistance may also be heightened by the number of surveys conducted apparently independently of one another, but at the same time. For example, data were collected from irrigators in the North Coast region by ABS, ABARE and DLWC in 1996/97. Data collection agencies should be aware of and acknowledge these difficulties and assign reliability ratings accordingly to their information.

[10] A Surface Authority for a Joint Water Supply (SA) is one licence which supplies a group of farmers. These schemes are private and have no board of management.

[11] A Single Licence supplies water to one property.

11.2.2 Other issues for irrigation in the region

The major issues for irrigated agriculture in the North Coast region relate to the effects of water reform, market deregulation and rapid population growth. More specifically, access to water and daily extraction rates are of significance.

- **Expansion of the irrigation industry has been limited by the 1995 embargo on new licences.** The purchase of new water licences has been embargoed since 1995 in the North Coast region, making it difficult for irrigation enterprises to expand or new enterprises to develop. For example, expanding olive and pecan industries on the upper northern arm of the Clarence River between Tabulam and Woodenbong are limited by access to water (*pers. comm.* C. Rolfe).
- **Highly permeable soils may limit the siting of farm dams.** New access rules may allow irrigators to access high-flow water and store it in farm dams. However, some soils, such as krasnozem types, are highly permeable and therefore unsuitable for dams.
- **Expansion has been limited by prevention of water trading in highly stressed catchments.** Further development in these catchments will depend on irrigators adopting more efficient practices.
- **Expansion may be hampered in the upper parts of catchments.** Trading rules that allow downstream trading only may reduce the capacity of enterprises to expand existing operations or to branch into other crops.
- **There is increasing conflict between agriculture and non-farming rural residents.** With increasing population pressures and subdivision of land for rural-residential development there is increasing conflict between agricultural and non-agricultural rural residents.
- **Acid sulfate soils are affecting productivity of irrigated agriculture.** Loss of agricultural land due to acid scalding is an issue in the coastal floodplains of the North Coast region. For example, acid scalding has rendered large areas of Micalo Island, in the Clarence catchment, semi-sterile (Talau 1999). This will affect irrigated crops grown on these low-lying areas, for example, tea-tree and pasture.
- **Rapid population growth will increase the conflict between irrigators and other water users.** This is one of the major challenges facing the North Coast region, as rapid population growth increases the competition for water between agriculture, the environment, industry and urban users (Healthy Rivers Commission of New South Wales 1999). The potential pressure of agriculture, urban, industrial and rural residential developments on river systems are considered to pose a risk to the health of the subcatchments (see Appendix 14.11).

- **Hobby farmers may be less likely to adopt improved irrigation management.** Land is increasingly being viewed as an alternative form of superannuation rather than as profitable irrigation enterprise. This is already an issue in the Hawkesbury-Nepean catchment (Sydney South Coast region) (Healthy Rivers Commission of New South Wales 1999). The same applies to areas of the North Coast region, namely the Tweed and Brunswick catchments (see Appendix 14.11).
- **Continuing development will limit irrigator access to low flow water.** Extraction of low-flow water during drought will continue to be an issue for irrigated agriculture in the North Coast region. This is especially a problem for subcatchments where extraction levels are already considered high (see Appendix 14.11) and in areas where the population is forecast to increase. For example, population increases are expected in Brunswick and Richmond catchments and the Coffs Harbour meso-catchment.

12. SUMMARY

This study highlighted difficulties in obtaining information on irrigation in the NSW North Coast region. Data were scarce, unreliable or provided at inappropriate scales.

- Scarcity of data. Data have been collected for various purposes in the past that may not meet the present data needs of NSW. Natural resource management has been a low priority in the past and therefore data required for this type of resource management are either scant or missing.
- Reliability. The reliability of data varied with source of water. Data on irrigation from regulated rivers are more reliable than data from unregulated rivers, groundwater, farm dams and reticulated water supplies.
- Provision of data at inappropriate scales**.** Data have been reported at scales that are of little use, for example, to people engaged in natural resource planning at the subcatchment or river-reach scale.

A more comprehensive and consistent approach to the collection of irrigation statistics is needed. This would help to ensure that data are comparable across different water sources and industries. The following are needed to improve the situation.

- Data are needed at scales that are large enough to ensure confidentiality of individual enterprises but small enough to allow users to aggregate information to useful scales.
- Protocols for provision of data to users are needed. For example, information providers need to attach reliability ratings to data to help users make better choices about the reliability and therefore the usefulness of the data.
- Two-way flow of information between agencies and irrigators needs to be fostered. Typically, data have been extracted from irrigators by agencies. These data need to flow back to irrigators in forms that might potentially assist them make better water management decisions. This would in turn, over time, improve the reliability of information.

Finally, such a comprehensive approach can only be developed with the full involvement of the many irrigators, agencies and community groups that require these data.

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14. APPENDICES

14.1 Definitions of statistical units used by the ABS

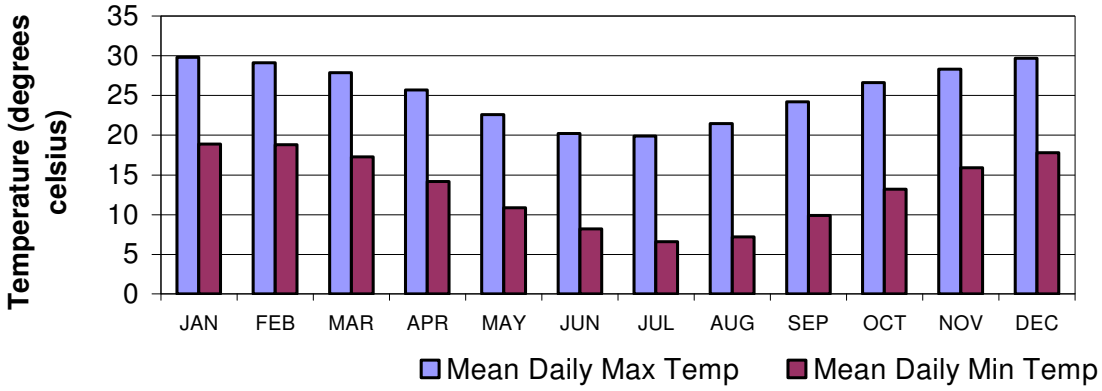
Extract from ABS Web Page (1999).

> An SLA is a general purpose spatial unit. It is the base spatial unit used to collect and disseminate statistics other than those collected from the Population Censuses. SLAs are based on the boundaries of incorporated bodies of local government where these exist. These bodies are the Local Government Councils and the geographical areas which they administer are known as Local Government Areas (LGAs). In the Northern Territory, an incorporated administrative body gazetted under the Northern Territory Local Government Act can take the form of a Community Government Council (CGC). Where there is no incorporated body of local government, SLAs are defined to cover the unincorporated areas
>
> An LGA is an SLA if:
>
> - the LGA fits entirely within an Statistical Subdivision (SSD); and
> - the LGA is broadly similar in size, economic significance and user needs for statistics to other LGAs in Australia
>
> An LGA forms two or more SLAs when the two conditions above are not met. This can occur when:
>
> - an LGA is divided by the boundary of one or more SSDs. The LGA is split into two or more SLAs each of which falls within the relevant SSD; or
> - an LGA is substantially different in size, economic significance and user needs for statistics to other LGAs. The LGA is split into two or more SLAs which generally correspond to one or more suburbs (as occurs in the predominantly urban LGA of the City of Brisbane) or other areas of interest.
> - For those parts of Australia which are not administered by incorporated local government bodies, an SLA is an unincorporated area. Unincorporated SLAs cover the following areas:
> - unincorporated on-shore area(s) and/or off-shore island(s) in an SSD;
> - that part of an unincorporated area which is considered of sufficient economic significance as to warrant the formation of a separate SLA;
> - Off-Shore Areas & Migratory SLAs, formed for census purposes for all S/Ts except the Australian Capital Territory and Other Territories to encompass off-shore, shipping and migratory CDs (off-shore, shipping and migratory CDs are explained in chapter 2);
> - the entire area of the Australian Capital Territory. Each SLA is either a suburb, a locality or the non-urban area of an SSD; and
> - the unincorporated part of the Northern Territory. In some SSDs (e.g. Daly, Bathurst-Melville) the entire area is covered by one unincorporated SLA. In other SSDs (e.g. East Arnhem), the unincorporated area is split into several SLAs to distinguish an economically significant town (e.g. Nhulunbuy), island (e.g. Groote Eylandt) or administrative region.

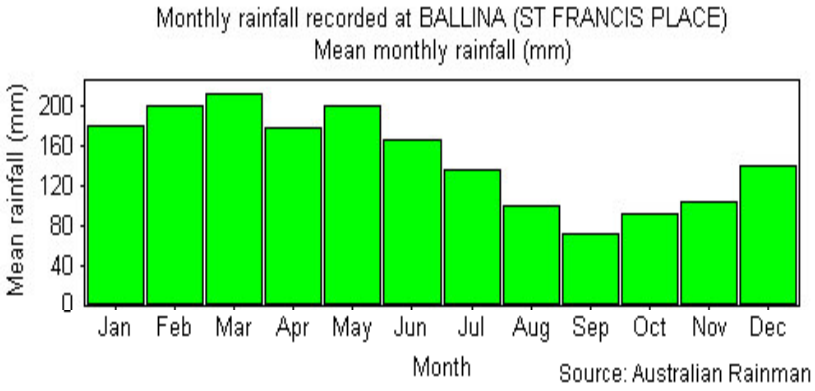
14.2 Summary of ABS data collection

Year	EVAO	Collection Unit	Survey (S) or Census (C)	Number of irrigation enterprises and area irrigated	Crop area by number of enterprises	Source of water by area and number of irrigation enterprises	Methods by area by number of enterprises	Adoption of scheduling by area irrigated by no. of enterprises
1986–87	20,000	SLA	C	Yes			Yes	
1987–88	No record	No record	No record	No record	No record	No record	No record	No record
1988–89	No record	No record	No record	No record	No record	No record	No record	No record
1989–90	20,000	SLA	C	Yes		Yes	Yes	
1990–91	20,000	SLA	C	Yes	Yes	Yes		
1991–92	22,500	SLA	C	Yes	Yes			
1992–93	22,500	SLA	C	Yes	Yes			
1993–94	5,000	SLA	C	Yes	Yes	Yes		
1994–95	5,000	SLA	C					
1995–96	5,000	SLA	C	Yes				Yes
1996–97	5,000	SLA	C	Yes	Yes			
1997–98	22,500	AER	S	Yes	Yes			
1998–99	22,500	AER	S	Yes	Yes			
1999–00	22,500	AER	S	Yes	Yes	Yes	Yes	
2000–01	5,000	SLA	C	Yes	Yes			Yes
2001–02	5,000	SLA	S			?	?	

14.3 North Coast climate

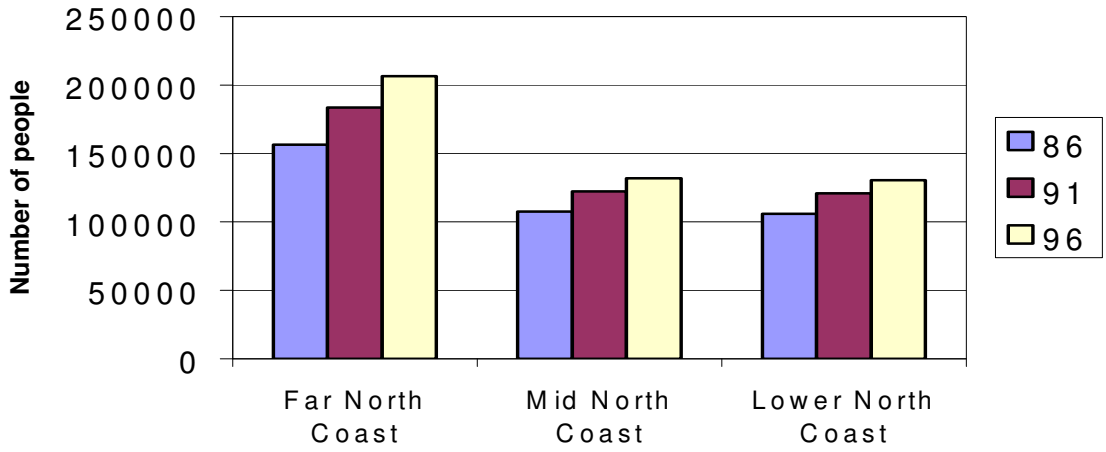


Mean daily maximum and minimum temperatures at Lismore in the Richmond catchment (Bureau of Meteorology 2000)



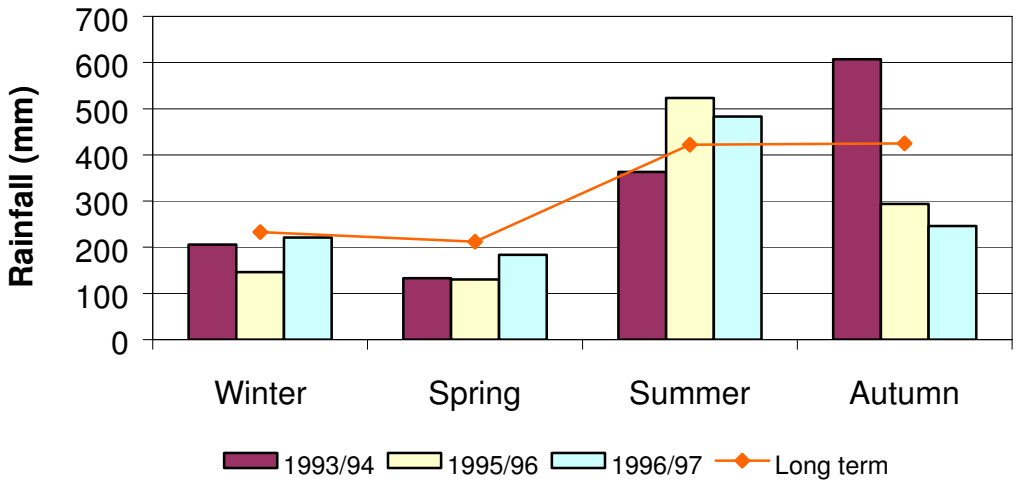
Average monthly rainfall at Lismore station in the Richmond catchment (Clewett et al. 1999)

14.4 Population in the North Coast region



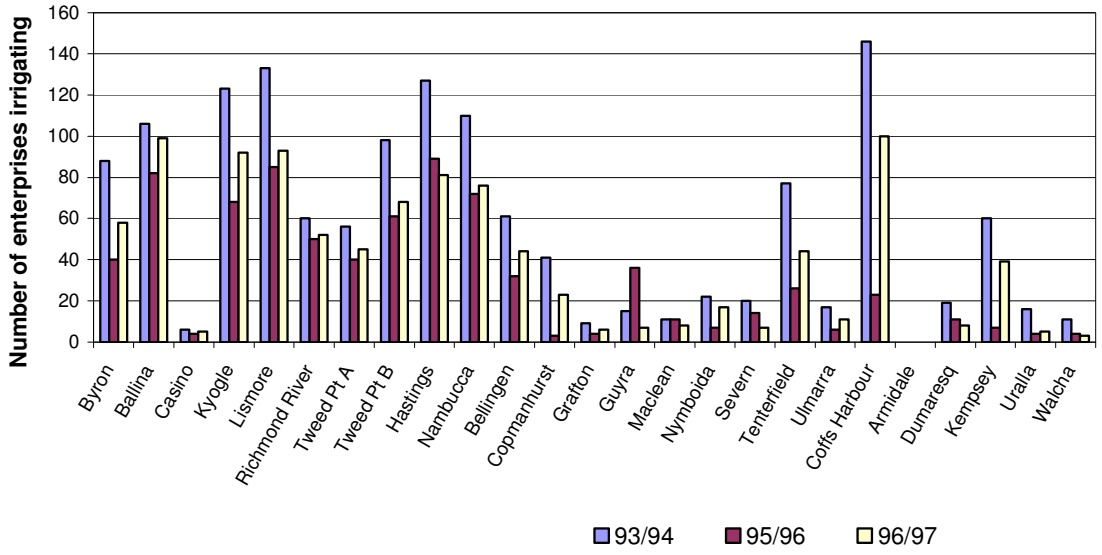
Source: (ABS 2000) ②. Far North Coast (Tweed, Brunswick and Richmond catchments), Mid North Coast (Clarence and Macleay catchments and Bellinger and Coffs Harbour meso-catchments), Lower North Coast (Hastings–Camden Haven catchment and Nambucca meso-catchment).

14.5 Rainfall in 1993–94, 94–95 and 1996–97 and long-term mean rainfall

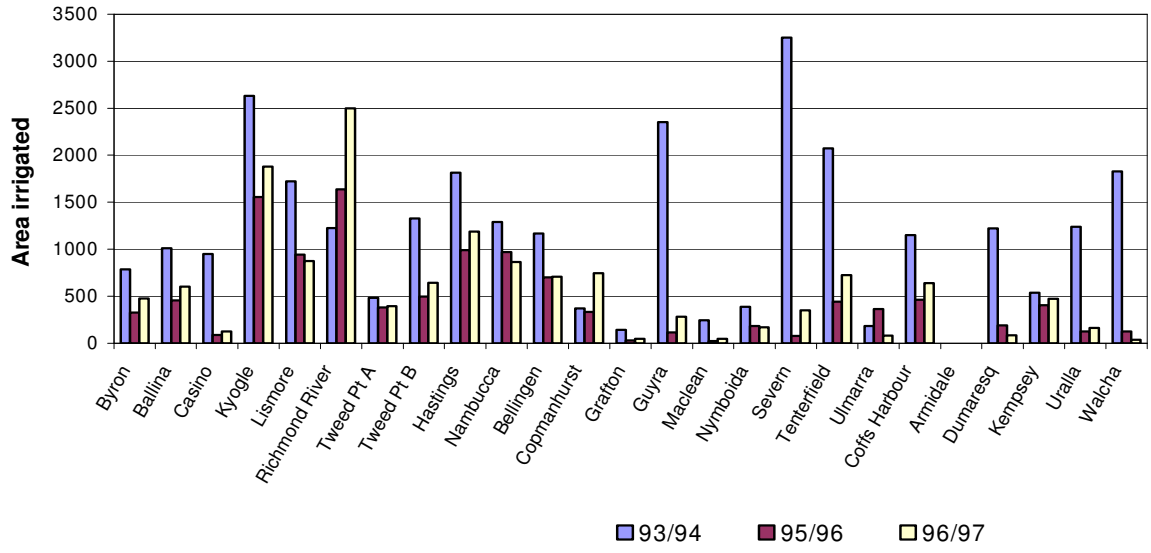


Source: (Clewett *et al.* 1999)

14.6 Number of enterprises and area irrigated in each SLA in the North Coast region

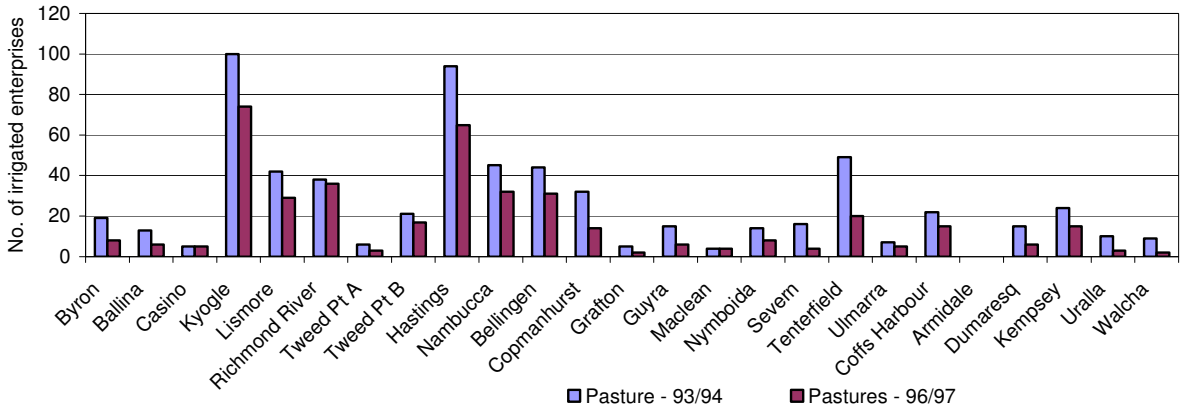


Source: (ABS 1998)②

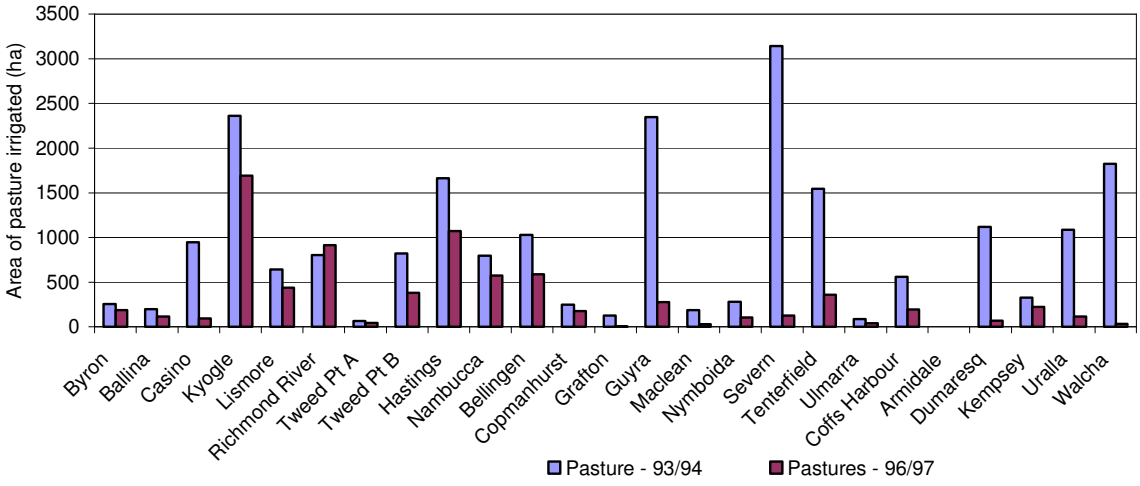


Source: (ABS 1998) ②

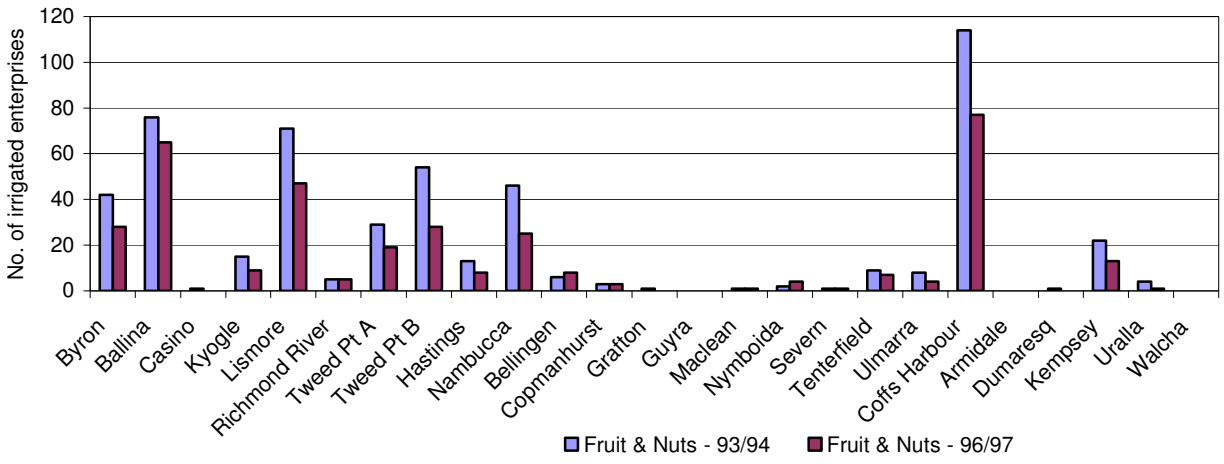
14.7 Number of enterprises and area irrigated by crop type in the North Coast

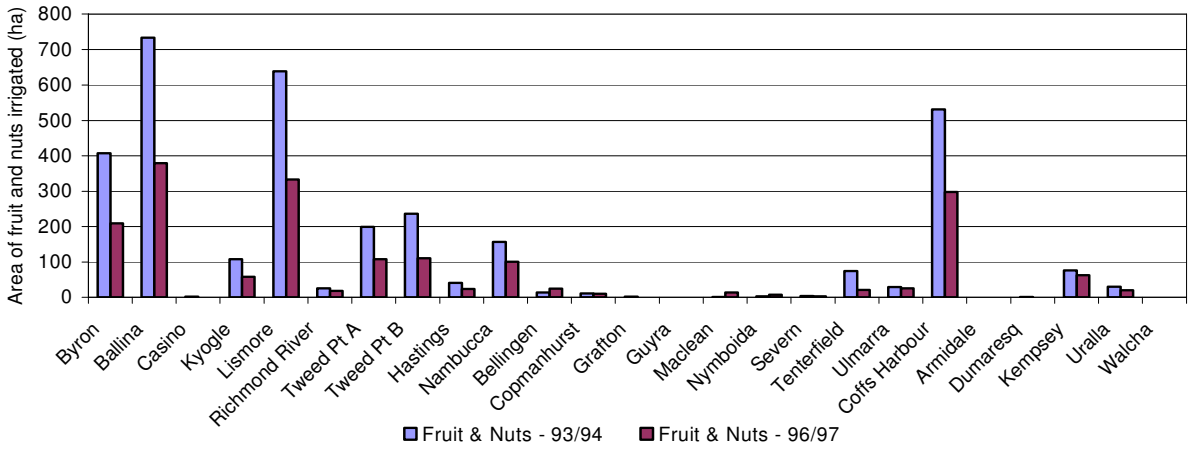


Source: (ABS 1998) ②



Source: (ABS 1998) ②





Source: (ABS 1998) ②

14.8 Crop data for the North Coast region

Location	Kyogle					Tweed Valley		
Crop class[a]	Cereals	Pasture			Stone fruit	Tropical fruits	Vegetables	
Crop	Maize	Annual temperate	Perennial temperate	Perennial tropical	Orchards (low chill)	Bananas	Potatoes crop 1 & 2	
CWR [b]Ave (ML/ha)	6	5.5	7	7.5				
CWR Min (ML/ha)	5	4	5	5				
CWR Max (ML/ha)	7.5	7	8.5	10				
IR[c] Ave (ML/ha)	1	6	7	5		3		
IR Min (ML/ha)	0	4	4	1		5		
IR Max (ML/ha)	5	7	8	8		0		
Y[d] Ave (t/ha)		12	13.5	15		31		
Y Min (t/ha)		8	9	8		10		
Y Max (t/ha)		16	18	20		35		
Root depth (m)						2		
Sowing date [e]	15-Oct				1-Jul	1-Sep	15-Jun	1-Feb
Time of growth Total[f]	125	245	275	275	300	365	169	89
System[g]	traveller	traveller	traveller	traveller		overhead or under tree sprinklers		
Efficiency (%)[h]						poor		

④

[a] Crop class refers to a category under which similar crops can be grouped.

[b] CWR (crop water requirement) – the depth of water needed to meet the water loss through evapotranspiration of a disease-free crop growing in a large field under non-restricting soil conditions including soil water and fertility and achieving full production potential under the given growing environment. Note this figure excludes leaching fractions and does not allow for system inefficiencies. Average, minimum and maximum figures correspond to water requirements in normal, wet and dry seasons respectively.

[c] The depth of water required to satisfy crop water requirement, leaching requirement and system inefficiencies (conveyance, distribution, and application). Essentially the depth of water that must be delivered *to the farm* to ultimately satisfy actual crop water use. Average, minimum and maximum figures correspond to irrigation requirements in normal, wet and dry seasons respectively.

[d] Y Ave, Min and Max – Average, Minimum and Maximum Yield or the total seasonal production derived from the irrigated crop. The unit being considered should be specified (for example, dry matter, grain, fibre and so on).

[e] Date on which annual crops are typically sown.

[f] For field and vegetable crops, the total number of days between sowing and harvesting. For perennial crops usually 365 days.

[g] System refers to irrigation system used.

[h] Effic (Irrigation Efficiency) – meaning the ratio between crop water requirement and the irrigation water delivered *to the farm*. It therefore describes losses due to leaching requirement

and conveyance (deep percolation and evaporation), distribution and application inefficiencies.

14.9 North Coast region crop information

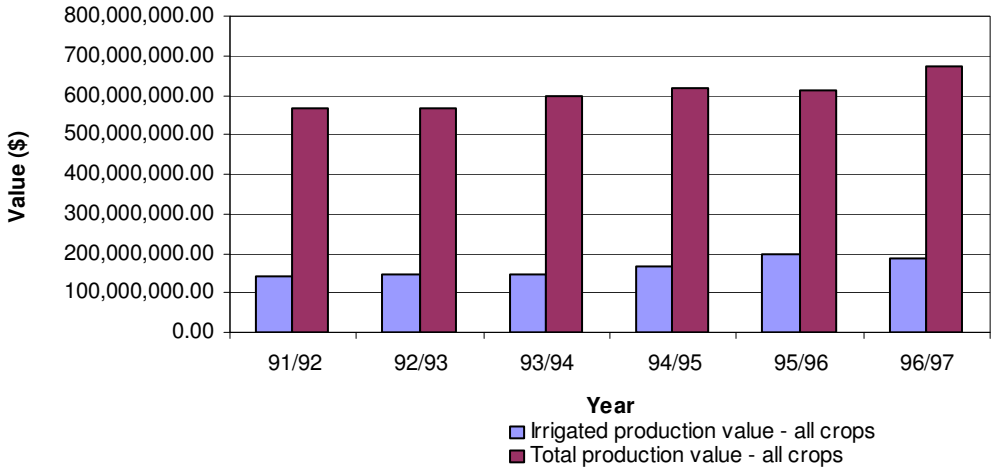
Industry	Area/ trees	Number holdings	Yield	Value	Remarks
Avocados	80,000 trees	200	-	$4.2 million	-
Bamboo		unknown	-	unknown	Sunrise industry
Bananas	900 ha irrigated	-	30,000 t	$5.3 million irrigated crop	-
Blueberries	240 ha	-	1200 t	$19 million	-
Bush foods	-	unknown	-	-	Sunrise industry
Citrus (irrigated limes, mandarins and oranges)	-	-	>60 t	$1.07 million	-
Coffee	-	unknown	3.5 t/ha	Industry estimate $2.6 million	Sunrise industry
Custard apples	120,000 trays	100	-	-	Some irrigated
Dairy industry	-	-	-	$130 million	10% of State's production. 10% irrigated
Native flowers	-	-	-	-	Sunrise industry
Grapes (table and wine)	-	-	-	$0.5 million	Sunrise industry
Herbs	15 ha	-	-	-	Sunrise industry (expanding medicinal and culinary markets).
Lemon myrtle	400 ha	-	-	-	Sunrise industry.
Lychees	13,370 trees	12	241 t	$1.25 million	-
Macadamias	-	-	-	$70 million	60% of Australian production, 25% farms irrigated
Mangoes	-	-	-	-	50,000 trays sunrise industry
Nursery	-	>500	-	$55 million to $140 million	33% of NSW production
Olives	-	-	-	-	sunrise industry

Industry	Area/ trees	Number holdings	Yield	Value	Remarks
Passionfruit	124 ha	-	-	-	35% of Australian production
Pecan nuts	192 ha	-	-	-	Sunrise industry
Stone fruit	300,000 trees	250	-	$15 million	70% of Australian low-chill production
Sugar	-	-	-	-	Mostly unirrigated
Tea-tree	-	-	-	-	Sunrise industry
Vegetables	-	-	-	$25 million	-
Total	**-**	**-**	**-**	**$330 million**	**-**

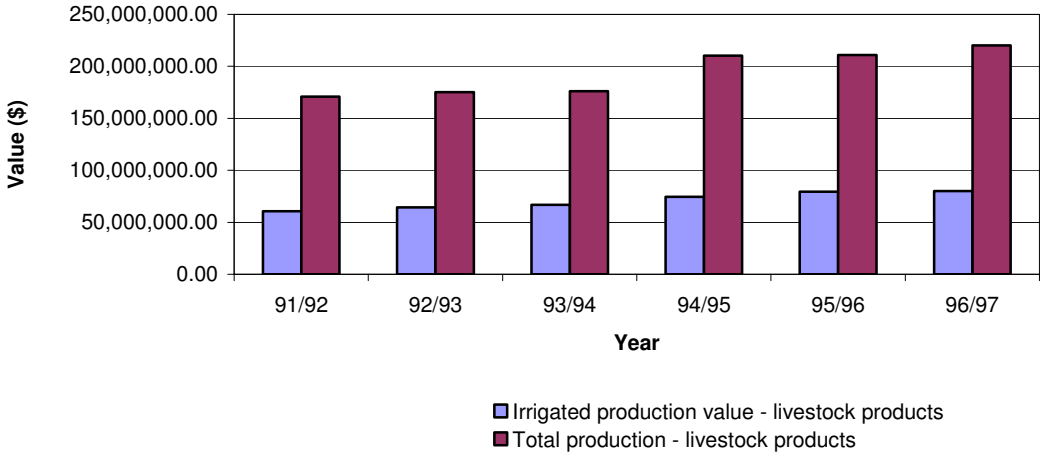
Source: (*pers. comm.* C. Rolfe) ④.

14.10 Value of irrigated agriculture in the North Coast region

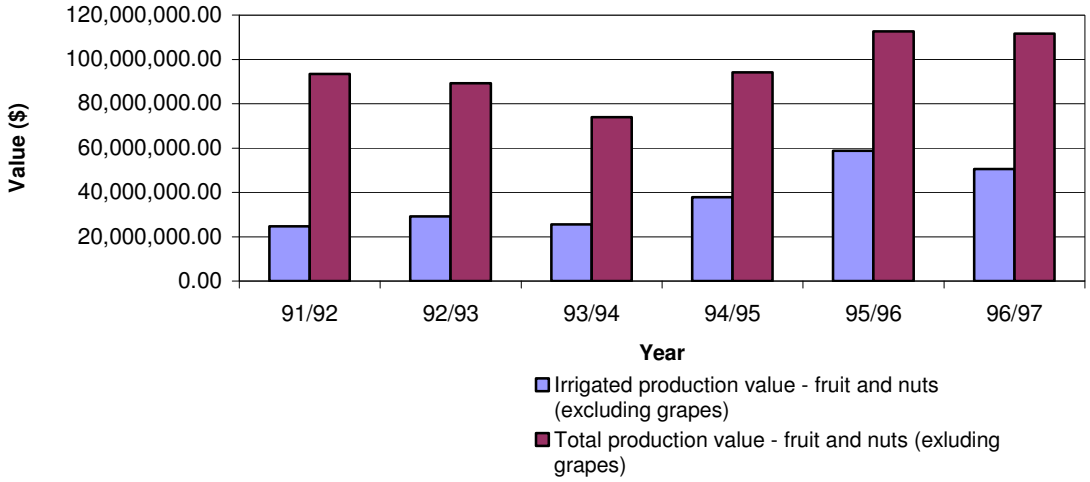
Value of irrigated production and total agricultural production for all crops (Donovan 2000) ③



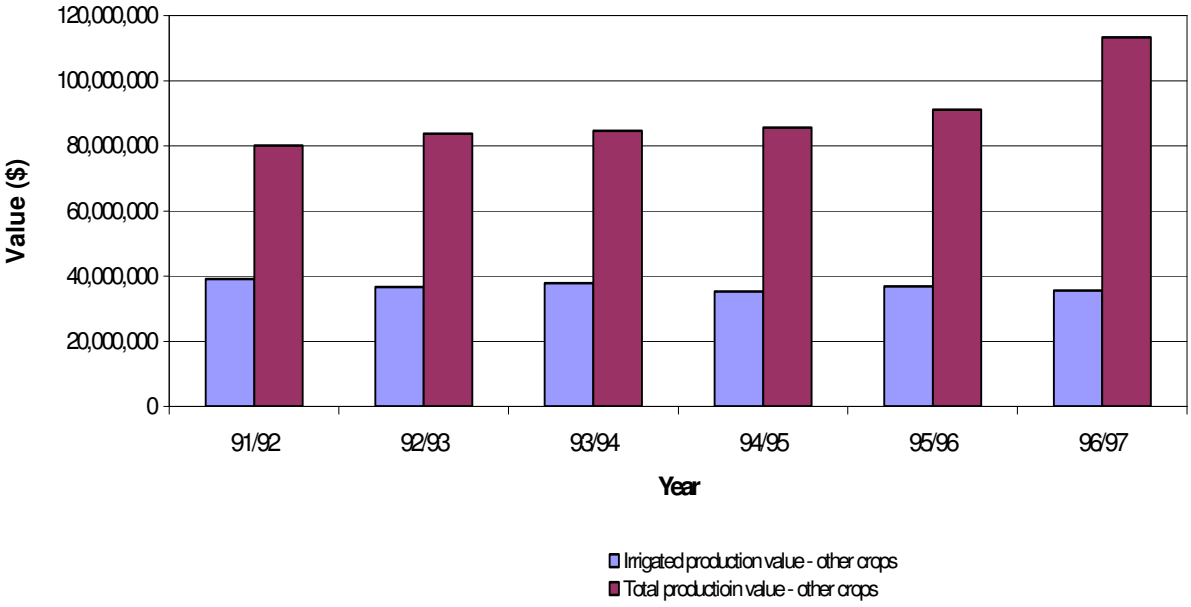
Value of irrigated production – livestock products (Donovan 2000) ③.



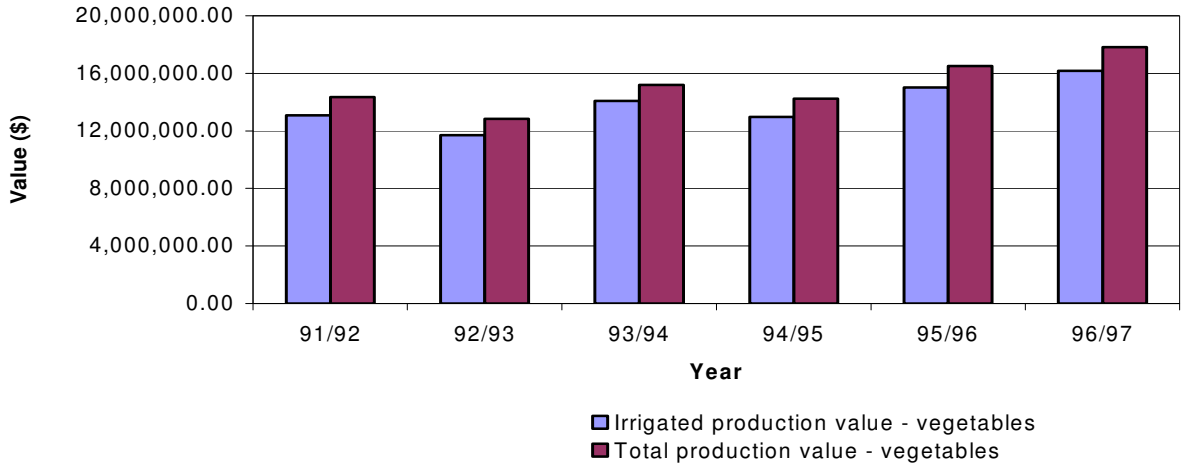
Value of irrigated production – fruit and nuts (Donovan 2000) ③



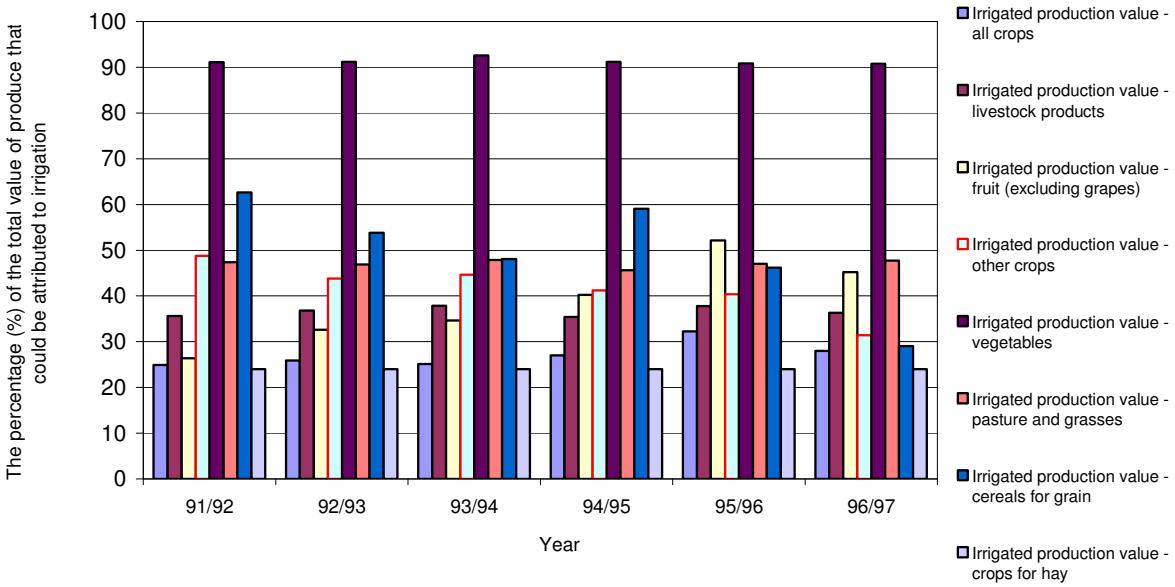
Value of irrigated production – other crops (Donovan 2000) ③



Value of irrigated production – vegetables (Donovan 2000) ③



Percentage of the total value of produce that could be attributed to irrigation in the North Coast region



Source: (Donovan 2000) ③

14.11 ABS Question profile

Part 8. Do you irrigate or use any artificial fertilisers or soil conditioners

No Go to part 9

Yes *show details below*

a. Pastures and Crops Irrigated – Season 1993-94

Where any area of pasture or crop was irrigated more than once during the season, show this area once only

Hectares

- Pasture (native or sown) .....
- Cereals .....
- Vegetables for human consumption .....
- Fruit (including nuts) .....
- Grapevines .....
- All other crops .....

b. Source of water – season 1993-94

Where more than one source of water is used on a particular area of pasture or crop, show the area only once according to the main source.

Area irrigated using: Hectares

- Channel or pipe supply in an irrigation area or district .....
- Other surface water (*Include* • private group schemes) .....
- A river or stream controlled by water board or a water resources commission dam or weir .....
  - An uncontrolled river or scheme .....
  - A farm dam with its own catchment and not filled by pumping from a river or stream .....
- Underground water supply (e.g. bore, spear, well)
  - Within State schemes .....
  - Other .....

Source: (ABS 1994)

14.12 Stressed stream classification of subcatchments in the North Coast region

The DLWC undertook a desktop assessment of the environmental and hydrological stress of subcatchments in the North Coast region.

An environmental stress rating or each of the freshwater subcatchments within each catchment was assessed using the following environmental indicators:

- extent of riparian vegetation
- geomorphological health
- presence of major dams
- barriers to fish passage
- gully erosion
- dryland salinity
- presence of acid sulfate soils
- water quality (indicative purposes only – not used in decision tree)

Following the analysis of these indicators, an overall environmental stress rating was made for each subcatchment. The environmental stress was determined using a decision tree method. This method was used for both the estuarine and freshwater indicators. Where two-thirds of the environmental indicators returned a high classification for a particular subcatchment, the overall environmental stress was assessed to be high. Where two-thirds of environmental indicators returned a low classification for a particular subcatchment, the overall environmental stress was determined to be low. The remaining subcatchments were classified as being of medium environmental stress.

The hydrological stress of a subcatchment was calculated as the estimated proportion of daily flow that has been made available for extraction under existing licences. This required estimation of streamflow and water use.

Streamflow was estimated using information from DLWC's flow gauging network and a range of hydrologic predictive techniques to extend estimates into rivers without local gauging sites. Estimates of the peak monthly water extractions have been made using the surface water returns lodged by licence holders. However, not all survey cards are returned to DLWC and volumes were adjusted for the proportion of licence holders who have chosen not to lodge a return. A hydrologic index (indicating hydrologic stress) was derived for each subcatchment for current use and full water use development by proportioning estimated water extraction to the estimated streamflow.

Each subcatchment was then classified as being of low (0 to 30% extraction of flow), medium (40 to 60% extraction) or high (70 to 100% extraction) hydrologic stress.

The data that were used to generate hydrological and environment stress ratings and therefore management options, were not always reliable. For example, the hydrological stress rating was determined using crop return card information, a source that is known to be unreliable. Despite underlying difficulties and concerns with the data, the assessment provides the most comprehensive overview of the land and water resources of subcatchments in the North Coast region.

Catchment	Subcatchment	Hydrological stress	Environmental stress	Future risk	No.of irrigation licences	Authorised area (ha)	80th % flow (ML/d)
Tweed	Bilambil Creek	High	Medium	High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	8	61	1
Tweed	Brays Creek	High	Low	High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	5	23	2
Tweed	Byrill Creek	Low	Low	Increased extraction of water for town water supply, exotic vine infestation of streamside vegetation, camphor laurel and privet. Low risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	4	16	5
Tweed	Christies Creek	Low	Medium	Urban and highway development, sea ranch proposed. Medium risk of over-use of low flows assuming a 4 ML/ha extraction rate at full dev.	3	15	2.5
Tweed	Clothiers Creek	Low	High	Rural residential and highway development. Medium risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	4	13	3
Tweed	Cobaki Broadwater	Medium	High	Urban and highway development increased population at Cobaki Broadwater. High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	8	33	2
Tweed	Cobaki Creek	High	High	High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	9	64	1
Tweed	Crystal Creek	Medium	Low	High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	3	21	2.5
Tweed	Cudgen Lake	Low	High	Urban, rural residential and highway development.	4	21	no data

Catchment	Subcatchment	Hydrological stress	Environmental stress	Future risk	No.of irrigation licences	Authorised area (ha)	80th % flow (ML/d)
Tweed	Cudgera Creek	Low	High	Highway and urban development. High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	5	19	1.5
Tweed	Doon Doon Creek	Medium	High	High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	5	36	2.5
Tweed	Dubible Creek	Unresolved	High	High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	6	33	2.5
Tweed	Dungay Creek	Low	Medium	High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	6	21	1.5
Tweed	Duroby Creek	High#	High	High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	21	99	1
Tweed	Hopping Dicks Creek	Unresolved	Medium	High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	8	48	2.5
Tweed	Lower Burringbar River	Unresolved	High	Rural residential and highway development.	5	34	no data
Tweed	Lower Oxley River	Low	Medium	Exotic vine infestation along streamside, sewage. Medium risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	11	66	15
Tweed	Mid Rous River	Low	High	High risk of vine infestation of streamside vegetation.	4	22	7.5
Tweed	Mid Tweed River	High	Medium	Urban and rural-residential development, water quality problems, extraction for town water supply, flow change.	21	167	15

Catchment	Subcatchment	Hydrological stress	Environmental stress	Future risk	No.of irrigation licences	Authorised area (ha)	80th % flow (ML/d)
Tweed	Mooball Creek	Low	High	Population increase.	0	0	no data
Tweed	Nobbys Creek	Low	High	Medium risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	1	9	1.5
Tweed	Piggabeen Creek	High	Medium	High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	5	22	1
Tweed	Pumpenbil Creek	High	Medium	High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	4	32	2
Tweed	Rolands Creek	Low	Low	High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	4	14	1
Tweed	Sheens Creek	High	High	High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	4	27	1
Tweed	Smiths Creek	Low	Low		1	3	1
Tweed	Terranora Broadwater	Medium	High	Urban development increased exotic infestation. High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	9	78	4
Tweed	Tweed Estuary	Low	High	Urban, highway, rural residential, agricultural and industrial development. Exotic weed infestation.	0	0	96
Tweed	Upper Burringbar River	Unresolved	Medium	Unknown	31	118	no data
Tweed	Upper Oxley River	Medium	Low	High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	5	21	2
Tweed	Upper Rous River	Low	Low	Unknown	3	12	7

Catchment	Subcatchment	Hydrological stress	Environmental stress	Future risk	No.of irrigation licences	Authorised area (ha)	80th % flow (ML/d)
Tweed	Upper Tweed River	High	Medium	High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	9	59	2
Brunswick	Belongil Creek	Unresolved	High	Medium risk investigation for potential urban development.	0	0	no data
Brunswick	Kings Creek	Low	High	High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	1	50	0
Brunswick	Lower Brunswick River	Low	High	High risk water quality, poor effluent treatment.	2	5	7.37
Brunswick	Lower Marshalls Creek	Low	High	High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development. Urban development.	6	28	3.35
Brunswick	Mullumbimby Creek	Medium	High	High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development. Rural residential development.	9	25	2.01
Brunswick	Simpsons Creek	Low	Medium	Urban and highway development.	0	0	4.5
Brunswick	Tallow Creek	Unresolved	High	Urban expansion and development water quality problems.	0	0	no data
Brunswick	Tyagarah Creek	High	High	Potential growth in nurseries, high risk of low flow usage with full development 4 ML/ha.	15	146	6.03
Brunswick	Upper Brunswick River	High	High	High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	11	71	4.03
Brunswick	Upper Marshalls Creek	Medium	High	Water quality	16	82	3.37

Catchment	Subcatchment	Hydrological stress	Environmental stress	Future risk	No.of irrigation licences	Authorised area (ha)	80th % flow (ML/d)
Richmond	Alstonville Area	High	High	High groundwater quality risk, urban and agricultural developments, porous soils. High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	127	1290	15
Richmond	Bangalow Area	Medium	High	Rural residential and horticulture developments. High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	152	1455	37.5
Richmond	Broadwater Area	Low	High	Unsewered villages, cane growing and potential for poor farm management.	2	67	180
Richmond	Coopers Creek	Medium	High	High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	131	2026	70
Richmond	Coraki Area	Unresolved	Medium	Agricultural, highway and river gravel extraction. Low risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	73	1144	180
Richmond	Double Duke Area	Unresolved	High	High risk of tea-tree expansion, wetland interference. Medium risk of over-use of low flows assuming a 4 ML/ha extraction rate at full dev.	6	786	0
Richmond	Doubtful Creek	Low	High	High risk of agricultural and tourism dev.	12	92	14.5
Richmond	Eden Creek	Medium	Medium	High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	13	172	5
Richmond	Evans River	Unresolved	Low	High risk of urban, rural residential, highway, gravel extraction and tourism industry developments.	0	0	0
Richmond	Gradys Creek	Medium	Medium	High risk from future tourism pressure.	36	422	40.5

Catchment	Subcatchment	Hydrological stress	Environmental stress	Future risk	No.of irrigation licences	Authorised area (ha)	80th % flow (ML/d)
Richmond	Huonbrook Area	Low	Low	Hydropower diversion from Wilson River across catchments into Yankee Ck of the Brunswick River.	10	64	2.5
Richmond	Kyogle Area	High	High	Rural residential, agriculture (dairy and other intensive enterprises) and highway developments.	131	2121	66.5
Richmond	Lennox area	Low	High	Population increase.	0	0	11.5
Richmond	Leycester Creek	Medium	High	Rural residential and agricultural developments.	46	295	11.5
Richmond	Myall Creek	Unresolved	High	Tick dips, dispersive soils.	1	4	0
Richmond	Myrtle Creek	High	High	Potential for high flow licences and off stream storages for tea-tree. High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development. Tick dips and dispersive soils.	5	211	2
Richmond	Roseberry Creek	High	High	Medium risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	48	475	5.5
Richmond	Sandy Creek	Low	High	High risk from rural residential, agriculture, highway and river gravel extraction developments. Potential for high flow and off stream storages for tea-trees. Medium risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	4	50	2.5
Richmond	Shannon Brook	Medium	High	High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development. High risk from rural residential, agriculture, highway and river gravel extraction developments.	23	152	4

Catchment	Subcatchment	Hydrological stress	Environmental stress	Future risk	No.of irrigation licences	Authorised area (ha)	80th % flow (ML/d)
Richmond	Terania Creek	High	High	High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	81	897	23
Richmond	Toonumbar Area	Low	High	High risk from tourism pressure.	1	4	5
Richmond	Tuckean Area	High	High	High risk from agriculture on acid sulfate soils. High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development. Implications of groundwater management on the Plateau and its contribution to base flows of the tributaries flowing into the Tuckean area.	104	1309	15
Richmond	Wyrallah Area	Unresolved	Unresolved	High risk from agriculture, river gravel extraction and tourism. Low risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	39	1133	105
Clarence	Aberfoyle River	Low	High	Low risk from mining and agriculture. Low risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	4	64	11.27
Clarence	Acacia Creek	High	High	High risk from agriculture. High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	13	137	0.98
Clarence	Alumy Creek	Unresolved	Unresolved	High risk from urban and commercial infill and stormwater. Low risk from acid sulfate soils.	31	263	0
Clarence	Angourie/ Redcliffe	Unresolved	Unresolved	Low risk from urban developments.	0	0	0

Catchment	Subcatchment	Hydrological stress	Environmental stress	Future risk	No.of irrigation licences	Authorised area (ha)	80th % flow (ML/d)
Clarence	Beaury Creek	Low	Medium	Urban, agricultural and highway development. High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	4	24	0.98
Clarence	Blicks River	Low	Low	Low risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	7	279	22.54
Clarence	Bookookoorara Creek	Medium	Medium	Low risk from agriculture. High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	10	185	4.9
Clarence	Boonoo Boonoo River	Low	Low	Low risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	3	63	14.7
Clarence	Bottle Creek	Low	High	Low risk of rural residential growth. Usage of low flows unresolved.	0	0	0.98
Clarence	Boyd River	Low	Low	Low flow usage unresolved	0	0	38.22
Clarence	Bucca Bucca Creek	Low	High	Future growth area. High-risk rural residential growth.	19	198	5.39
Clarence	Cataract River	Low	Medium	Dam development for Tenterfield water supply. Low risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	3	6	19.6
Clarence	Clarence Coastal	Low	High	High risk from urban, agricultural and aquaculture. Risks from acid sulfate soils on floodplains where there are drains, barrages and sugar cane farming. High risks from unsewered villages.	2	6	323.4

Catchment	Subcatchment	Hydrological stress	Environmental stress	Future risk	No.of irrigation licences	Authorised area (ha)	80th % flow (ML/d)
Clarence	Clarence Tidal Pool	Low	High	High risk from urban run-off, rural residential, agriculture, highway, river gravel extraction and industry. Medium risk to water quality from unsewered village.	53	597	232.4
Clarence	Coldstream Creek	Unresolved	Unresolved	High risk from acid sulfate soil management. Medium risk from unsewered village of Tucabia.	6	73	0
Clarence	Coombadjha Creek	Low	Low	Low flow usage unresolved	0	0	19.11
Clarence	Copmanhurst-Low/ Mid Clarence	Low	High	Medium risk to water quality from an unsewered village of Copmanhurst.	11	161	323.4
Clarence	Dandahra Creek	Low	Low	Nil	0	0	12.25
Clarence	Deep Creek	Low	High	Low risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development. Risk from rural residential developments.	1	5	2.45
Clarence	Demon Creek	Low	Medium	Low risk from Timbarra Mine	0	0	9.8
Clarence	Esk River	Unresolved	Unresolved	Medium risk from horticultural development (coffee) in the upper area of the subcatchment.	0	0	0
Clarence	Guy Fawkes River	Low	Low	Low risk from mining and agriculture. High risk from the unsewered village Ebor. Low risk from low flow usage with full development at 4 ML/ha.	1	4	11.27
Clarence	Henry River	Low	Low	Low risk from agriculture. Low risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development. Potential soil erosion and nutrient from agriculture (principally grazing).	2	31	7

Catchment	Subcatchment	Hydrological stress	Environmental stress	Future risk	No.of irrigation licences	Authorised area (ha)	80th % flow (ML/d)
Clarence	Koreelah Creek	Medium	Medium	High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development. High risk from effluent and bio-solid disposal.	14	202	4.41
Clarence	Little Nymboida River	Low	Low	Low risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	12	115	22.05
Clarence	Lower Duck Creek	Low	High	Low flow usage unresolved.	0	0	1.96
Clarence	Lower Mann River	Low	Medium	High risk from reduced flow regimes from hydropower and town water diversions.	5	118	117.6
Clarence	Lower Nymboida River	High	Medium	High risk of reduced flow regimes from diversion for hydropower and town water supplies.	2	22	73.5
Clarence	Lower Orara River	Low	High	Diversions for town water supply. Impacts on river ecosystems from changed flows.	9	85	205.8
Clarence	Lower Timbarra River	Low	Medium	Low risk from rural residential, mining and agriculture. Potential risks from mining operations.	1	5	46.5
Clarence	Maryland River	Medium	High	Low risk from rural residential and agriculture. High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	3	27	0.49
Clarence	Mid Mann River	Low	Low	Low risk from rural residential and agriculture. Medium risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	8	271	14.21
Clarence	Mid Nymboida River	Low	Low	High risk from reduced flow regimes due to hydropower and town water supply diversions. Low risk from rural residential developments.	19	73	200.9

Catchment	Subcatchment	Hydrological stress	Environmental stress	Future risk	No.of irrigation licences	Authorised area (ha)	80th % flow (ML/d)
Clarence	Mid Orara River	High	Medium	Hight risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development. Exotic weed infestation of stream banks, activation of sleepers and dozer licences, diversion of water from towns, poor water quality.	158	2618	20.58
Clarence	Paddys Flat Upper Clarence	Low	High	Low risk from agriculture. Low risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development. Medium risk of algal blooms.	8	200	39.2
Clarence	Peacock Creek	High	High	Low risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development. High risk of sedimentation from mining.	5	172	1.96
Clarence	Plumbago Creek	Low	Medium	High risk from urban, agriculture, mining and highway developments. High risk to water quality from mine tailings.	0	0	12.25
Clarence	Sandon River	Unresolved	Unresolved	Nil	0	0	0
Clarence	Sara-Oban River	Low	Medium	Low risk from mining and agriculture. Low risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	4	55	12.74
Clarence	Shark Creek	Unresolved	Unresolved	Usage unresolved. High risk of acid sulfate soils.	0	0	0
Clarence	Sportsmans Creek	Unresolved	Unresolved	Usage unresolved. High-risk from acid sulfate soils.	3	20	0
Clarence	Stockyard Creek	Unresolved	Unresolved	Usage of low flow unresolved. Medium risk from continued infestation of exotic species in streamside vegetation. High risk of sedimentation.	2	25	0

Catchment	Subcatchment	Hydrological stress	Environmental stress	Future risk	No.of irrigation licences	Authorised area (ha)	80th % flow (ML/d)
Clarence	Swan Creek	Unresolved	Unresolved	Unresolved	18	330	0
Clarence	The Broadwater	Unresolved	Unresolved	Low risk from rural residential and agriculture.	6	88	0
Clarence	The Georges/Upper Mid Clarence	Low	High	High risk of sedimentation from mining and agriculture.	24	1004	186.2
Clarence	Tooloom	Medium	High	Low risk of urban, rural residential, mining, agriculture and highways. High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	17	263	5.88
Clarence	Tunglebung Creek	Medium	High	Medium risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development. Potential risk from rural residential development.	7	69	0.98
Clarence	Upper Duck Creek	High	High	High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	15	181	59
Clarence	Upper Mann River	Low	High	Low risk from mining and agriculture, soil erosion from agriculture. Low risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	1	13	4.41
Clarence	Upper Nymboida River	Low	Medium	Low risk from urban development.	59	1273	98
Clarence	Upper Orara River	Medium	High	Medium risk from pressure from small holdings. High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development. Coffs Harbour town water supply.			

Catchment	Subcatchment	Hydrological stress	Environmental stress	Future risk	No.of irrigation licences	Authorised area (ha)	80th % flow (ML/d)
Clarence	Upper Timbarra River	Low	Medium	Nil	0	0	33.32
Clarence	Washpool Creek	Low	Low	Low risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	1	40	23.52
Clarence	Wooli River	Unresolved	Unresolved	High risk water quality issues from the unsewered village, Wooli.	0	0	0
Clarence	Wooloweyah Lake	Unresolved	Unresolved	Moderate risk from urban, agriculture and industrial development	1	2	0
Clarence	Yarrow River	Low	High	Low risk from agriculture. Potential soil erosion and nutrients pollution from agriculture (principally grazing).	0	0	1.47
Coffs Harbour Waterways	Arrawarra Creek	Low	Medium	High risk from urban and rural residential development and potential increases in riparian rights usage. High risk from agricultural and highway development. High risk from effluent disposal from commercial sites and sewerage treatment works. Water quality impacts from unsewered villages.	0	0	
Coffs Harbour Waterways	Boambee Creek	High	High	High risk of over-use of 50th percentile flows assuming a 4 ML/ha extraction rate at full development at 4 ML/ha. High risk of urban, rural residential, agriculture, highways and industrial development. Increase in water use from the golf club. Acid sulfate soils.	36	137	

Catchment	Subcatchment	Hydrological stress	Environmental stress	Future risk	No.of irrigation licences	Authorised area (ha)	80th % flow (ML/d)
Coffs Harbour Waterways	Bonville Creek	High	High	High risk of over-use of 50th percentile flows assuming a 4 ML/ha extraction rate at full development at 4 ML/ha. Medium risk from rural residential and agricultural developments, highways and river gravel extraction.	30	128	
Coffs Harbour Waterways	Coffs Harbour Creek	High	High	High risk of over-use of 50th percentile flows assuming 4 ML/ha extraction rate with full development. Medium risk of urban and rural residential development, agriculture, highway and industrial development.	24	90	
Coffs Harbour Waterways	Corindi River	High	Medium	Low risk from rural residential development.	3	19	
Coffs Harbour Waterways	Dirty Creek	Low	Low	Low risk from rural residential development.	0	0	
Coffs Harbour Waterways	Double Crossing Creek	Low	High	High risk from urban, rural residential, highways and industrial developments. Discharge from sewerage treatment plants. High risk of over-use of 50th percentile flows assuming 4 ML/ha extraction rate with full development.	1	1	
Coffs Harbour Waterways	Korara Basin	Low	High	High risk of over-use of 50th percentile flows assuming 4 ML/ha extraction rate with full development. High risk of rural residential dev.	25	85	

Catchment	Subcatchment	Hydrological stress	Environmental stress	Future risk	No.of irrigation licences	Authorised area (ha)	80th % flow (ML/d)
Coffs Harbour Waterways	Moonee Creek	High	Medium	High risk from urban, rural residential, agricultural and highway developments. High risk of water pollution from sewage disposal. High risk of over-use of 50th percentile flows assuming 4 ML/ha extraction rate with full development.	4	24	
Coffs Harbour Waterways	Pine-Bundagaree Creek	High	Low	High risk of over-use of 50th percentile flows assuming 4 ML/ha extraction rate with full development. Low risk from rural residential, agriculture and highway developments and river gravel extraction.	4	15	
Coffs Harbour Waterways	Red Bank River	Low	High	Low risk from rural residential development. Increased recreational pressure at Red Bank.	0	0	
Coffs Harbour Waterways	Station Creek	Low	Low	Nil	0	0	
Coffs Harbour Waterways	Woolgoolga Creek	High	High	Medium risk from urban, rural residential, agriculture and highway development.	11	68	
Bellinger	Bellinger River	Low	High	Low risk from urban/rural-residential developments. High risk from carp infestation. High risk of weed infestation of streamsides. Requirements for fish passages near tidal limit and downstream of Boggy Ck Junection.	21	145	59.16
Bellinger	Boggy Creek	Low	Low	Riparian rights users.	3	9	4.95

Catchment	Subcatchment	Hydrological stress	Environmental stress	Future risk	No.of irrigation licences	Authorised area (ha)	80th % flow (ML/d)
Bellinger	Coastal Bellinger	Low	High	Low risk urban/rural residential. Leachate from tip. Medium risk from unsewered village.	5	89	59.6
Bellinger	Coastal Kalang	Low	High	Low risk from urban/rural residential. Medium risk from unsewered Newry Island.	2	5	6.96
Bellinger	Dalbouse Creek	Unresolved	Unresolved	Low risk of rural residential and further horticultural development	1	68	no data
Bellinger	Hydes Creek	Low	High	Low risk from potential effluent reuse site.	5	40	9.86
Bellinger	Kalang	Low	Medium	Riparian rights issues	5	33	12
Bellinger	Never Never Creek	High	Medium	Riparian rights issues	8	109	0.5
Bellinger	Rosewood Creek	Low	Low	Nil	0	0	11
Bellinger	Spicketts Creek	Low	High	Nil	1	5	1.65
Bellinger	Thora-North Arm Bellinger	Low	Low	Riparian rights issues. High risk of streamside vegetation smothering exotic weeds.	14	108	73
Nambucca	Buckrabendinni Creek	High	Medium	High risk from bed instabilities, potential loss of pool storage.	10	172	3.85
Nambucca	Coastal Nambucca	Low	Medium	High risk from urban, rural residential, agriculture and highways.	16	99	24.2
Nambucca	Lower Deep Creek	High	Medium	High risk from urban, rural residential, agricultural and highways. High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development. Water quality problems.	5	32	0.55

Catchment	Subcatchment	Hydrological stress	Environmental stress	Future risk	No.of irrigation licences	Authorised area (ha)	80th % flow (ML/d)
Nambucca	Missabotti Creek	High	High	Further riverbed and bank instability, small head cuts moving upstream.	10	61	3.85
Nambucca	North Arm Nambucca River	Medium	High	Town water supply augmentation, activation of sleeper licences. Direct interaction of the town water supply bore upstream of Bowraville with stream flow.	24	245	24.2
Nambucca	Oyster Creek	Unresolved	Unresolved	Rural residential development	0	0	no data
Nambucca	South Creek – South Arm	High	High	Bed instability. High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	8	100	3.85
Nambucca	Taylors Arm	Medium	Medium	Medium risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development. Activation of sleeper licences during drought.	27	165	9.35
Nambucca	Upper Deep Creek	High	Medium	High risk from rural residential and agriculture. High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	27	159	0.55
Nambucca	Warrell Creek	High	Low	Low risk from urban, rural residential, agriculture and highways. High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	19	198	2.2
Macleay	Apsley Gorge	Low	Low	Nil	0	0	40.32
Macleay	Bakers Creek	Low	High	High value wilderness area. High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	2	15	1.2

Catchment	Subcatchment	Hydrological stress	Environmental stress	Future risk	No.of irrigation licences	Authorised area (ha)	80th % flow (ML/d)
Macleay	Blue Mountain Creek	Unresolved	Unresolved	Nil	0	0	0
Macleay	Chandler Gorge	Low	Medium	Nil	0	0	2.8
Macleay	Chandler River	Medium	High	High risk contributes to high value wilderness area. High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	5	67	2.8
Macleay	Christmas Creek	Low	Low	Low risk from rural residential, agriculture, forestry, quarrying. Unresolved low flow usage.	0	0	1.2
Macleay	Coastal Macleay	Low	High	Extraction of water for town water supplies. Groundwater quality issues and potential for seawater intrusion into freshwater aquifers. Water quality risk from unsewered water. Flood plain management issues. Exotic weed infestation of stream sides. . Low risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	26	138	196
Macleay	Collombatti Creek	Low	Medium	Low risk from rural residential, agriculture, forestry and quarrying. Low risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	3	15	1.68
Macleay	Commissioners Waters	High	High	High risk of low flow reduction from reduced Sewerage Treatment Plant releases. . High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	35	695	1.68

Catchment	Subcatchment	Hydrological stress	Environmental stress	Future risk	No.of irrigation licences	Authorised area (ha)	80th % flow (ML/d)
Macleay	Dungay Creek	Low	Medium	Low risk of rural residential, mining, agriculture, river gravel extraction, forestry, quarrying. Medium risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development. High risk continued bed and bank instabilities and adjustments.	9	50	3.36
Macleay	Dyke Creek	Low	Medium	Low risk recreational and forestry access.	0	0	7.28
Macleay	Euroka Creek	Low	Low	Low risk of rural residential, agriculture, river gravel extraction. Medium risk riparian rights issues. . Low risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	1	4	0.56
Macleay	Five Day Creek	Low	Medium	Low risk from rural residential, agriculture and forestry.	1	40	19.6
Macleay	Gara River	High	High	High risk of low flows dependent on management of town water supply dams. High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development. High value wilderness areas. Low risk from turbidity arising from unsealed approaches to river crossings/roads.	7	528	0.56
Macleay	Georges River	Low	Low	High risk from hydro scheme proposals	0	0	9.52
Macleay	Gills Bridge Creek	Low	High	High risk from urban, highway, industry and sewage treatment plants. Risk from aquatic plant infestation of waterways in response to elevated nutrients.	0	0	0.56

Catchment	Subcatchment	Hydrological stress	Environmental stress	Future risk	No.of irrigation licences	Authorised area (ha)	80th % flow (ML/d)
Macleay	Green Gully	Low	Low	Nil	0	0	12.88
Macleay	Hickeys Creek	High	High	High risk from further bed instabilities. High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development. Lack of fish passages.	4	31	2.24
Macleay	Kunderang Creek	Low	Low	Medium risk from hydro scheme proposal.	0	0	20.16
Macleay	Macleay Gorges	Low	Low	Medium risk from recreational pressure	0	0	137.2
Macleay	Macleay Valley	Low	Medium	Medium risk of poor water quality from unsewered village. High risk of river gravel extraction rates. Low risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	38	589	196
Macleay	Malpas Dam	High	High	High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	2	48	0.56
Macleay	Mungay Creek	Low	High	Low risk of rural residential and agricultural developments. High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	3	10	1.12
Macleay	Nulla Nulla Creek	Low	Medium	Low risk from rural residential, agriculture and forestry. Medium risk of poor fish passages. Low risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development. Medium risk from bed and bank instabilities.	3	24	15.68
Macleay	Oaky River	Low	High	Nil	2	30	5.6

Catchment	Subcatchment	Hydrological stress	Environmental stress	Future risk	No.of irrigation licences	Authorised area (ha)	80th % flow (ML/d)
Macleay	Salisbury Waters	Unresolved	Unresolved	High value wilderness areas. Unresolved flow usage. Sensitive groundwater recharge area in headwaters.	8	319	0
Macleay	Stockyard Creek	Low	Low	Low risk from rural residential, agriculture and forestry. Low flow usage unresolved.	0	7.84	0
Macleay	Styx River	Low	Medium	High risk from hydro scheme proposals	3	115	24.08
Macleay	Tia River	Low	High	Medium risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	5	237	13.44
Macleay	Toorumbee Creek	Low	Medium	Low risk from rural residential and forestry. Unresolved usage figures. Further bed and bank instabilities.	0	0	8.4
Macleay	Warbro Creek	Low	High	Low risk from rural residential, agriculture and forestry. Low risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	2	15	1.68
Macleay	Yarrowitch River	Low	Medium	Medium risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	3	45	3.92
Hastings–Camden Haven	Camden Haven River	Medium	Medium	High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development. High-risk water quality problems due to unsewered village. Low-risk rural residential.	34	346	11.13

Catchment	Subcatchment	Hydrological stress	Environmental stress	Future risk	No.of irrigation licences	Authorised area (ha)	80th % flow (ML/d)
Hastings–Camden Haven	Coastal Hastings	Low	High	High risk from urban, rural residential, mining, agriculture, highway and industrial developments. Low risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development. High-risk salinity issues as significant connection between bores on floodplain and river flows.	8	48	127.2
Hastings–Camden Haven	Ellenborough River	Medium	Low	Medium risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development. Medium risk water quality due to high levels of turbidity during rainfall.	15	212	37.1
Hastings–Camden Haven	Forbes River	Low	Low	Low risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development. Exotic weed infestation of stream banks.	2	21	36.04
Hastings–Camden Haven	Kindee Creek	High	Medium	Medium risk of exotic weed infestation. High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	5	26	1.06
Hastings–Camden Haven	Lake Innes	Low	High	High risk of urban and mining development. Medium risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	3	21	1.59
Hastings–Camden Haven	Limeburners Creek	Unresolved	Unresolved	Low risk from urban, rural residential and agriculture. High-risk sensitivity, downstream oyster industry.	0	0	0

Catchment	Subcatchment	Hydrological stress	Environmental stress	Future risk	No.of irrigation licences	Authorised area (ha)	80th % flow (ML/d)
Hastings–Camden Haven	Maria River	Low	High	High risk of rural residential, agriculture (tea-tree) and highway development. High-risk areas of acid sulfate soils, shallow groundwater management. Low risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	4	11	12.72
Hastings–Camden Haven	Middle Hastings River	Medium	High	Medium risk from rural residential and river gravel extraction. Medium risk of elevated nutrient levels from unsewered village of Long Flat. Medium risk of exotic species infestation of stream banks. Medium risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development. Aquatic weeds.	41	471	118.19
Hastings–Camden Haven	Mortons Creek	High	Medium	High risk from rural residential, riparian rights, first creek to dry up. High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development. High risk from significant connection between floodplain bores and river flows at the bottom of the subcatchment. Infestation of riparian zone from exotic species.	27	174	3.71
Hastings–Camden Haven	Pappinbarra Creek	High	Medium	Low risk from rural residential. High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development. Medium risk of bed instability and pools infilling. Medium risk from aquatic weeds.	31	362	6.36

Catchment	Subcatchment	Hydrological stress	Environmental stress	Future risk	No.of irrigation licences	Authorised area (ha)	80th % flow (ML/d)
Hastings–Camden Haven	Queens Lake	Low	High	High risk from urban, industry. High risk from poor tidal flushing. Low risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	6	42	5.3
Hastings–Camden Haven	Stewarts River	High	Medium	High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development. High risk from exotic weed infestation of streamside vegetation.	35	323	1.59
Hastings–Camden Haven	Thone River	Medium	High	High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development. Unlicensed users. Medium risk from turbidity problems related to the disturbance of basaltic soils on the plateau.	37	312	9.54
Hastings–Camden Haven	Upper Hastings River	Low	Medium	Low risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	7	74	3.9
Hastings–Camden Haven	Watson Taylors Lake	Low	High	Low risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development. High risk from poor water quality.	4	46	12.72
Hastings–Camden Haven	Wilson River	High	High	High risk of bed and bank instabilities. High risk of over-use of low flows assuming a 4 ML/ha extraction rate at full development.	39	435	12.72

Source: (DLWC 1999e); DLWC 1999f; DLWC 1999g ④

14.13 Crop area and water use in the North Coast region (unregulated rivers)

Crops	1989–90	1990–91	1991–92	1992–93
Summer cereal	86	182	173	115
Winter cereal	35	163	154	188
Summer oil	15	27	45	28
Winter oil	0	0	0	0
Cotton	0	0	0	0
Citrus	44	87	126	31
Lucerne	555	105	152	90
Summer pasture	2362	2086	2688	1684
Winter pasture	2139	2458	2537	2053
Vegetables	798	404	414	182
Vines	24	41	28	20
Wheat	0	0	0	0
Other	2608	2566	2314	1458
Total area (ha)	8668	8119	8631	6021
Total water usage (ML)	20032	12612	14668	54491

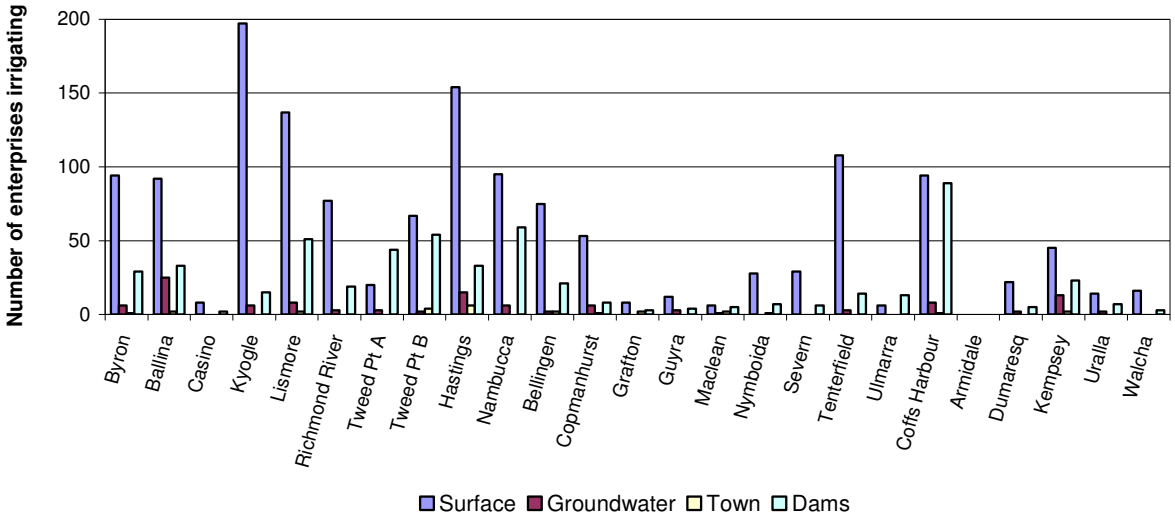
Source: (DLWC 1998)④

Crops	1993–94	1994–95
Adzuki beans	0	20
Barley	41	78
Carrots	23	0
Citrus	230	230
Cotton	0	0
Garlic	0	0
Grapes	3	0
Hybrid seed	0	0

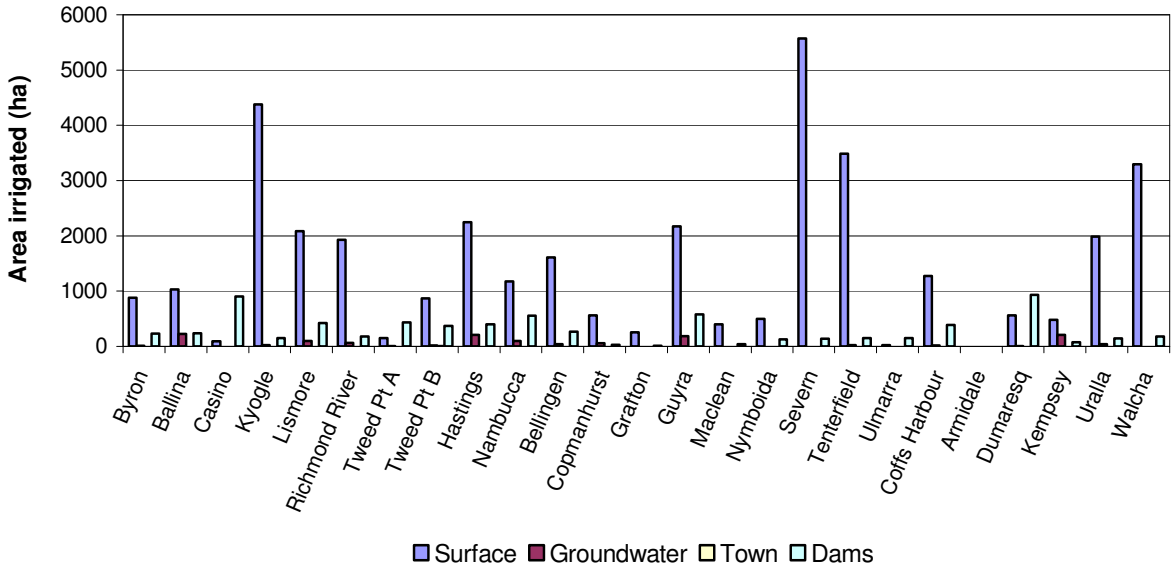
Crops	1993–94	1994–95
Lucerne	293	349
Maize	30	0
Millet	0	0
Oats	1	17
Orchard	1570	1600
Other crops	558	901
Other vegetables	239	257
Peas	0	169
Potatoes	175	0
Pumpkins	0	0
Rice	0	2
Safflower	0	0
Sorghum	595	0
Soybeans	4	699
Summer cereal	94	38
Summer grains	0	0
Summer pasture	3944	291
Sunflower	0	3943
Sweet corn	0	0
Tomatoes	18	0
Triticale	0	27
Turf	279	0
Vegetables	0	0
Vines	111	230
Wheat	0	85
Winter cereal	0	0
Winter grains	0	0
Winter pasture	4003	3747
Total area irrigated (ha)	12300	12720
Water usage (ha)	11271	12601

Source: (DLWC 1998)④

14.14 Number of enterprises irrigating and area irrigated by source of water



Source: (ABS 1998) ②



Source: (ABS 1998) ②