

Food grows where the water flows. A review of water usage in the Lockyer Valley in South-east Queensland

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Abstract. The average outflow of the Lockyer alluvial catchment is 169 gigalitres (GL). The accepted Australian figure for aquifer recharge is 29 GL; this represents a total yield from rainfall of less than 10%. The farmers who rely on underground water supplies for irrigation are running out of water and will have to scale back production in the forthcoming seasons if the drought continues. This paper investigates where the water is being used.

Keywords: Lockyer Valley, water usage, sustainable agriculture, irrigation

Introduction

The Lockyer Valley is comprised of Laidley and Gatton Shires and is situated 90 kilometers west of Brisbane. The main industry is agriculture. The landscape encompasses steep ranges, low undulating hills and wide alluvial plains. Lockyer Creek, an important sub-catchment of the Brisbane River, bisects the Valley, draining approximately 295 410 hectares. The average yearly rainfall is 800 mm, most of which falls in summer from thunderstorms of high intensity or from cyclonic disturbances. This pattern of rainfall produces significant amounts of runoff.

Soils in the Lockyer Valley are associated with different rock types. From a farming viewpoint, the significant soil types are alluvial, scrub and forest soils. The alluvial soils are volcanic in origin and range from deep sand to loams to heavy clays, of which the loams and clays are considered to be the most fertile. Physically the loams and clays demonstrate good structure, are initially high in phosphorus, potash and nitrogen, and are high in organic matter.

From the early explorers' records it can be deduced that pre-European vegetation in the Lockyer Valley was predominantly open forest dominated by tall growing eucalypts with an understorey of grasses. Thirty per cent of the Lockyer catchment is covered by vegetation considered by legislation to be remnant, occurring on the steep ranges that were not clear felled.

Currently 21,000 hectares in the Valley is under irrigation, with estimates that up to 24,000 hectares is suitable for irrigated agriculture. Available figures show that the irrigators are using less than 2% of the rainfall, yet the aquifer appears to be failing during recent drought events. The farmers, convinced that this is not their fault, are demanding access to water from nearby impoundments or renewed water from cities. If water becomes more plentiful, it is likely that farmers will grow higher value crops rather than expand the area under production.

This audit of the water balance suggests two contributing factors that should be taken into consideration when determining catchment management strategies.

Physical factors influencing water yield.

Workers such as Vertessy *et al* (1998) and Davidson (2004) have demonstrated that the condition and composition of the vegetation of a catchment determines the quality and quantity of water that will be harvested from that catchment. Disturbances such as fire events and the harvesting of timber also impact on the catchment. In spite of obvious differences between catchments with differing physical characteristics, such as soil type, topography, climate and vegetation species, some generalizations can be made about response to changes in the catchment:

- i) a reduction in forest cover will give an increase in water yield, with an increase in storm flow runoff peaks. Conversely, an increase in forest cover, or its density, leads to a decrease in water yield and flood runoff (Vertessy *et al* 1998).
- ii) the rise or fall in water yield is proportional to the percentage of forest cover removed or added respectively (Vertessy *et al* 1998; Davidson 2004).
- iii) the higher the mean annual rainfall, the greater the impact of changes in forest cover on water yield (Vertessy *et al* 1998).

- iv) at least 20% of the catchment must be disturbed before significant changes to the water yield are detected (Vertessy *et al* 1998).
- v) grassland catchments have higher runoff and greater potential for recharge than forested catchments, as forests tend to use more water than grassland (Vertessy *et al* 1998; Davidson, 2004).
- vi) during active growth by regenerating trees and seedling germination, large amounts of water are absorbed and transpired, significantly reducing groundwater flow over large areas (Davidson 2004) .

Current vegetation status of the Lockyer catchment.

The Europeans who settled the Lockyer Valley in the mid 1800s were credited as the first to clear the vegetation after the cessation of the aboriginal burning regimes had allowed regrowth. The area was significantly cleared again after the Second World War when labour was relatively cheap and increased food production was essential. The regrowth from this most recent bout of clearing is the density that is assumed to be the pre-European density (Blake 1991).

While there is little or no high density vegetation on the alluvial plains, the upland areas are generally well vegetated with Eucalypt open forests and woodlands. Table 1 summarizes the land use and thus the current vegetation types in the Lockyer.

Table 1. Land use in the Lockyer catchment.

Land Use.	Percentage of Catchment.
Conservation	2.0
Forestry	52.7
Grazing/grassland	33.1
Cropping	11.2
Rural residential	1.0

(Adapted from Connell Wagner, 2003)

Conservation areas and forestry have been reclassified as forest reserve, and so forest grazing is being phased out. The grazing/grassland area is the fraction of most contention in this table as the grasslands are invaded by regrowth, causing it to function as regenerating forest. With the exception of tree crops and Lucerne, crops are usually annuals and function as grassland. Rural residential land use has huge potential for uncontrolled expansion into high quality farming land, placing increased demands on resources.

Vegetation and water use in the Lockyer catchment.

Water is essential to all living organisms and constantly forms cycles between biotic and abiotic environments. The hydrological cycle describes the natural interactions of water between vegetation, soil, surface water and the atmosphere and is the basis of all life systems (Odum 1993). Zhang *et al* (1999) found that vegetation has a major impact on the hydrological cycle and this has implications for the management of forested catchments. Vegetation management may profoundly influence the availability of water for both fresh water aquatic ecosystems and human systems.

After a rainfall event certain amounts of water return to the atmosphere as evapo-transpiration. Factors influencing the rate of evapo-transpiration include rainfall interception, net radiation, advection (heat transfer by horizontal flow of air), turbulent transport, leaf area and plant available water capacity (Zhang *et al*. 1999). The relative significance of these factors is determined by vegetation, climate and soil type.

Zhang *et al*. developed an equation for determining the relationship between long-term average evapo-transpiration and rainfall, based on observations of fifty-five paired catchments. This equation

can be used to scientifically determine the effect of vegetation changes on catchment average water balance:

$$\frac{ET}{P} \times 100\% = f \left[\frac{1 + 2 \times \frac{1410}{P}}{1 + 2 \times \frac{1410}{P} + \frac{P}{1410}} \right] + (1-f) \left[\frac{1 + 0.5 \times \frac{1100}{P}}{1 + 0.5 \times \frac{1100}{P} + \frac{P}{1100}} \right]$$

where,

ET is the evapo-transpiration from all sources including vegetation.

P is the long-term average rainfall.

f is the fraction of the catchment under forest cover.

(After Zhang *et al.* 1999.)

For the Lockyer catchment: $P = 800\text{mm}$ and $f = 0.54$.

$ET = 80\%$. This indicates an expected yield of 20% of the annual rainfall of 800 mm. If the area of the catchment is

295,410 hectares (2,954 square km), the expected average annual yield is $(2,954 \times 0.8 \times 0.2)$ GL = 472.6 GL.

The theoretical annual yield of the Lockyer catchment from rainfall of 2,363 Giga litres (GL) is:

Total from rainfall = 2,363 GL

Expected ET from Zhang *et al.* = 1,890.4 GL

Expected yield = 472.6 GL

Observed yield = Outflow + Recharge

Observed yield = 169 GL + 29 GL

= 198 GL (From SEQWCG 2004)

This represents a short fall of 274.6 GL.

This calculation indicates that the alluvial aquifer of the Lockyer Valley should receive sufficient recharge to compensate for diversion to irrigation, even in years where the rainfall is less than the average used in this calculation. The observation that the aquifer does not appear to receive sufficient recharge, even in wet years, is at odds with this result. The mathematical model developed by Zhang *et al.* tells us to look for historical mismanagement of the vegetation in this catchment.

Woodland thickening on the poorly managed lower slopes must be considered, but even this condition does not adequately explain the water loss. The quantity of water theoretically derived from cropping and grassland should yield more than the observed total yield.

Deep drainage.

In the mathematical model, allowing f (the fraction of the catchment under forest cover) to approach 1, it is possible to estimate the expected rate of water usage of the forest. This gives an expected maximum water use of 90% ET (evapo-transpiration) for the forested uplands. It would be expected that the steeper forested hillsides have limited capacity to intercept the laterally moving soil moisture or runoff, suggesting a contribution of 127.6 GL. The grassland and cropland generally occurs on the lower slopes and flats, and the water that comprises the catchment yield (including that from the uplands) must move over, through or under this area. In the mathematical model, allowing $(1-f)$ to approach 1, gives an expected estimate of the yield from this segment of the landscape as 30%, 326 GL. Sufficient inappropriately placed regrowth, or landscaping, could significantly reduce this. The upland contribution of 127.6 GL is funneled through narrow riparian zones where inappropriate vegetation could easily use all the potential recharge except in the wettest of years. Even this extreme

scenario cannot explain the low observed yield of the catchment. The only option remaining is unaccounted throughflow.

Conclusions

The complete elimination of irrigation from the catchment would only contribute the current recharge figure of 29 GL, hardly enough to replenish the aquifer and create a base flow. Management of the terrestrial ecosystem (grassland, open woodland) to better resemble pre-European vegetation, as can be determined from historical records, should result in a yield of water at least commensurate with the 274.6 GL predicted by the model of Zhang *et al.*

It is likely that this amount would satisfy both the environmental demand for a stream base flow and provide more water than the irrigators could use, essentially drought proofing the catchment.

Deep drainage remains a 'wild card' in this catchment. The alluvial Lockyer aquifer may not function as a long-term storage body. However the deep drainage can reduce the risk of salination.

Unlike some other irrigation systems, taking into account the soil and water quality, the Lockyer can clearly be ecologically sustainable -but it requires that the terrestrial ecosystems that are not cultivated contribute water. Lack of appropriate management of these ecosystems appears to be a major problem.

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