Sustainability Rating For Decentralised Water Systems

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Abstract

Decentralised water systems can readily contribute towards water environmental sustainability. It is important to be able to rate environmental sustainability of decentralised systems so that home buyers can have confidence on claims of water sustainability, builders can have guidance on how to improve sustainability, land developers can justify their marketing claims and regulators can assess and regulate promotion of water sustainability of decentralised water systems. The Environmental Technology Centre has developed a rating tool for such a purpose. The rating tool quantifies the volumes of water drawn from all sources and wastewater disposed or reused through all routes, compares these with best practice water use volumes for a decentralised system and arrives at a score out of 10 (equivalent to best practice). The algorithm for the rating tool is implemented using Excel workbook/ worksheets prompting users to enter required input values. Application to four case studies is presented.

Keywords

sustainability, decentralised water system, best practice, rating tool

Introduction

A number of challenges face the water industry and the professionals working in the water services sector. These challenges range from coping with increasing water demand from population growth and industrial development, rainfall variability and in many cases decreasing amounts, to aging water infrastructure. The latter is a problem of the developed world, whereas in the developing world there is the problem of inadequate water infrastructure and deteriorating environmental water quality.

Sustainability has also been an issue, and the question that the community has been asking is whether we will be able to maintain the supply of water to meet the demand, if we continue to develop our water services in the way we have been doing for at least the past half a century.

It is imperative therefore for us to consider current water management practices, particularly in urban areas, to examine whether they are sustainable, and how we can make them so. This is outlined below, followed by consideration of the contribution of decentralised systems to sustainability. It is important to be able to quantitatively rate how well a decentralised water system is in achieving sustainability, and a sustainability rating tool is described. Application of this rating tool is illustrated.

Water Management And Sustainability

Water services in an urban area usually consist of supplying drinking quality water, collecting wastewater, treating and disposing of it safely to the environment, collecting stormwater run-off and directing it to a receiving water, controlling flooding, and preserving amenity and water quality of surface and groundwater. These services may be the responsibility of several government agencies or corporations.

In an urban area with centralised water and wastewater systems, each area of responsibility is generally substantial enough to be handled by a single agency. Water supply service involves construction and operation of a surface water reservoir (dam) and its management, pumping it the city, treatment and distribution. Wastewater service involves building a sewerage system, pumping station, treatment plant and an effluent outfall. Even when water supply and wastewater services are handled by one agency, they are located in different sections within the organization. In general the provision of water supply service precedes that of wastewater sewerage service, and it is only in recent decades that provision of both is required during land development. The two services are in a sense completely different in nature, such that there is little need for the service providers to talk to each other.

Similarly stormwater drainage is a substantial responsibility. It involves the collection of stormwater run-off from urban surfaces that are impermeable (roof, driveway, road, car park) and directing it away to minimise the risks of flooding in the city. Stormwater may be collected in the same sewerage system as wastewater or separately, and responsibility is with usually with same agency as for wastewater.

Amenity provided by water environments (streams, lakes, wetlands) is usually looked after by local government or more recently a government agency responsible for the environment. Water quality of water environments is invariably affected by wastewater and stormwater that are discharged to them.

The centralised urban water infrastructure, particularly wastewater infrastructure, has been very effective in protecting public health in the developed world. The investment for water supply, wastewater and stormwater infrastructure is estimated to be between $5,000 to $10,000 per housing lot for new land development. This may appear to be considerable, but is a small fraction of the cost of land and building (less than 4%), and furthermore the direct (medical treatment) and indirect (loss of income) public health costs of not having the infrastructure may be 5 to 25 times.

The centralised water systems in the developed world are generally well managed with well established institutions, trained personnel and regulatory framework. The assets managed by centralised systems institutions are considerable, of the order of $10billion per million of population served. The direct costs or rates payable by householders for operation and maintenance is estimated to be $500 per year per household.

The centralised water systems can be depicted as in Figure 1. Despite the excellent management of the individual systems the impact of these systems on the environment is significant. The impact is in three areas.

Water is imported to the city for water supply. If the source is surface water it may involve building a reservoir (dam) across a river. The river downstream of the dam does not receive water in amount and variability as before the dam was built. At the same time impermeable surfaces in the city results in more rapid and greater amount of stormwater run-off in the stormwater sewer, which may increase the risks of flooding where the run-off is discharged.

Because not all pollutants are removed from treated wastewater that is disposed to a receiving water environment (river or ocean), the receiving water

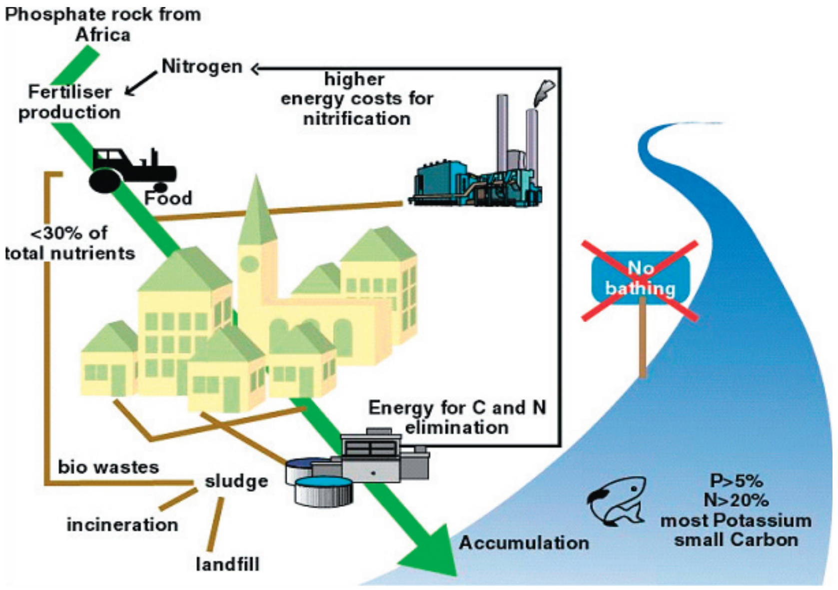


Figure 1. Unsustainable urban water management (UNEP, 2002)

environment is polluted. This pollution is exacerbated if industrial wastewater is collected with domestic wastewater. Wastewater and stormwater when collected in the same sewer also causes combined sewerage overflow during heavy rainfall periods, which generally bypasses treatment altogether.

There is loss of opportunity for the nutrients in wastewater (nitrogen and phosphorus) to be recycled on agricultural land. In fact nutrients are removed in many wastewater treatment plants, which adds to treatment costs to meet effluent discharge standards. The latter have become more stringent as regulatory authorities attempt to control and reduce pollution of receiving water environments. There is also the need to synthesise nitrogen fertilisers and mine phosphate rock to supply the fertiliser need of agriculture.

To overcome the environmental impact there have been efforts made to reuse wastewater, recycle stormwater and to return nutrients to agricultural land through recycling biosolids recovered from wastewater treatment. Integrated urban water management was introduced to ensure that planning for water supply, wastewater and stormwater is coordinated.

To reuse wastewater from a centralised system generally requires treated water to be piped and pumped to where large scale wastewater reuse can be applied, for example for replenishment of over-extracted groundwater, for agricultural or industrial purposes. The need for another water distribution system and the necessary large amount of investment is a challenge facing centralised water systems if sustainability is a desired outcome.

Sustainable water management

To achieve environmentally sustainable water management the undesirable environmental impacts have to be overcome. Figure 2 shows a possible scenario to achieve sustainability.

Industrial and domestic wastewaters are separately treated and collected. Industry is currently required to pre-treat its wastewater prior to discharge to the sewer. This is to protect the sewer and the treatment plant. This requirement can in the future be extended so that industry can also achieve sustainability objective by not discharging pollutants to the environment.

Future planning may include co-location of industry so that there will be opportunity for common treatment of industrial wastewater and its reuse. Industry with wastewaters that have similar characteristics to domestic wastewater (e.g. abattoir, food processing) can still discharge their wastewater to the domestic wastewater sewer. As a result domestic wastewater is not contaminated with industry wastewater, such as heavy metals, so treated domestic wastewater is suitable for reuse.

Stormwater run-off is infiltrated to the ground as much as possible through permeable pavements, infiltration strips and swales, constructed wetlands, ponds and lakes. Flow of the stormwater is slowed down and brought back as far as possible to the pattern before land clearing. Pollutants in the

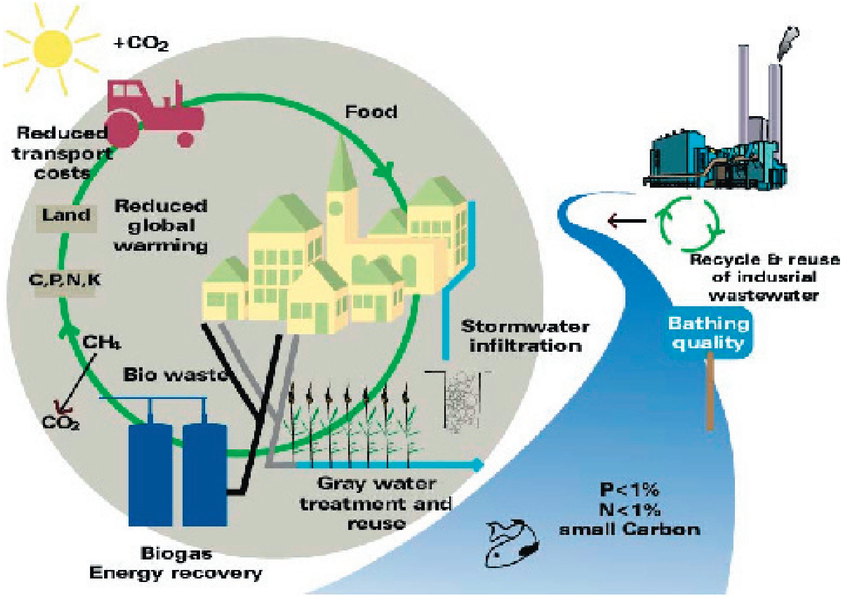


Figure 2. Sustainable urban water management (UNEP, 2002)

stormwater are also filtered by soil and plants. The wetlands, ponds and lakes provide environmental amenities and habitat for wildlife. There may also be opportunities to return streams that have been covered in the process of urban development to be restored to a condition closer to their natural state prior to development.

In the example shown in Figure 2 greywater, which is water from the bathroom and laundry, is separately collected and used for irrigation of garden or public open space. Blackwater, which is water from the toilet and kitchen, containing most of the solids and nutrients, is treated to extract methane. The nutrients are then recycled back to agricultural land. The nutrient cycle is then closed and no or less nutrients need to be imported. Little nutrients and pollutants are intentionally discharged to water environments, so that water quality in these environments is protected.

The use of greywater and stormwater for irrigation of garden and public open spaces means less scheme water is required. Less surface water is drawn for water supply and more environmental flow is restored to the river.

Decentralised water system contribution to sustainability

Closing the water and nutrient cycle for decentralised water systems is generally more feasible to achieve, because of the small scale nature of single dwellings, cluster of buildings or even village scale development. For a single dwelling, for example, roof rainwater can be harvested and stored for potable water and in-house uses (Ho and Anda, 2006). Wastewater can be treated to secondary standard using an aerobic treatment unit and the treated wastewater can be used for garden irrigation. The water and nutrient cycles can be more readily closed on-site without the need for piping and pumping water over long distances.

Progress in green building design has also facilitated the reuse and recycling of water. Stormwater run-off can also be infiltrated on-site and if desired stored under permeable pavements for use during long periods without rainfall, such in a Mediterranean climate. Green building design also facilitates integration between water and energy sustainability.

There is an advantage with cluster of dwellings or village scale development. There is an economy of scale, because one wastewater treatment plant instead of for each building is required, and there is public open space that can be irrigated with treated wastewater, instead of only gardens within property boundaries.

There is evidence of a growing desire by home buyers to have a home with water sustainability features. This appears to be driven by a range of reasons including consciousness for reducing water consumption in areas with decreasing rainfall, the desire to be more self-sufficient in water supply or wanting to be or become green. There is usually also the desire to have more energy efficient home, so that both water and energy use will be less while still maintaining the same lifestyle.

Home builders and land developers have responded to the demand by incorporating decentralised water systems, and advertising the properties as having water sustainability features. It may be bewildering for a home buyer faced with a variety of environmental sustainability claims by land developers, and it may also be difficult for the government to assist with advice. It is desirable to be able to rate decentralised water systems for their sustainability.

Sustainability Rating For Decentralised Water Systems

We have developed a rating tool that consists of 3 main steps (Hunt et al., 2006; Ho et al., 2007), and these are described below.

1. Ranking and assigning weighting values for water flows into and out of a land development

Figure 3 shows the flows of water into and out of a land development. Three sources of water are available to supply water to the land development, and five means for wastewater disposal. Scheme water and reticulated sewer are options for a land developer if a centralised system is desired, and rainwater and rainwater recharged groundwater for water supply if a decentralised system is desired.

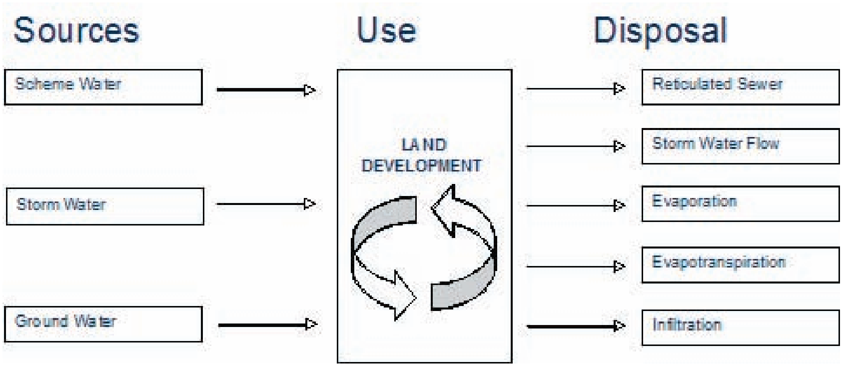
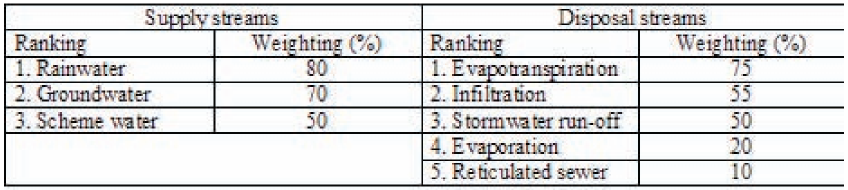


Figure 3. Water flow into and out of a land development



Supply streams		Disposal streams	
Ranking	Weighting (%)	Ranking	Weighting (%)
1. Rainwater	80	1. Evapotranspiration	75
2. Groundwater	70	2. Infiltration	55
3. Scheme water	50	3. Stormwater run-off	50
		4. Evaporation	20
		5. Reticulated sewer	10

Table 1. Supply and disposal stream ranking and weighting for land development

It may be necessary to draw water from scheme water if local rainfall, roof catchment or space for rainwater tanks is not adequate. Disposal of excess wastewater during the rainy season to a centralised sewerage system may also be necessary. If the objective of a decentralised system is to minimise impact outside the land development, then we want to minimise or avoid drawing water from scheme water or discharge wastewater to a centralised sewerage system.

For water supply we may give water from local rainfall the highest priority, followed by local groundwater which is replenished by rainfall and water from a centralised scheme the lowest priority.

For wastewater disposal our first priority can be evapotranspiration, because this is through plants and hence a means of maintaining a vegetated landscape (parks and gardens) or for growing food locally if desired. The next priority can be infiltration to the ground, because this is the means for recharging the local groundwater. Stormwater run-off can be next, because this will contribute to stream and river flow, although we may want to retain as much stormwater onsite, mimicking natural systems and may prevent flash flooding in streams and rivers. Evaporation from excessive irrigation and disposal to a centralised reticulated sewer are least desirable when we wish to minimise impact on the environment and increase water use efficiency in a land development.

If we adopt the priority scheme as described above we can develop a weighting system that reflects it (Table 1).

Assigned values for the weighting of each stream should not only reflect our priority ranking (i.e. decreasing from ranking 1 to ranking 5), but also reflect local conditions. For example, if average local rainfall is relatively abundant and availability of land for rainwater storage tank is not limiting, then the weighting factor for supplying water through rainwater harvesting can be given a higher value, while for scheme water can be given a lower value. The weighting values shown in Table 1 reflect the local conditions in south west of Australia and in particular in the Perth metropolitan region and surrounding areas. The climate of the region is Mediterranean with four distinct but mild seasons. Rainfall is primarily in winter and long-term average rainfall is about 800 mm, although a significant decrease (-20%) has been noted in the trend over the past 20 years. There is a long dry period over summer and storing harvested rainwater for this period is an important consideration. Balancing this disadvantage is the existence of an unconfined aquifer beneath the predominantly sandy soils, acting as storage for infiltrated rainwater in winter that can be drawn in summer.

2. Determining best practice figures for volumes of water flows into and

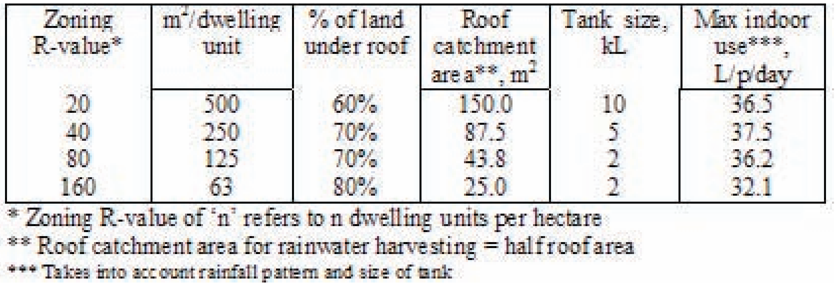
out of a land development

Best practice volumes are estimated for each of the eight flow streams and they are discussed individually below as they involve quite a number of assumptions. Estimates will improve as we gain experience from application of the rating tool to real cases.

Rainwater

The best practice use of rainwater is determined by calculating the water that could be harvested and used in a home with moderate ease and cost. This usage is determined using standard household usage figures for the density of housing in the development. Different housing densities will have differing capacities to capture rainwater. For example if the development is high density the volume of water that could be captured per home is reduced as there is less roof catchment area per home than in a lower density development, and potentially less space for a rainwater tank.

The household usage is based on a tank size ranging from 2kL to 10kL. The water usage is for laundry, toilet flushing and a garden tap. Table 2 details this household (or indoor) usage further.



Zoning R-value*	m^2/dwelling unit	% of land under roof	Roof catchment area**, m^2	Tank size, kL	Max indoor use***, L/p/day
20	500	60%	150.0	10	36.5
40	250	70%	87.5	5	37.5
80	125	70%	43.8	2	36.2
160	63	80%	25.0	2	32.1

* Zoning R-value of 'n' refers to n dwelling units per hectare

** Roof catchment area for rainwater harvesting = half roof area

*** Takes into account rainfall pattern and size of tank

Table 2: Calculation of rainwater best practice usage

Groundwater

Best practice groundwater usage is determined by the volume of water required to irrigate household and public open space areas using average areas and efficient irrigation systems. Average areas of public open space and of household gardens for Perth developments were used. These averages were determined from a survey of land developments and are dependant on zoning density. The irrigation water required for these areas was calculated assuming efficient irrigation systems (90%), low crop factor plants (0.5) and improved soil. Table 3 outlines this information further. Washing machine used-water is assumed to supplement groundwater for irrigation of private garden.

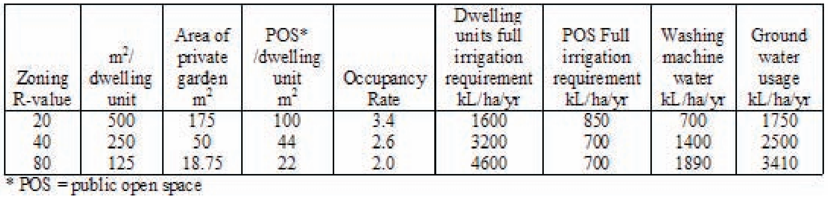
Scheme Water

The best practice scheme water use is determined by subtracting the best practice rainwater use from the Perth average indoor water use. Water for indoor use is therefore from rainwater harvesting, and only when this is not sufficient that scheme water is used.

Evapotranspiration

The best practice volume of water that evapotranspires is determined by a percentage of the best practice groundwater use. That percentage is determined by the efficiency of the irrigation system. For an irrigation installed professionally a value of 80% groundwater used can be assumed.

Infiltration



Zoning R-value	m^2/ dwelling unit	Area of private garden m^2	POS* /dwelling unit m^2	Occupancy Rate	Dwelling units full irrigation requirement kL/ha/yr	POS Full irrigation requirement kL/ha/yr	Washing machine water kL/ha/yr	Ground water usage kL/ha/yr
20	500	175	100	3.4	1600	850	700	1750
40	250	50	44	2.6	3200	700	1400	2500
80	125	18.75	22	2.0	4600	700	1890	3410

* POS = public open space

Table 3: Minimum Irrigation Use

The best practice volume of infiltration is the sum of three infiltration flow paths. They are the infiltration from rainfall, the infiltration from irrigation use and the infiltration from seepage of any open water body. The infiltration from rainwater is the total rainwater falling on the development minus the volume of water harvested in the rainwater tanks and minus the volume of water leaving the site from runoff.

Storm Water Surface Runoff

The volume of surface water runoff is related to the volume of water infiltrated to the ground. Because of the sandy soils and the presence of unconfined aquifer in Perth, maximising infiltration of rainwater in winter and storing it in the unconfined groundwater for withdrawal in summer when there is little rainfall is the preferred option. In this case best practice means zero surface water runoff.

Evaporation

The best practice volume of water evaporated is determined by a percentage of the best practice volume of groundwater use, because groundwater is used for irrigation and excess irrigation should be minimised under best practice. That percentage is determined by the efficiency of the irrigation system. Assuming that the irrigation is installed professionally a value of 7% evaporation is assumed.

Reticulated Sewer

This volume of water is calculated from the Perth average in-house water use subtracting the volume of water used by the washing machine (this volume is used for garden irrigation, see above).

3. Determining actual values of volumes of water flows into and out of a land development and assigning a score compared with best practice.

For all flow streams the score of the development is determined by the difference between the actual quantity of water used by the development and the best practice volume for each flow stream. The higher the difference (deviation) the lower the score and vice versa. Differences can be negative and this results in the maximum score. The deviation calculation is given below for the eight flow streams. The equation is for Rainwater and Evapotranspiration

Deviation = (best practice volume – actual volume)/reasonable maximum difference

and for the other flows

Deviation = (actual volume – best practice volume)/reasonable maximum difference.

Score Calculation

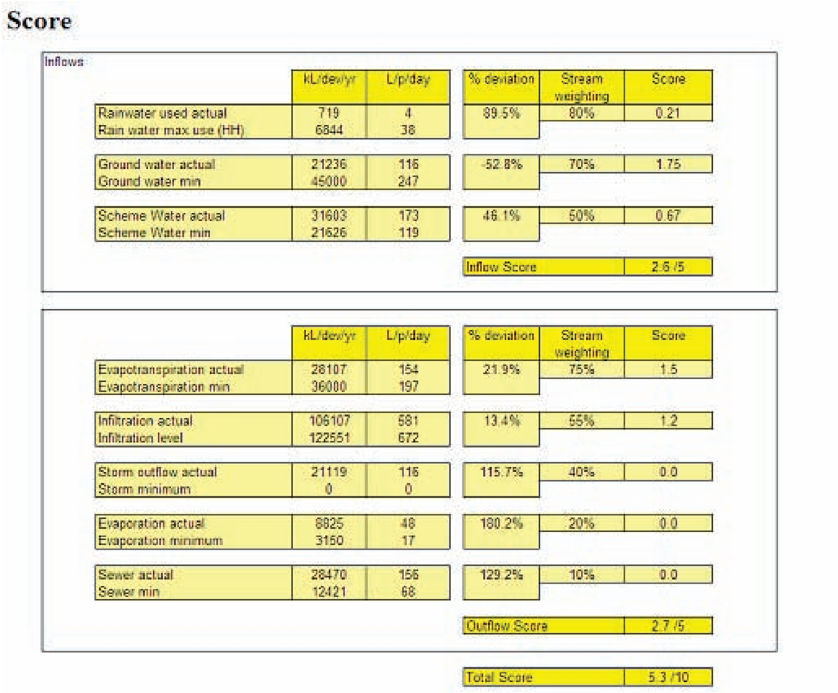
To obtain the score for each flow stream the compliment of the deviation percentage for that flow stream is multiplied by the stream weighting. This number is then normalised so that the final score is out of 10.

Flow stream score = (1 - deviation) x weighting x normalising factor

The closer the actual is to the best practice, the lower the deviation resulting in a higher score. If the deviation is negative it is set to zero resulting in the maximum score. A reasonable maximum difference is set that corresponds to a likely worst scenario if no effort is made, e.g. reliance on scheme water only and disposal of wastewater through a centralised sewer. For deviations greater than 1 a score of 0 is assigned.

The algorithm for arriving at the final score as described above is set out in an Excel workbook. Inputs as required by the algorithm are requested at appropriate points in the relevant worksheets. An example of a score calculation is shown in Figure 4.The flow stream scores for the three supply flow streams are then added to give a total score for the supply flow streams out of five. The same is done for the five disposal flow streams. These two scores are then added together to give a total score out of ten.

Application To Case Study Land Developments



Score

Inflows

	kL/dev/yr	L/p/day	% deviation	Stream weighting	Score
Rainwater used actual	719	4	89.5%	80%	0.21
Rain water max use (HH)	6844	38			
Ground water actual	21236	116	-52.8%	70%	1.75
Ground water min	45000	247			
Scheme Water actual	31603	173	46.1%	50%	0.67
Scheme Water min	21626	119			
			Inflow Score		2.6 /5

	kL/dev/yr	L/p/day	% deviation	Stream weighting	Score
Evapotranspiration actual	28107	154	21.9%	75%	1.5
Evapotranspiration min	36000	197			
Infiltration actual	106107	581	13.4%	55%	1.2
Infiltration level	122551	672			
Storm outflow actual	21119	116	115.7%	40%	0.0
Storm minimum	0	0			
Evaporation actual	8825	48	180.2%	20%	0.0
Evaporation minimum	3160	17			
Sewer actual	28470	156	129.2%	10%	0.0
Sewer min	12421	68			
			Outflow Score		2.7 /5

Total Score	5.3 /10

Figure 4: Example Score Calculation

The rating tool was applied to land developments in south west of Western Australia. Three actual case studies (South Beach, Bridgewater and Timber's Edge) were chosen not only for their innovative water systems, but also because these systems meant there was accompanying documentation. These included water balance audits, nutrient and irrigation management plans and Water Sensitive Urban Design and Integrated Urban Water Management plans. Much of the case study data was obtained from these documents produced by the developer or by consultants on behalf of the developer. A hypothetical case study considered a development in Perth that reflects current practice in the city. Pertinent characteristics of the case studies are shown in Tables 4 and 5.

The case studies have differing water regimes. Bridgewater has 100% onsite recycling of greywater for each house as its key feature, Timber's Edge has centralised grey water recycling and South Beach Village has no recycling system. The Perth average case study has no innovative water systems representing current practice in the Perth metropolitan area. The three real case studies have efficient irrigation systems, water-wise landscaping, promote efficient in-house water use and good storm water management.

Table 5 shows the rating scores for the case study land developments. The table also shows water saving features of the land developments. The rating score correlates well with increased use of water saving or efficient appliances, techniques or design.

	Perth*	South Beach Fremantle	Bridgewater Mandurah	Timber's Edge Mandurah
Parameters				
Number of houses**	280	300	389	260
Occupancy/ house	3.35	3.3	1.6	2.0
Land Area	20 ha	22.1 ha	13.7 ha	18.0 ha
Land area/ house	600 m^2	370 m^2	230 m^2	540 m^2
Roof area/ house	214 m^2	180 m^2	132 m^2	150 m^2
Land Use Classification^	Urban – Green Title	Urban - Green Title	Caravan Park & Camping	Urban – Strata Title
Greywater reuse#	0%	0	100%	100%
Rain water reuse	Some rain tanks	none	Unplumbed rain tanks	Some rain tanks

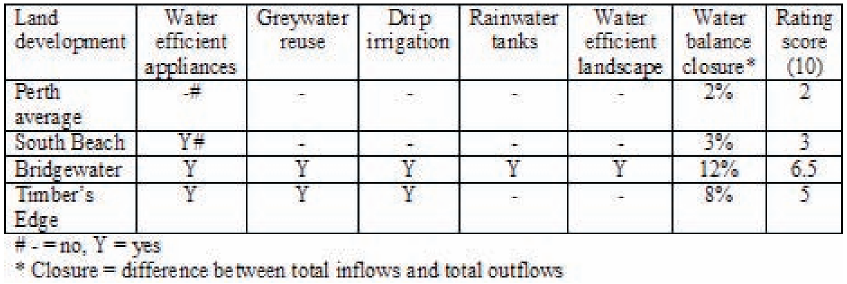
* average or typical values for Perth, ** detached dwellings in all cases, # blackwater to sewer in all cases, ^Green title = individual title for each land lot, Strata title = common title for land development.

Table 4. Characteristics of land development case studies

Discussion

Accurate estimates of water inflows and outflows are important in using the assessment tool. An indicator for the accuracy of the estimates is the difference between the total of the inflows and outflows, called the water balance closure. A closure of less than 10% is generally considered good, and this was the case for the estimates for the case studies (Table 5), except for Bridgewater. Further metering of flows can achieve better water balance closure.

Quite a number of assumptions are made in deriving the final rating score for a land development. In particular the derivation of the best practice figures for each flow stream can be refined to reflect improvements or advances in technologies, and will therefore change with time. The rating score values will correspondingly change with time (decrease with advances in technology and practice for the same land development unless a retrofit or better management practice is implemented). Viewed in this way the score should be regarded as an indication of the water use performance efficiency and not an absolute value. Its utility is in comparing between land developments and for a particular land development the relative improvements in overall water efficiency when different techniques, measures or management practices are adopted.



Land development	Water efficient appliances	Greywater reuse	Drip irrigation	Rainwater tanks	Water efficient landscape	Water balance closure*	Rating score (10)
Perth average	-#	-	-	-	-	2%	2
South Beach	Y#	-	-	-	-	3%	3
Bridgewater	Y	Y	Y	Y	Y	12%	6.5
Timber's Edge	Y	Y	Y	-	-	8%	5

- = no, Y = yes
* Closure = difference between total inflows and total outflows

Table 5. Rating scores for case study land developments

Utility of the rating tool

As indicated above the rating tool will be useful for a land developer to assess the water use performance efficiency of a land development, to compare alternatives for improving the efficiency and assist with choosing alternatives which are more cost-effective.

The rating tool will be useful to regulators who want to promote the efficient use of water. Appliances are now star rated for their water (and energy) use efficiency. The higher the number of stars the higher the efficiency, and the rating will assist consumers in choosing the appropriate appliance taking into account not only price but efficiency, with the former affecting investment cost and the later operating cost. In the same way land developments can be rated. This rating can be employed by land developers to market their land developments to home buyers. They are currently doing this, but their claims are not supported by a rating scheme.

Land developers in Perth are currently required to prepare a water management plan and in some cases a nutrient management plan. The former is largely driven by the decreasing amount of rainfall and hence less scheme water supply and availability of local groundwater, while the latter by the desire to protect surface and groundwater from nutrient pollution. The next logical step is for regulators to establish a land development water use performance efficiency rating that will facilitate both land developers to market their land developments and consumers to choose which land development to live in.

Refinement to the rating tool

The rating tool provides flexibility for assigning ranking for preferred use of sources of water and preferred route of disposal of wastewater. While the ranking as proposed is robust, the assignment of weighting factors relies on local factors. These include whether rainfall is relatively abundant, whether there is groundwater that is naturally recharged by rainfall and ease of withdrawal of the groundwater, the slope of the landscape that will govern how easily stormwater is retained on site, the nature of the soil and underlying materials that may or may not allow rapid infiltration, and thus local climatic, physical and geological features, and of course existing water supply and wastewater sewer infrastructure. Refinement of the rating tool could provide guidance on allocating weighting factors that will remove much of the subjectivity involved.

The rating tool requires that best practice water use and wastewater reuse and disposal be quantitatively determined. As discussed above best practice will continue to improve. What is considered best practice now may not be best practice in the future. Furthermore local best practice may lag behind international best practice. Using local best practice is preferred if the rating tool is to be used to rate local land developments and how future developments can be improved. Using international best practice may not provide a fair comparison because best practice is affected by local factors (climatic, physical and geological factors cited above), so that any comparison should select similar local factors.

Having discussed possible refinements to the rating tool we must not forget that the purpose of the rating tool is to provide a guide for comparing land developments and not absolute score values for the land developments. Precise values are therefore not needed, but only good estimates to allow comparison of land developments to be made by land developers, consumers and regulators.

Measuring progress towards decentralised water systems using the rating tool

The rating tool provides a means of measuring progress from a centralised water system to a decentralised water system. If the best practice conditions for a land development are set with zero flow of water from scheme water and zero flow of wastewater to a centralised sewerage system, then the score will indicate how well the land development is in performing as a decentralised system. The score is a quality measure with the higher score indicating better achievement.

The rating tool highlights the need to consider the broader questions of whether it is realistic to set best practice as equivalent to disconnecting to (or independent of) a centralised water and wastewater systems. In water deficient areas rainfall precipitation on the land development may not be sufficient, and water will have to be imported. Even in areas where rainfall is adequate there is the question of how much water should be retained within the land development area, and whether water is released through run-off to local stream outside the land development or through groundwater flow. In this regard there is an imperative in mimicking nature, i.e. how water would have behaved in the natural uncleared area prior to any development.

As the rating tool is applied to more case studies with differing local conditions we will gain greater experience that will provide guidance on how to apply it to general and particular situations.

Application to developing countries

Developing countries do not usually have adequate water infrastructure, but they endeavour to provide safe drinking water and adequate sanitation provision. Centralised water infrastructure is generally not affordable by developing countries, if wide spread coverage of water and sanitation services are to be provided to as many people as possible. The high upfront investment costs are the main deterring factor.

It can be argued that decentralised water systems could be more appropriate, because there are low cost systems for harvesting rainwater for potable use, and for sanitation. Information on these should be provided. The Environmental Technology Centre has developed monographs, training materials including eLearning packages in Rainwater Harvesting, Water Demand Management and Wastewater Reuse (Ho and Priest, 2005). The training materials can be used for face to face training workshop, whereas the eLearning packages for distance learning. Both should ideally be used at the same time.

Conclusions

A rating tool has been developed to assess the water use performance efficiency of land developments. The rating tool provides a structured, systematic and quantitative way all to assess the water flow streams into and out of a land development. It is a quantitative tool that gives a quality rating of not only water use efficiency of a land development, but also progress towards best practice decentralised systems. The rating or score is also a measure of attainment towards water sustainability of the land development, because the smaller the import of water and the export of wastewater the smaller the environmental impact outside the land development.

It will be useful for land developers to assess and promote its land development water sustainability, for consumers to choose alternative land developments and for regulators to facilitate more efficient water use at the land development scale.

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