PRACTICAL APPLICATION OF TRIPLE BOTTOM LINE SUSTAINABILITY TO WATER MANAGEMENT ON A SUBDIVISION SCALE

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Abstract

In 1987, the United Nations published a document that challenged the economic orthodoxy of the relationship between development and environmental degradation called "Our Common Future." It was one of the first documents that provided the concept of sustainable development. These challenges to economic theory were occurring even as early as the 1960's and 1970's. In today's world, one of many interpretations of sustainability is as a term that is used widely to describe a range of actions needed to reduce the impact of the built environment on the natural environment. At its core, true sustainability is about leaving a higher quality of life for future generations while still providing for the present. For this to occur, sustainability should be considered in the context of Triple Bottom Line (TBL). The concept of TBL is based on three interdependent criteria of Environmental, Economic and Social elements that are all considered equally important for any development project to be truly sustainable.

This paper provides a case study for a 40 dwelling subdivision located in northern New South Wales, in which the principles of triple bottom line have been applied to engineer the projects water, wastewater and stormwater infrastructure. This case study will concentrate on how the criteria of TBL were applications in the technology selection and economic feasibility analysis for a subdivision. The proposed design has incorporated the use of rainwater harvesting for potable water supply; wastewater collection; on-site treatment and reuse for use in toilet flushing; crop and landscape irrigation. This case study will showcase the sustainability model and the technologies used in the project. In keeping with the principles of TBL, a detailed life cycle costing over a 20-year period was conducted to calculate the true cost of providing a sustainable alternative to the standard model of centralised council services. The economic modelling investigated the long-term economic viability of both infrastructure models.

Keywords

sustainability, triple bottom line, environmental sustainable development, on-site wastewater treatment, water recycling, rain water

1 Applying Sustainability using a Triple Bottom Line Perspective

There are over 200 definitions of sustainable development commonly used. At WJP Environmental Services we view it in the context of triple bottom line sustainability - three interdependent circles of equal importance of Economic, Environmental and Social sustainability. In essence, sustainability is about providing a framework for development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

Figure 1 illustrates the principles of Triple Bottom Line Sustainability (Greenpeace. 2000).

The ten guiding principles used in the design of this village were:

1. Think long term;
2. Understand systems;
3. Recognise limits;
4. Conserve nature;
5. Challenge present thinking;
6. Be socially responsible;
7. Encourage innovation and creativity;
8. Look at the total economic picture;
9. Always look for multi-beneficial outcomes;
10. Understand and incorporate the human elements in design.

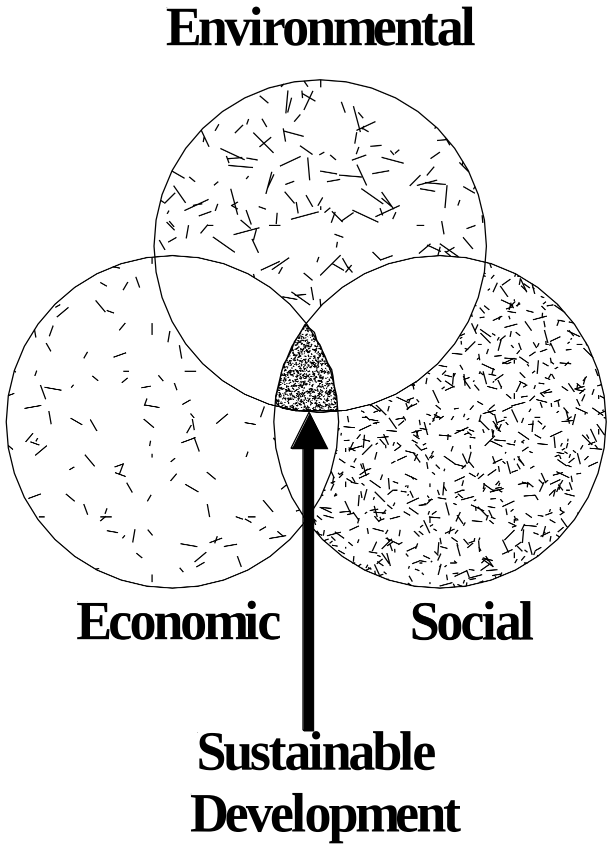

Figure 1: The Principles of Triple Bottom Line Sustainability (U.S. Department of Energy, 2001)

2 Case Study Overview

Australia's first rural inner-city subdivision is to be built in northern New South Wales. The subdivision will contain 40 terrace houses, cafes, restaurants, a health spa and light industries such as food processing. The total population of the village is expected to be 150 people. The 4.9 ha village is surrounded by organic farms that will supply the village with fresh produce and raw materials and in turn will utilise the organic waste and excess wastewater produced by the village. The village and surrounding organic farm is completely self-sustaining; producing its own power supply, using rainwater, treating and reusing its wastewater, and treating its organic solid waste on-site. The sections below describe the water and wastewater infrastructure that will form an integral part of this sustainable subdivision. A schematic of the water, wastewater and waste scheme is provided below in figure 2.

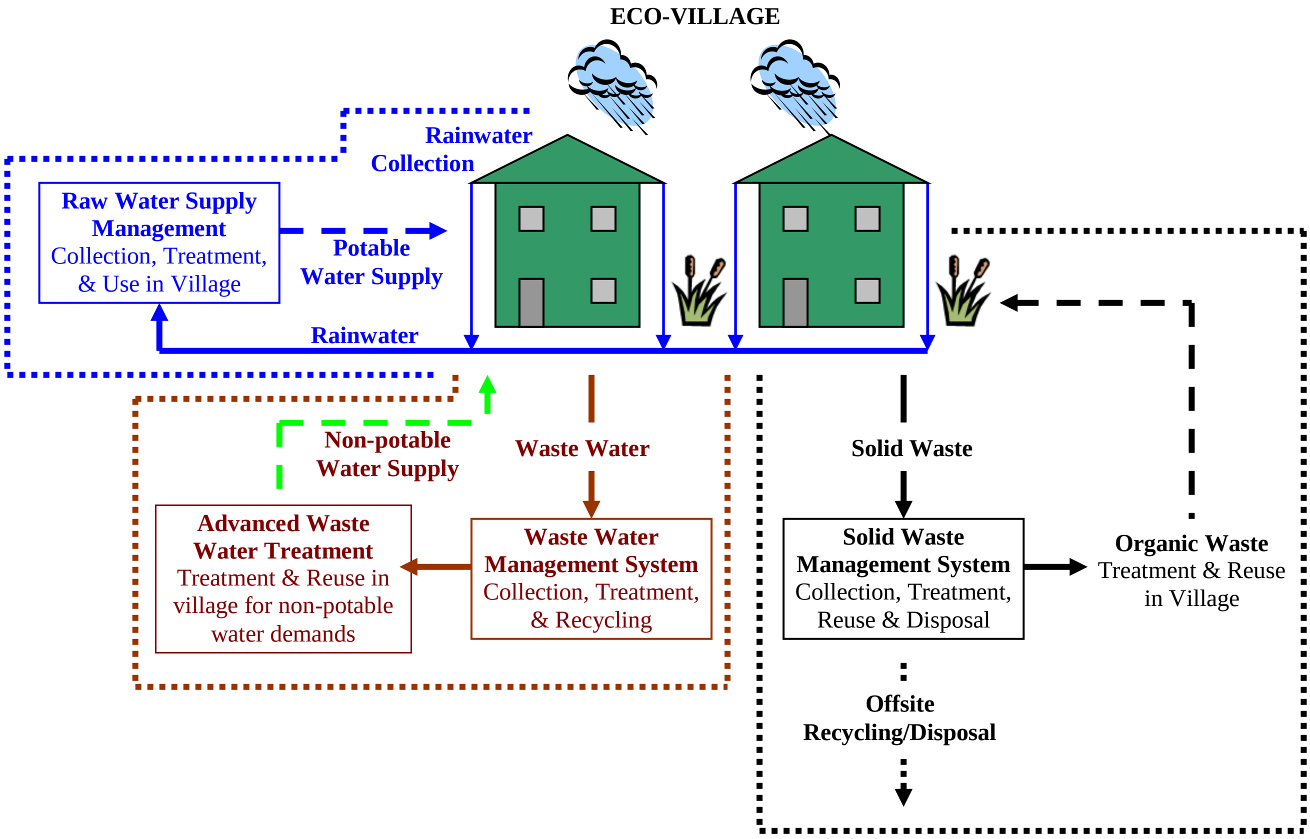

Figure 2: Schematic process flow diagram of water, wastewater and waste infrastructure

2.1 Water treatment

Potable water will be collected by harvesting rainwater from the roofs of buildings in the village and by capturing the rain that falls over the area of the rainwater storage dam. Water from the roofs will be gravity drained to a first-flush device that diverts the initial rainwater, which contains most of the pollutants, to stormwater. The remaining clean water will be stored in a temporary storage tank before being transferred to a potable water storage dam.

The temporary storage tank and transfer pumps are sized to transfer 96% of the rain water expected for storm events over a 100 year period. Modelling revealed that 25% of water losses in the property are due to evaporative losses from the potable water storage dam. Consequently, the design of the dam will concentrate on minimising evaporative losses.

From the dam the water will be treated through a pre-filtration process followed by micro-filtration, ultraviolet disinfection and residual chemical disinfection. Treated water will be distributed to the village with variable speed drive pumps to supply residences and businesses with potable water for drinking, showering, kitchens, hand basins, sinks and laundry.

2.2 Wastewater treatment

The proposed wastewater treatment and management system treats wastewater as a valuable resource that can be reused. The plant selection and performance outcomes have been designed to minimise any environmental damage and energy use. The proposed system is a completely passive treatment system that relies on natural processes. The wastewater treatment plant requires no additional energy to treat the wastewater. The only energy used is for the transfer of wastewater from one treatment strand to another.

The wastewater collection and treatment infrastructure will consist of gravity sewerage collection, bioremediation of trade waste, anaerobic digestion for primary treatment, intermittently fed recirculating aerobic sand filtration for secondary treatment and a submerged attached growth reactor for nitrogen removal. The proposed wastewater treatment plant is a modular stepped system designed to cope with changing occupancy rates with minimal disruption to the biological process. The effluent discharged from the treatment plant will be further polished for reuse in a recycle water treatment plant.

2.3 Recycled water treatment

The entire portion of treated wastewater will be polished to produce recycle water of class "A" standards. This water quality is suitable for use in toilet flushing, washdown water and for irrigation of landscape areas and crops. The polishing process will remove any colour and odour that may be present in the treated wastewater. The recycled water will go through a process of triple disinfection (chemical and physical) before being reused. The recycle water treatment plant will consist of self-cleaning mesh filters followed by low energy micro-filtration, ultraviolet irradiation and residual chemical disinfection.

3 Application of Triple Bottom Line Elements to the Design

3.1 Social

The social elements incorporated in selecting the water, wastewater and waste infrastructure for the eco-village were:

1. Incorporating the design of water treatment infrastructure at the planing stage to provide the best outcomes;
2. Utilising rainwater, wastewater and organic solid waste as resources to improve the liveability of the village.
3. Increasing resident awareness of the infrastructure by incorporating the plant and equipment into the development as an aesthetic feature;
4. Changing attitudes to efficient resource use through education and increased awareness;
5. Increasing green spaces by reusing wastewater and organic waste for beneficial outcomes and dramatically increasing the liveability of the community;
6. Selecting the technology based on consideration of the social, economic and environmental factors.

Water, wastewater and waste infrastructure incorporated at planning stage

The social elements incorporated into the design development of the water and wastewater infrastructure involved integrating these aspects at the very early stage in the planning process to deliver economical, multi-beneficial outcomes.

Redefining resources

The wastewater and solid waste were considered to be valuable resources that can contribute to improving the social wellbeing of the community. By implementing this shift in thinking it was possible to consider ways of incorporating the wastewater and waste infrastructure into the community as a feature instead of a problem that needs to be hidden and dealt with by others in some corner of the village. The wastewater treatment plant will be incorporated into the landscape design and will have architectural features to enhance the aesthetics of the plant, making the plant a feature in the development. The wastewater treatment plant and recycle water plant will produce water of high quality suitable for toilet flushing and irrigation. The guaranteed supply of irrigation water and nutrients has provided the opportunity to increase public green space, lifting the overall quality of life for the community.

Education

The water, wastewater, recycle water and organic waste treatment plants will be features in the village that will be used to educate the residents as well as visitors. By making the treatment plants a feature of the development it will increase the awareness of the residents and gives them a sense of ownership of the plants, removing the ***flush and forget*** mentality as well as making them responsible for their water resources.

Online metering of water and energy consumption will enable usage information from each house to be fed back to the user via the internet. The feed back information will provide real-time data on water and energy consumption and wastewater and waste generation for each residence. This will provide a valuable feedback loop to educate and retrain people in sustainable resource management. Based on our experience, insufficient or no performance feedback to the user is a major contributor to system and/or plant failure (Victorian Water Industry Association Inc, 2002).

Technology selection

The technology selection process undertaken for this project has not just considered economics but has also considered ways of adding value to social elements of the project while still maintaining a low ecological footprint.

3.2 Environmental

The environmental elements incorporated into this project are:

1. The use of rainwater as the primary source of potable water;
2. Reducing storm water runoff and managing stormwater through the principles of Water Sensitive Urban Design – does this consider the impact on the surrounding ecosystem and its incorporation into the TBL?;
3. The paradigm shift of viewing waste and wastewater as valuable resources;
4. The use of energy efficient and low maintenance technologies;
5. Managing the water cycle on the eco-village using the principles of Reduce, Reuse and Recycle;
6. Not using PVC in the water, wastewater and recycle water infrastructure; (Greenpeace, 1997)
7. Dramatically reducing the use of chlorine in the project;
8. Recycling of organic solid waste as nutrients in the organic farms surrounding the village;
9. Beneficial reuse of greenhouse gases to increase agricultural yields

3.3 Economic

The process selection for the project incorporated economic life cycle modelling of the capital, operational and plant replacement cost.

The economic modelling and life cycle costing were conducted for the following options:

- Option 1: Connecting to council infrastructure with subsidises for a 33 residence subdivision;
- Option 2: Connecting to council infrastructure with no subsidises for a 33 residence subdivision;
- Option 3: Provision of on-site water and wastewater infrastructure for a 33 residence subdivision;
- Option 4: Connecting to council infrastructure with subsidises for a 40 residence subdivision;
- Option 5: Connecting to council infrastructure with no subsidises for a 40 residence subdivision;
- Option 6: Provision of on-site water and wastewater infrastructure for a 40 residence subdivision.

The results of the life cycle cost analyses for the six options are provided in Table 1.

Options 2 and 5 investigated the true cost of connecting to council water and sewerage infrastructure without the subsidies. Councils via State Government funding subsidise the cost of providing water and sewer infrastructure to the country areas (section 64 charges). If connecting to council infrastructure, this project will receive a cross-subsidy of 25% for its water and 50% for its sewer connection (Mr Au Atukorala, Lismore City Council).

OPTION	ESTIMATED CAPITAL COST	LIFE CYCLE COST AFTER 20 YEARS
Option 1 Council Subsidised 33 ET	$699,534.00	-$1,500,328.00
Option 2 Un-subsidised 33 ET	$955,878.45	-$1,756,672.50
Option 3 On-site 33 ET	$1,149,458.40	-$1,492,980.70
Option 4 Council Subsidised 40 ET	$847,920.41	-$1,885,487.40
Option 5 Un-subsidised 40ET	$1,158,640.42	-$2,196,206.90
Option 6 On-site 40 ET	$1,346,911.05	-$467,986.56

Table 1: Results of the life-cycle costing exercise for the 6 options

4 Break-even Calculations

A break-even calculation was conducted to calculate the required charge rate of water, wastewater and recycled water to enable the replacement of plants at the end of their lives. The life of these plants are expected to be 20 years, after which time it is assumed that they will be replaced. The plants expected to be replaced after 20 years are:

- Water treatment plant
- Wastewater treatment plant
- Recycled water treatment plant

The present capital costs of these plants are provided in Table 2 below.

ITEM	TOTAL COST
Water treatment plant	$140,000.00
Sewage treatment plant	$256,000.00
Recycle water treatment plant	$110,000.00
TOTAL	**$506,000.00**
Contingency	**20%**
TOTAL REPLACEMENT CAPITAL COST	**$607,200.00**

Table 2: A list of plants and their present replacement value

Based on a 3% inflationary affect, it is expected that the total replacement cost of the equipment would be $1,064,700. Based on the break even economic modelling water, wastewater and recycle water service charges need to increase by 119% to produce enough revenue to maintain, operate and replace the treatment plants and infrastructure at the end of 20 years.

Table 3 provides the required charge out rates based on the 119% increase from current council charge rates.

ITEM	CURRENT COUNCIL CHARGE RATE	BREAK EVEN CHARGE RATE
Water Service charge	$86.00/ year	$188.34/ year
Water usage charge	$0.86/ kL	$1.84/ kL
Wastewater usage charge	$1.74/ kL	$3.81/ kL
Recycle water usage charge	$0.46/ kL	$1.00/ kL

Table 3: Summary of break-even charge out rates

5 Conclusion

Since the United Nations publication of "Our Common Future" challenging the economic orthodoxy of the relationship between development and environmental and social sustainability, there has been an increasing awareness of the need for the practical framework within which future developments can be conducted in a sustainable manner. This paper has offered a practical framework and a case study example of how environmentally sustainable development (ESD) can be achieved in the context of Triple Bottom Line principles. The case study of a 40 residence sustainable subdivision clearly illustrates the importance of providing equal credence to environmental, social and economic aspects of the project to achieve the outcome of true sustainability.

The case study also revealed that the economic models for developments must consider life-cycle costs and not just capital costs. The case study also concludes that the current water and wastewater charges do not consider ecological and social costs and are therefore greatly undervalued. It is clear from this case study that more work needs to be conducted into developing a practical and workable framework through which future developments can be environmentally sustainable, ensuring that we provide a higher quality of life for future generations.

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