



**Waste Management and greenhouse gas emissions  
from Bridgewater Lifestyle village, Mandurah, Western  
Australia**

**Report No. 2  
Onsite Solid Waste Management in an Urban Village-  
Treatment of Kitchen Waste through composting and  
vermicomposting to minimise waste generation  
Contract No: 22260-**

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## **Abstract**

The contribution of wastes on greenhouse gas (GHG) emissions depends on the treatment technology, transport of waste to the treatment and/or disposal centres and the decomposition processes. Onsite treatment is expected to have reduced emission due to the less transport, opportunities for energy efficient technologies and the potential to use the end product onsite. Although only methane emission is taken into account in organic waste treatment, for a complete assessment of the GHG emissions in a waste management facility, it would be interesting to account CO<sub>2</sub> from waste decomposition and streamline life cycle activities in the net GHG balance. The objective of this study was to estimate GHG emissions from the waste management activities adopted at the Bridgewater Lifestyle Village (BWLTV) in Mandurah (Western Australia) compared to a situation if the waste is land filled. The results showed an eight fold reduction in GHG emissions achieved through onsite treatment of organic wastes and recovery of recyclable materials when compared to landfill and five fold reductions when compared to landfill with energy recovery. Emissions from the village are minimal, and are mostly inevitable. Current waste management strategies and behavioural patterns in the village should be maintained to ensure continuous minimal GHG emission.

## **Introduction**

The majority of wastes produced in all the major cities are directed to landfills where anaerobic conditions generate methane (CH<sub>4</sub>) and carbon dioxide (CO<sub>2</sub>). These two gases can be identified as green house gas (GHG) with a global warming potential of 25 and 1 respectively (IPCC 2007). The IPCC has estimated that waste management (WM) sector contribute 5% to the global GHG budget (Bogner *et al.*, 2008) and within Australia, the WM sector has been responsible for approximately 4% of the national carbon (C) budget (SoE, 2006).

Western Australia has responded to this need for diversion of waste to landfill with an initiative called 'Towards Zero Waste'. This would effectively minimize the amount of waste, especially organic waste, disposed at landfills which in addition to several managerial, economical and other environmental advantages also reduce GHG.

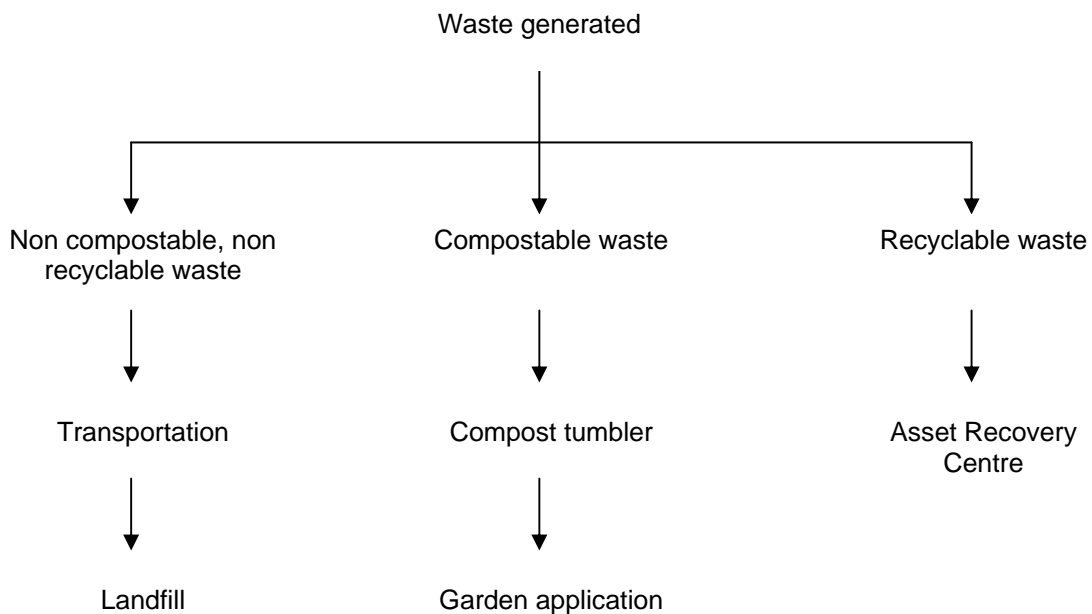
There are several strategies at various scales adopted for onsite management of waste world wide, the more common strategies implemented are recycling of inorganic fraction of the waste stream while composting and/or vermicomposting of organic fraction of the waste stream. Recycling and composting are more commonly performed at centralized facilities, and the latter being relatively common as a form of on-site WM too. The objective of this study is to estimate GHG emissions from the waste management practices implemented at the Bridgewater Lifestyle Village (BWLTV), a residential village of 380 houses in Western Australia.

### ***Description of BWLTV WM strategy***

BWLTV has a planned capacity of approximately 389 houses and the village was designed around the principle of sustainable living and environmental consciousness and has also implemented an on-site Waste Management strategy. The details are provided in the earlier report of this research contract

to the Waste Management Board (Contract No. 22260) (Nair, Anda and Trowbridge, 2007). Waste generated at the each household are divided into three streams – recyclable wastes, compostable waste and landfill waste (Figure 1). Three Asset Recovery Centre (ARC) centres are established at different locations in the village to where the residents manually take the household wastes. In the ARC there are several sorting bins and bays to which the residents dispose the waste after manually sorted. The sorted materials such as aluminium, cardboard, plastics, metals, batteries etc are collected by the recyclers or taken to the recyclers when reached sufficient quantities.

Compostable wastes, comprising mainly of food and green garden wastes treated onsite through a composting process. The initial stage of composting is carried out in a cement mixer, operated by a 2 KW motor for one hour/day to aerate the wastes. This is vital as anaerobic decomposition facilitates the production of methane. Following waste stabilization, compost produced is used in the village garden. Wastes that cannot be recycled or composted are sent to the Millar Road Landfill in Baldivis.

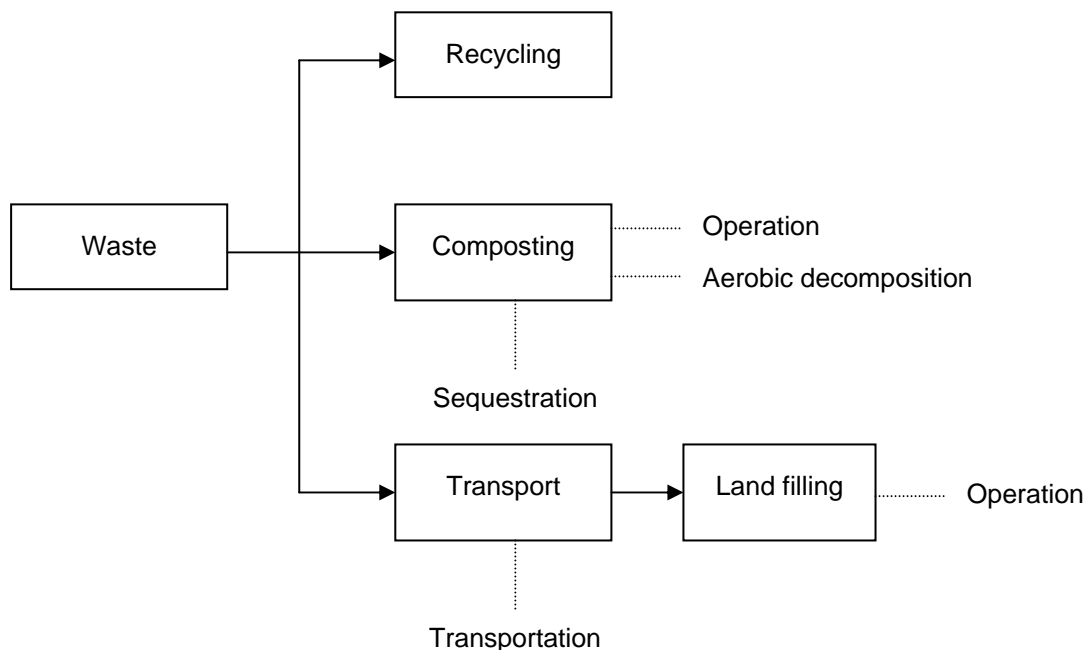


**Figure 1:** Summary of current Waste Management strategy employed at BWLV

### ***Estimating GHG emissions at BWLV***

Currently, there are no legislative requirements for composting facilities to report their GHG emissions. Carbon dioxide (CO<sub>2</sub>) from organic waste decomposition is not accounted in emission models as it is considered to be of biogenic sources and the only GHG emission that is supposedly emitted are those from operational activities. However, in this study in order to have a more holistic and accountable form of GHG accounting, CO<sub>2</sub> from waste decomposition and emissions resulting from streamline life cycle activities of composting was taken into account when quantifying a facilities impact on GHG emissions.

Firstly, the scope of GHG accounting was determined (Figure 2) and accounting starts from the point waste is generated (i.e. households in this case) and the end point is where the waste is either land filled or found an alternative use.



**Figure 2:** Scope of GHG estimation showing the WM process considered in the model

For the estimation of GHG at the BWLV, potential emission sources from the process of Waste Management were identified and input data, such as

transportation and operational fuel consumption was gathered through the completion of a questionnaire. The list of input data required and reflected in the questionnaire is presented in Table 1.

**Table 1:** List of input data that are required for the calculation of total GHG emission from the BWLV

<b>Category</b>	<b>Input</b>	<b>Units</b>
Waste	Amount of waste	Ton
	% proportion of waste stream	fraction
	LFG capture efficiency	fraction
	LFG recovered	ton
	Oxidation factor	fraction
	Amount of inert waste produced	ton
Transport	Truck tonnage	ton/truck
	Distance	km/truck/load
	Distance	Km
	Fuel consumption	L/km
	Total fuel consumption	kill
Operation	Total fuel consumption (electricity)	kill
	Total fuel consumption (coal)	Mwh
Biogas combustion	Biogas engine efficiency	Fraction
	Amount of biogas captured in anaerobic digester	ton or m <sup>3</sup>
	Amount of energy offset	GJ
Compost produced	Amount compost produced	ton

Regular annual waste audit is conducted at BWLV to understand the efficiency of the process adopted and to assess the success of the project. Based on the audit, the average waste composition going to each waste treatment facility is illustrated in Figure 3. In the collection of recyclable waste at ARC no GHG emissions was associated as transportation and sorting is performed manually. Therefore the resultant emissions identified were from the composting process of food and green waste, and land filling of materials that cannot be recycled or composted. With regards to land filling of waste, no

CH<sub>4</sub> is accounted as only inert materials from the BWLV are land filled. Hence, emissions from landfills are a direct result of transportation and operational activities.

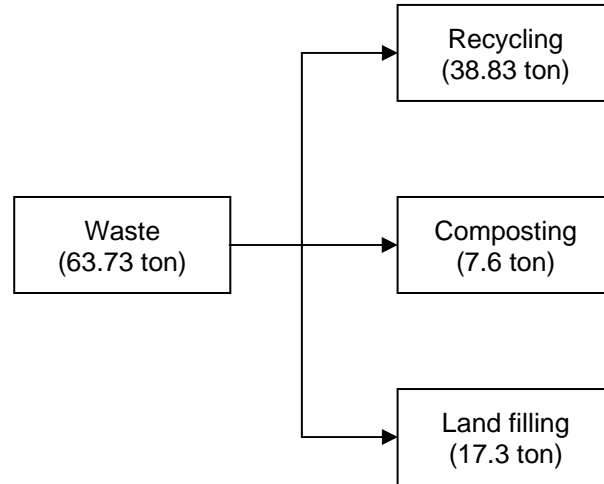


Figure 3: Average waste input into each waste treatment stream of BWLV

In the calculation of GHG emission a different approach was taken. Carbon dioxide generated from waste decomposition was assumed to be from biogenic sources and part of the normal carbon cycle and therefore not accounted for in the current emission models (Table 2). However CO<sub>2</sub> emitted from large scale organic waste decomposition in urban situation could be classified as anthropogenic sources. With respect to the waste management strategy employed by the BWLV, what used to be a null estimate using current assumption; inclusion of CO<sub>2</sub> from waste decomposition will lead to an increase in the village's GHG impact on the environment (Figure 6). This would therefore result in a larger implication for WM facilities for issues such as achieving carbon offsets. Nonetheless, CO<sub>2</sub> inclusion would induce higher accountability for all waste facilities.

Table 2 The GHG emission for organic waste from BWLV

Amount of organic waste (ton)	Waste type	Amount of waste (ton)	GHG emissions (ton CO <sub>2-e</sub> )
24.9	Food waste	0.434	0.374
	Paper	0	
	Green waste	7.159	
	Wood	0	
	Others	17.30	

## Results

Inclusion of CO<sub>2</sub> from SLC activities contributed significantly to the overall GHG emission from the village (Figure 4). This shows that the majority of emissions from BWLV's WM strategy are a result of transportation of inert waste to landfill and operational requirements for the management of waste, rather than from the actual decomposition of waste. However, the breakdown of activities showed that emissions from SLC activities are a result of land filling operations (Figure 6). This implies that for the village to reduce their GHG impact, focus should be directed towards the reduction of waste to landfills.

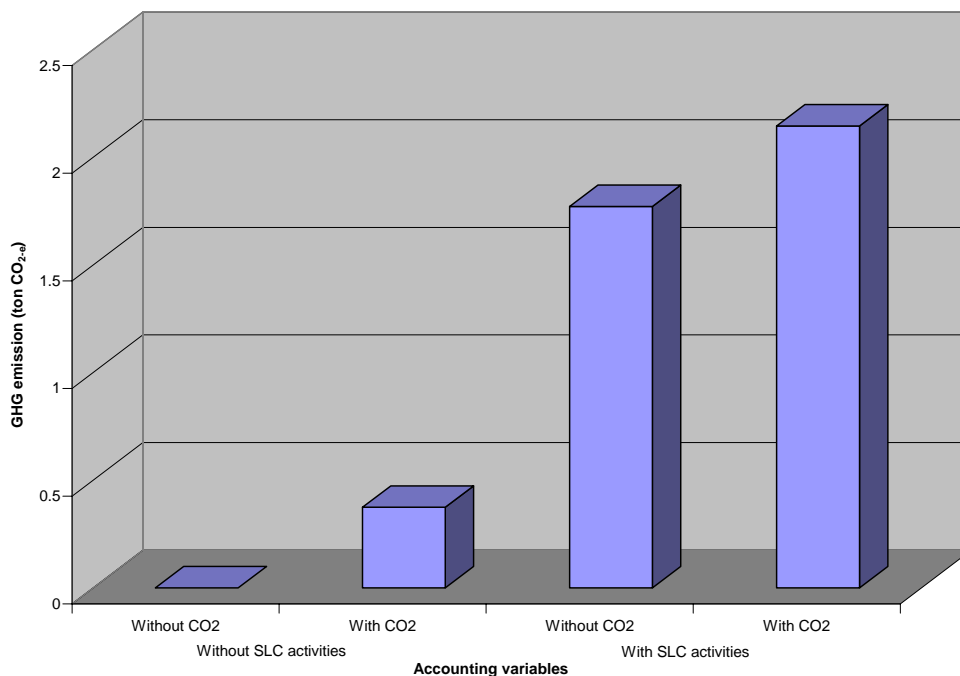
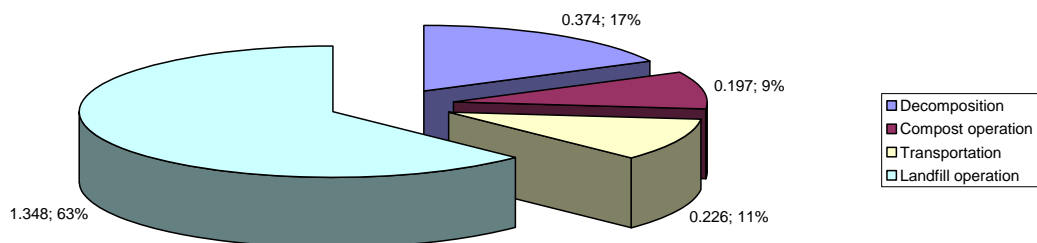


Figure 4: GHG emission of the BWLV's WM strategy under different accounting variables.

## ***GHG emission performance***

The majority of GHG emission from the village was a result of landfill operations from the land filling of non-recyclable and non-compostable waste fraction (Figure 5). This source of emissions was inevitable as a certain proportion of unusable waste will end up in landfill which will incur operational emissions. Community members of the BWLV will be required to maintain or improve their standard of waste source separation to minimize the amount of waste land filled and thereby reducing GHG emissions from the village.

The second highest activity emitter was CO<sub>2</sub> emission from aerobic decomposition of waste from the compost tumbler (Figure 5). Once again, this was inevitable as composting process releases CO<sub>2</sub> as a by product of decomposition. The possibility of an anaerobic digester to direct kitchen waste and other organic waste generated in the village as a means to reduce or possibly offset the village's GHG emissions and generate cooking gas or electricity for the village needs to be checked out (Edelmann *et al.*, 2000; Lou, 2008).



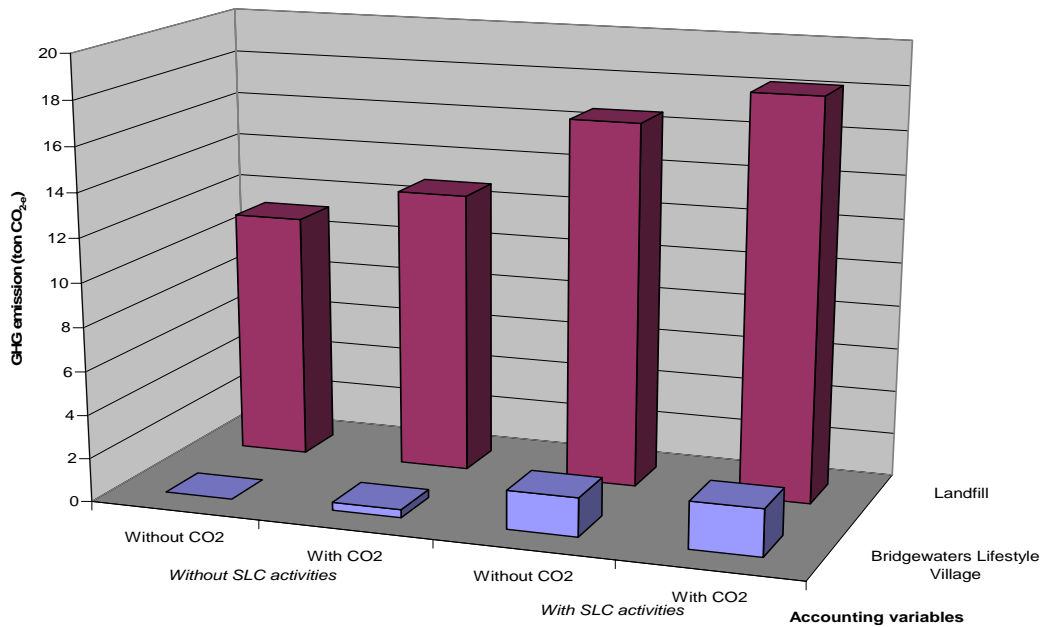
**Figure 5:** Percentage contribution of SLC activities overall GHG estimations (ton CO<sub>2-e</sub>; %) of BWLV

Under all accounting schemes, with all the village waste were land filled, GHG was greatly higher than what was practised in the village (Table 3). Even when CO<sub>2</sub> and emissions from SLC activities were accounted for, the GHG emission for the current BWLV WM strategy estimated to 2.145 ton CO<sub>2-e</sub>,

which was an eight fold reduction as compared to a complete land filling scenario (Figure 6). CH<sub>4</sub> generated from anaerobic decomposition of organic waste fraction in landfills are responsible for the high GHG emission from the landfill scenario. This demonstrated the significance of implementing innovative waste management strategies as a means of diverting waste, particularly organic waste, from landfills.

Table 3: Total Emissions from solid waste

<b>Emission source</b>	<b>Quantity (Q)</b>	<b>CO<sub>2-e</sub> emissions (ton)</b>	
Diesel consumption for operation of compost tumbler	2.628	0.197	Estimated using a 2KW motor that runs for 1 hour/day everyday. The motor runs the tumbler.
Diesel consumption transportation of residual waste to landfill	0.00780	0.226	Estimated using average distance of BWLV to Mandurah landfill (39.3km), where inert waste is collected once a month to be disposed there. Using average fuel from ABS 2006.
Diesel consumption for operation of landfill machineries	0.0179	1.348	Estimated using waste directed to landfill and the average fuel consumption of landfill operations/ton of waste from Baky & Eriksson (2003)
<b>Sequestration potential</b> Land application of compost	3.523 (183kg CO <sub>2</sub> /ton)	<b>CO<sub>2-e</sub> saved (ton)</b> 0.645	Estimated using USEPA conversion factor. Amount of compost produced available through consistent measurement.



**Figure 6:** Comparing GHG emission with the waste management strategies at BWLV with land filling scenario, taking into account different accounting variables

Therefore considering the conventional strategy where all waste from the village be directed to the Millar Road Landfill and energy from landfill gas is recovered, GHG emissions remained approximately five fold higher than the strategy adopted by the village (Figure 6). This illustrates the effectiveness of onsite Waste Management strategy currently employed by the BWLV as compared to landfill strategies (even with energy recovery) and should therefore be encouraged as a mean of reducing GHG emissions in the WM sector. So long as the BWLV maintains its current WM strategy, and diligent source separation of waste, GHG emission from the waste sector is highly likely to remain minimal, and will portray an example of how effective an on-site waste treatment facility can be at minimizing GHG emissions.

## Conclusion

The current Waste Management strategy at the BWLV is effective in reducing the GHG by around five to eight folds compared to land filling. The impact is primarily due to the onsite management of waste and maximum diversion of waste from landfills with recycling and composting programmes implemented in the village. With the expansion of the village, GHG emissions are predicted

to increase with increased waste production and the associated GHG emissions from SLC activities and composting emissions. An anaerobic digester may be an option for the village when it reaches full capacity for organic waste treatment for generating power, thereby further reducing the GHG possibly to a negative emission. The waste management strategies adopted at the BWLV is therefore an example of urban village waste management process that can be adopted for minimizing GHG emissions.

### **Current Status of the project**

The successful outcome of the research and implementation of an innovative approach to the waste management in Bridgewater lifestyle Village, Mandurah through the current project resulted in the parent company, National Lifestyle Village (NLV) to discuss with ETC the scope to implement such systems in their other 5 projects across Western Australia. There is still room for improving the system in BWLV as the audit shows waste that could be recycled going into the landfill bin. A stronger research collaboration with ETC and NLV is being discussed with an overall aim to reduce greenhouse gas emissions in the areas of energy, water and waste from urban villages.

### **Acknowledgements**

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## Images of the outcomes from the project



Vegetable garden utilising the compost



Worm farm at BWLV



Chook Pen at BWLV



ARC at BWLV