Perspectives of Solid Waste Management in Rural Cambodia

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ABSTRACT: *We present perspectives of solid waste in the Cambodian community of Koh Dambang, situated on the Mekong River, identified through a field-based mixed-methods study. We found that Koh Dambang had no waste service and households were responsible for their waste management. The residents interviewed produce approximately* 0.4 *to* 1 *kg of waste per person per day, where typically half of the waste is burnt, a quarter is buried and the remainder is dumped. Our research highlighted the desire for a community-level waste management plan. Some degree of waste management centralisation would have environmental, health and economic benefits for the residents, where expert consultation on a community-level incinerator or alternative would also be beneficial, although this is embedded in our existing external perspectives of waste management. Further consideration of the views of the whole community and its administration is required before a strategy could be proposed.*

KEYWORDS: *Waste Composition, Waste Management, Cambodia*

1 INTRODUCTION

The collection and management of waste is vital for good health and environmental sustainability in developing and developed countries alike. In Cambodia, a growing population, societal development, and industrialisation has encouraged increased consumption of resources and waste generation per capita (Agamuthu et al. 2007, Parizeau et al. 2006). Within Cambodia's large urban centres, such as the capital Phnom Penh, waste collection and management systems have been implemented by the government with the contract waste collection company Cintri (Heng & Laptaned 2007, CINTRI 2016).

Rural areas in Cambodia have limited access to basic waste management as municipal and district authorities can be reluctant or unable to provide basic waste management services due to a lack of resources, legislation, environmental ethics, education or support networks (Glawe et al. 2004, Muny, 2016). Management of waste is dependent on various factors including local drivers, resources, and waste composition. For the 84% of Cambodians living in rural areas, alternative waste management practices are used, with common methods including: informal waste collection, burning, dumping and burying (Muny 2016, Vanda & Heilmann 2015). In both rural and urban settings, dumping and burning can contaminate the ground and be dangerous if people are directly exposed to the waste and smoke, especially if disease and bacteria are cultivating inside (Stauffer & Spuhler 2016, Zurbrügg 2002).

These challenges and practices are prevalent in the island community of Koh Dambang located on the Mekong River in northern Cambodia (see Figure 1). Accessible only by boat, Koh Dambang is home to approximately 200 people. There are no waste collection services provided by the local Stung Treng province authorities and no organised waste management system on the island. Reasons for this are limited accessibility to the island to collect and manage generated waste, the substantial costs associated with transporting waste off the island, the lack of shared space on the island for a communal waste site, and Stung Treng authorities prioritising other services over waste management in the Mekong area.

This work explores waste management in Koh Dambang, as an example of the current waste challenges for rural communities in Cambodia. To investigate this and provide insights, community attitudes, practices and waste profiles are required. The next section outlines data collection and analysis approaches used, followed by the results obtained. A discussion draws together the results and considers potential opportunities and barriers to more sustainable waste management for Koh Dambang.

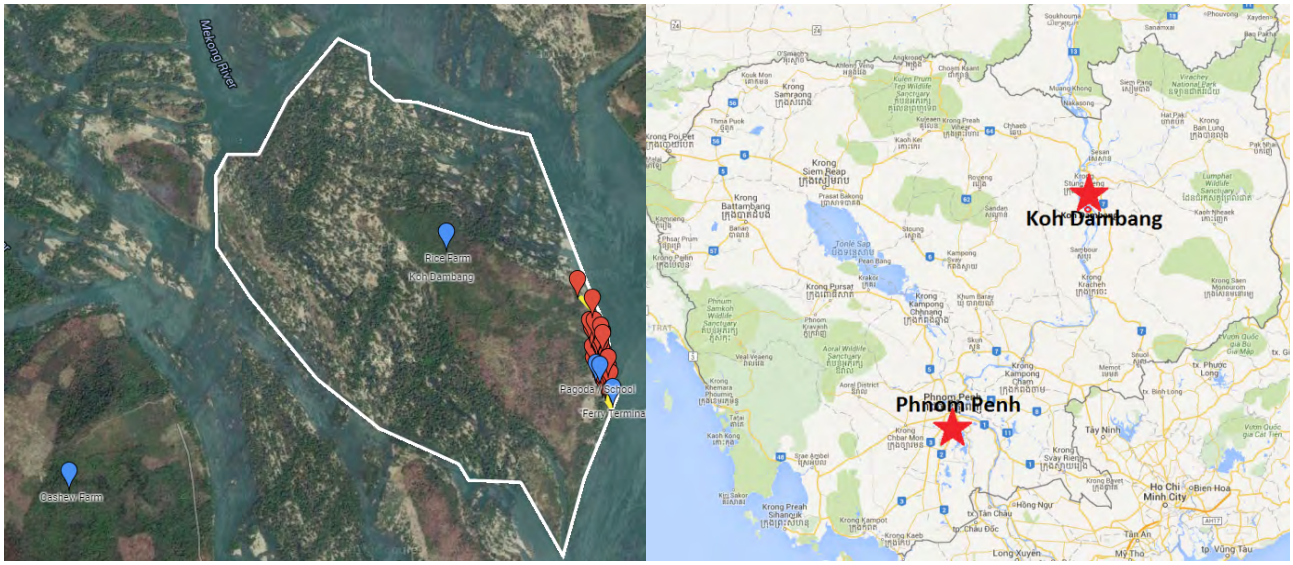

Figure 1: *The island of Koh Dambang* (*left*), *red arrows represent buildings* (21 *in total*), *and* (*right*) *the map showing Koh Dambang in relation to Phnom Penh* (*Google Maps,* 2016).

2 APPROACH

To investigate waste management in Koh Dambang a mixed-methods approach incorporating fieldwork and interviews was used. Interviews with residents captured the perspectives of Cambodians, which were supported by observations and solid waste analysis. Validity of research was examined by triangulating the three sources of data combined with existing literature, as shown in Figure 2. Fieldwork and data collection methods were developed in conjunction with Engineers Without Borders, Australia (EWB) and the AAA University and granted ethics approval.

The main fieldwork in Cambodia involved three days in Koh Dambang to engage with residents, observe current waste management practices, and understand the needs and interests of locals. The data collection methods used in Cambodia are outlined below.

Participant Questions and Conversations: Semi structured interviews on current waste management practices were conducted using the questions listed; the interviews were conducted in Khmer through a translator. Participant responses were recorded in a notebook during the interview process. All recorded information was qualitatively coded using an open coding style to identify and name common conceptual codes that emerged from participant comments. These codes were then grouped into common over-arching categories and reviewed by another member of the research team to give the framework for result analysis (Hoepfl 1997).

Photographs: Photographs were taken of waste and waste services around Koh Dambang. The photographs provided supporting visual evidence to participant responses.

Observations: General observations concerning disposal processes, behaviours, effectiveness, materials, and skills were undertaken during fieldwork to understand cultural and societal insights.

Solid Waste Composition: Observations included waste composition identification through measurements, volume estimation, participant responses to certain questions and photographs of waste.

3 RESULTS

During fieldwork in Koh Dambang, nine residents were interviewed (see Table 3). Participants were chosen based on their ability and willingness to explain their waste disposal practices, and were often senior members of their family. The categories arising from the qualitative coding are presented in Table 1, with respective sub-categories and sample comments.

Personal Roles and Responsibility: When it comes to the disposal of waste, there is no community or group based waste management system in Koh Dambang with all nine participants stating that they dispose of waste individually. Waste disposal is generally done by the female head of house with five out of the nine participants (Eoungh, Khim, Aai, Sarot and Hun) saying that they, or their wives, do the collection and disposal. The reason for this is noted by Som Aai saying 'she is in charge [of the rubbish disposal] as she is mostly at home. Husband is at work so away all day'. The other four participants said that both they and their partners help with collecting and disposing of the family's waste, with Soun Malim saying that 'she cleans or gathers rubbish. Her husband carries the rubbish to the forest to bury'.

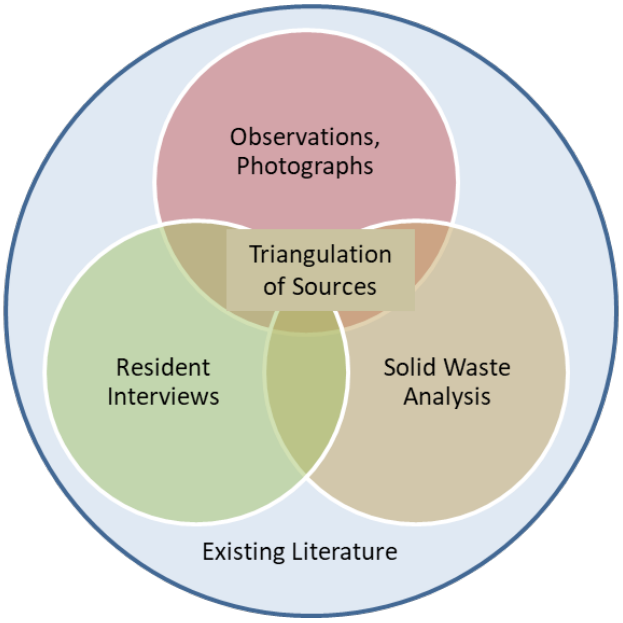

Figure 2: Triangulation of the information sources

Waste Disposal Practices: A variety of different waste disposal practices were identified including burning, dumping in the forest, and burying. Even though all participants burned at least part of their rubbish, the waste they burned varied. Five of the nine participants (Raksmey, Hun, Sreymom, Khim, and Aai) said that they burn all their combustible rubbish (paper, cardboard, plastic, textiles and dry organic matter) with Som Aai stating that she 'likes to burn rubbish behind her house'. The procedure to burn rubbish noted by Sem Hun is depicted in Figure 3.

This process of burning rubbish was visually observed when Han Sreymom swept up and placed various waste into a pile and ignited it by burning a piece of plastic or cardboard. The burn pile is shown in Figure 4a and Figure 4d. However, other community members (Eoungh, Sarot, Malum and Rai) prefer to burn just dry rubbish such as leaves and paper, with Soun Malim saying that she 'gathers dry leaves, paper, and burns'. The reason for this is stated by Elma Rai, who said she 'never burn[s] plastic bag[s] because she believes it is bad for her health'.

Table 1: Categories identified from responses from residents in Koh Dambang to the first set of questions

Categories	**Sub-categories**	**Sample responses**
Waste management	Waste disposal practices	Disposes [waste] in the forest far from house Burns rubbish every two days
	Reuse and recycling	Sells 1 kg of cans for 2,000 riel Uses bottles to store petrol or local wine
	Personal roles and responsibilities	Family individually manages their own rubbish Individual family member in charge of cleaning and disposing of rubbish
Waste characterisation	Waste composition	Separates plastic bottles, burns other useless rubbish 0.5 kg/day if just family
	Waste storage	Individuals keeps the rubbish in the bin
Barriers	Community member perceptions	Hard to convince people to dispose of rubbish properly Community wide [waste management] is hard, as different views of the importance to villagers
	Lack of alternatives	Doesn't know [any other methods], other than to bury, burn, or throw in jungle
	Disposal cooperation	Would be happy if the community wanted a [community wide waste management plan, (CWWMP])], but not sure if possible because there is little cooperation amongst villagers
	Health Considerations	Cambodian Rural Development Team (CRDT) told them about the health effects [of burning rubbish] so they burn [20 to 30 m] away from homes Never burn plastic bag because it is bad for health

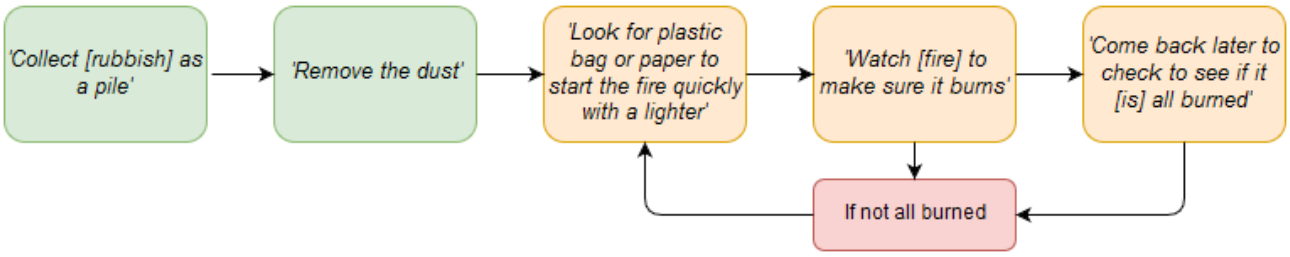

Figure 3: *Flow chart of ad hoc burn pile burning procedure* (*Hun,* 2016)

Figure 5 shows the respective approximate quantities of waste and its disposal method from responses, measurements, and observations. All participants burn some amount of rubbish, either as the primary method or secondary method (following sorting or disposal); this makes burning the most common disposal method, with burying and open dumping also remaining significant. This agrees with a comment by Kes Eoungh who said, 'everyone in the village burns rubbish'. The frequency of waste disposal varied across participants and their waste disposal behaviour. This information is summarised in Table 2.

It was found the temperature of burn piles, such as that in Figure 6, fluctuates sporadically. This is mainly due to extra combustibles such as cardboard being added onto the burn pile that ignites rapidly and intensely. Overall, the pile was mostly smouldering at temperatures around 180 to 250°C, far below the plastic and organic compound's complete combustion point of 500°C (Boettner et al. 1973) and 550 to 650°C respectively (EPA 2003).

Reuse and Recycling: It was found that most families do not separate waste into compostable and non-compostable materials due to limited individually owned crops or

Figure 4: *Clockwise from the top left*: *a*) *Han Sreymom tending to her rubbish burn pile. b*) *Plastic bottles and cans stored by a community member. c*) *A small ceramic bin containing empty drink cans. d*) *Han Sreymom and her pile of organic, plastic and cardboard waste.* (*Photographed by Creaser*).

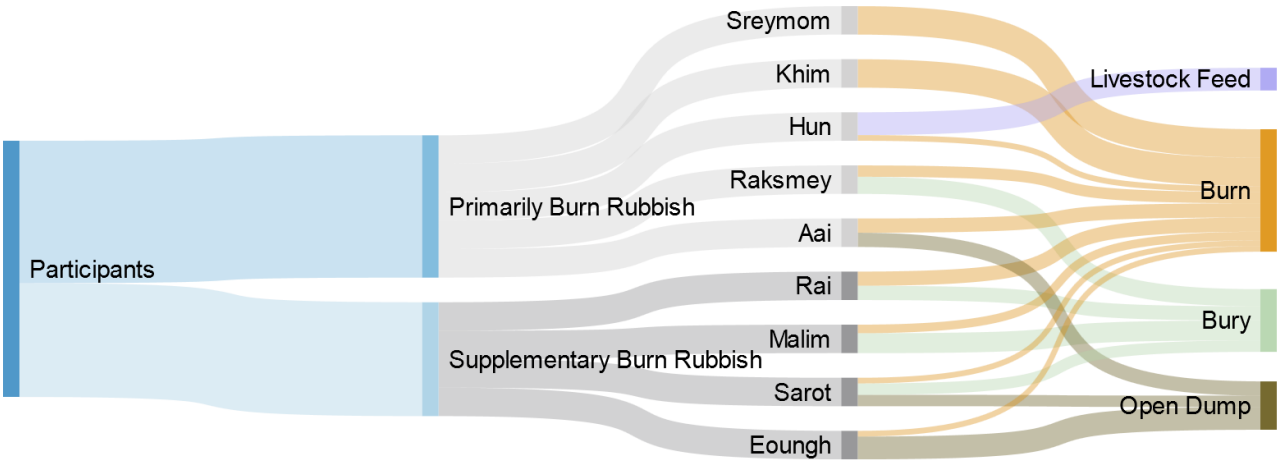

Figure 5: Sankey Diagram of the participants and their preference in waste disposal practices

Table 2: Disposal method and average frequency of disposal

Method	**Sample comment**	**Average frequency**
Burning	'every two days she disposes of rubbish by burning it'	Every three days
Dumping	'Three times a week he goes to the forest'	Every two days
Burying	'She buries rubbish once a week'	Every four days

Figure 6: Thick smoke from a small burn pile in Koh Dambang (photographed by Creaser)

incentive to do so. This is demonstrated with six of the nine participants not separating compostable waste, with Kes Eoungh saying that he has 'no time to separate and doesn't see why he should'. As for the other three participants, Elma Rai says that she 'feeds chicken with the left over organic waste' but participants like Sam Raksmey say that she 'buries vegetation waste'. Residents often separate cans to sell to informal collectors who buy and transport the recyclables to the mainland by boat. Han Sreymom said that she 'sells 1 kg of cans for 2,000 riel' the equivalent of $0.65 AUD. Other noted uses for plastic bottles were pot plants or to 'store petrol or local wine'.

Waste Composition: A day's volume of waste generated by the families of participants Sem Hun and Sam Raksmey was separated into categories and weighed. In Figure 7, a Sankey diagram shows the characterisation of Raksmey's waste along with the respective waste disposal method. Figure 7, shows that 46% of the measured waste is burned.

The amount of waste represented in Figure 7 was likely skewed due to do the inclusion of waste generated by visiting homestay participants living with the families during the fieldwork study. This would account for the discrepancy between the average waste generation rate reported by the families (0.4 kg to 1 kg of waste per day) and that observed during the study. The composition of the Raksmey family waste was observed to be similar to the other study participants.

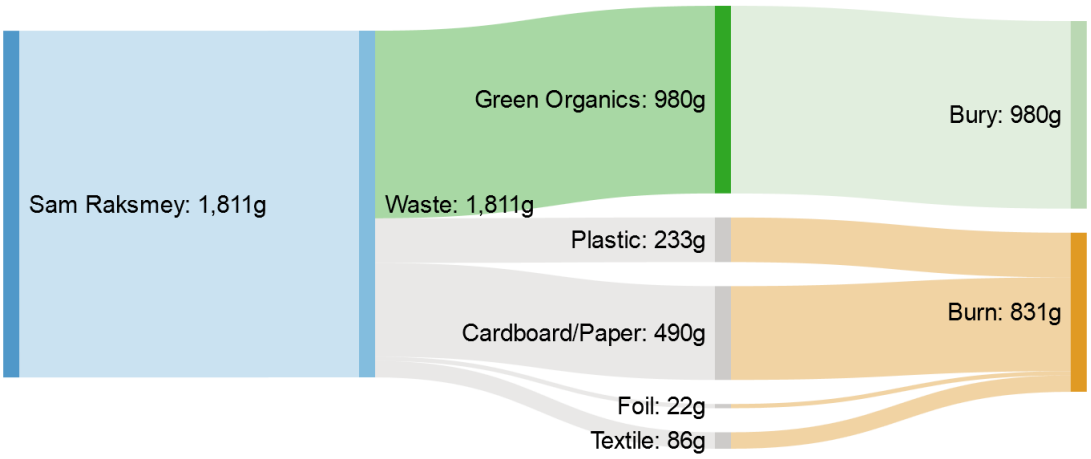

Figure 7: Waste type, weight, and disposal method of waste generated by participant Sam Raksmey's family

The Raksmey family's reported waste generation rate is comparable to other literature sources of waste generation in developing communities. Sethy et al (2014) reports a waste generation rate of 0.487 kg per capita per day for Phnom Penh in 2005, World Bank et al (2004) reported a waste generation rate of 0.3 kg per person per day for rural areas in Vietnam and 0.7 kg per person per day in urban areas in 2004. These values are however, over 10 years old.

It was observed that the residents' rubbish contained significant amounts of plastic. Two participants stated that their waste is 'mostly plastic bags' (Malim and Raksmey) with others saying that it is 'mostly plastic bag or paper boxes' (Sreymom, Sarot, and Eoungh) or 'mostly vegetable waste and plastic bags' (Rai). These comments are consistent with both Raksmey and Hun's rubbish measurements and anecdotal observations. Large quantities of plastic in the waste of Han Sreymom can be seen in Figure 4d along with green and dry organics and cardboard.

Waste Storage: All participants store waste in collection bins before disposal. Bins are either plastic bins with a lid or a simple cardboard box. Eoungh, Raksmey, and Aai stated that plastic bins are often lined with a plastic bag to contain the waste and is subsequently also disposed. The reason waste storage is practiced is due to local NGO, Cambodian Rural Development Team (CRDT), teaching residents of Koh Dambang proper waste storage for disease avoidance, as stated by CRDT worker Somboroth Dy.

4 DISCUSSION

4.1 Current Practices

It was found that for Koh Dambang, households are responsible for waste management. This matches findings from a survey of Municipal and District level administrations in Cambodia that found most agencies and district line offices believed that households should manage their waste through burying and burning. This was due to the belief that residents owned their land and hence had the resources available to handle their waste. (Muny, 2016)

There were four waste disposal streams for non-recyclable waste identified in the interviews:; burning, burying, dumping, and live-stockfeed or /re purposing. Another method identified method from literature is dumping of waste in the rivers. However, Waste dumping in rivers this is not practiced in Koh Dambang as community members believe that it is harmful to the ecosystem and unethical as the Mekong River provides support the local fishing industry and is a source of fish for food and income through a fishing industry as well as drinking water.

As shown from the burn-pile temperatures presented in Section 3, burning can occur at low-temperatures leading to dangerous particulates and gases from incomplete combustion. The extent of waste burned by participants varied due to the perceptions around health and safety. Soun Malim says that 'burying is better than burning because of the smoke' with Sem Hun also saying she 'believes that smoke causes a lot of problems to babies'. This leads to some participants burning their rubbish far away or preferring to use methods such as dumping or burying.

4.2 Alternatives Approaches

The current methods of waste disposal enact a large cost to community members both in time and physical effort. This is particularly true of the burning disposal method. Distance to dump sites, frequency of waste disposal, and the time taken to dig a hole to bury waste are all examples of cost factors associated with the current waste disposal methods.

When the community was questioned about alternative methods of waste disposal, the general consensus, as confirmed by the Chief Sa Khim, is that '[Koh Dambang] doesn't know any other methods [and] there is no transport of waste off the island'.

One alternative option is an organised community wide waste management plan (CWWMP). The idea of small-group waste management resonated with Sem Hun and Elma Rai who believe that it is 'better to do for only a small group - easier to cooperate, and discuss with like-minded people'. However, other residents saw potential issues. Kes Eough said that he 'wants [a] communal rubbish [plan], but thinks no one wants or cares about it, [and] no one will support him if he raises it'. It was expected that if a CWWMP were to work, the Chief stated that '[the community] needs an expert to come and teach them'.

As every participant's family disposes of waste individually, changing this social behaviour could be difficult. However, Han Sreymom mentioned that she disposes waste 'mostly individual[ly], but sometimes [a] neighbour helps out. If [a] neighbour's rubbish flies to her house, she will clean [it up] and vice versa', showing there is potential for communal waste management, especially in small groups who are like minded. However, further input from the residents is required to assess the options available to the community. This could consist of a survey based on the findings here to capture a more complete view of Koh Dambang residents, as well as perceived roles and responsibilities within community administration.

Options for CWWMP are burning, landfill, biogas and further recycling. With regular flooding and little available space, landfilling does not appear an appropriate option. An existing communal burning site on the rural island of Koh Pdao was noted by Ke Sarot. The burning site is a brick box, approximately one metric cube in volume (1×1×1 m), with a roof and chimney hole attached. Waste from villagers is placed inside and burned. It was implemented because 'someone in the community wanted it because Koh Pdao has a lot of tourism'. The communal contained burning example at Koh Pdao, may be a serve as a potential option for Koh Dambang, provided community support exists.

Supporting micro-businesses centered around recycling and/or waste management could be encouraged but may rely on external support which could limit their sustainability. For kitchen and garden waste management, small scale biodigesters could be utilised to generate fertiliser and biogas for cooking. However, the amount of waste generated may not be sufficient for household systems and, as with landfilling, flooding of the site can be a concern in the wet season. Further, as identified here, the majority of participants do not currently segregate organic compostable material from general waste.

External assistance for potential strategies is limited. Local NGO CRDT currently works in Koh Dambang to promote livelihood work to 'reduce poverty [and] conserve the environment' through regular visits. However, Somboroth Dy from CRDT, stated that 'waste management isn't a priority [because we are] not experts' but CRDT do 'tell impacts, provide [and] teach how to use rubbish bins, [and] raise awareness of keeping rubbish, burning it, [and] reusing [it]'. When asked if there are any other NGOs operating in the area who specialise in waste management, Dy said 'no NGO in [the] Mekong region [is] doing waste management'.

Koh Dambang is an example of the broader challenges present for solid waste management in rural Cambodia currently. As Muny (2016) highlights, within the current decentralisation policy of the National Government, responsibilities of the various administrative levels of government needs to be "further fine-tuned". Combined with the perception at District levels that households should manage their own waste, communities such as Koh Dambang may need to consider alternative options for sustainable solid waste management in at least the short and medium-term, including appropriate technologies and education programs (Vanda and Heilmann, 2015).

5 CONCLUSIONS

Increasing volumes of waste in rural Cambodia are proving difficult to manage. In these areas, it is the responsibility of individuals and households to manage their waste. Once green waste and immediately re-useable waste is removed, the majority that remains is buried, dumped or burnt. Burning, the most prominent disposal method, can be harmful, with incomplete combustion identified for small burn piles. Few community-led opportunities were identified, suggesting dedicated external support may be required to develop long-term sustainable waste management plans. However, comments from local NGO CRDT suggest that expert waste management support may be limited or non-existent within this region, despite local support by many community members for a long-term sustainable waste management plan.

6 ACKNOWLEDGEMENTS

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