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Solid waste management in tropical Asia: what can we learn from Bali?

Graeme MacRae

Abstract

Solid waste is a serious and growing problem throughout tropical Asia. Waste management technologies and policies have not kept pace with the increase in waste production. The island of Bali in Indonesia is an atypical case in which both production and awareness of waste are relatively advanced. As such it is a useful case for exploring the wider problem and possible solutions. This article reviews the current state of solid waste management in Bali. It shows that there is a fundamental tension between large-scale industrial solutions and small-scale community-based ones, but that the most successful solutions to date are at intermediate scales. It argues that the reasons for this relative success are primarily social, cultural and political ones rather than technical or economic ones.

Keywords

Indonesia, waste-to-energy, socio/cultural aspects, compost, recycling

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Introduction

Economic transformations throughout tropical Asia since the mid-twentieth century have led to corresponding ecological transformations and associated environmental and resource problems. Among these, the increasing production and consumption of manufactured and packaged goods has led to massive production of solid waste. Most countries in the region are struggling to deal with growing waste problems (Agamuthu et al. 2009, Hiramatsu et al. 2009).

In Indonesia, the most populous country in the region, per capita production of solid waste increased tenfold between 1971 and 2000 (Sutanto 2007: p. 10) but it has a poorly-developed infrastructure for waste management (Supriadi et al. 2000). The most acute problems are in the intensely populated and industrialized urban areas of Java and the resource-extraction zones of the outer islands such as Kalimantan. At the other extreme the island of Bali appears a relative haven of ricefields, forests, beaches and tourist resorts.

In reality however, Bali's ricefields and forests are rapidly being converted to urban uses, its rivers and beaches polluted with waste and behind the lush greenery and sparkling facades of resorts are less-than-ideal environmental practices (Tang 2004: p. 49). Bali's intensive tourism-driven development has led to a series of environmental contradictions, of which solid waste ideas and practices are an example.

Tourism has created a large and rapidly growing demand for new consumer products, many of them imported and packaged. It has also accelerated the development of a new middle-class with new consumption habits. At the same time, the tourism industry seeks to downplay the environmental consequences of its practices in favour of an image of timeless harmony with nature. Contemporary Balinese culture has responded to these images with a neo-traditional ideology known as *Tri Hita Karana*: an attractive but idealized notion of a tripartite harmony between humans, gods and nature (Pitana 2010). But the aesthetic tastes and environmental values of foreign tourists have also been the source of critical responses to environmental problems such as waste.

Although Bali is far from typical of tropical Asia, its condensed and intensified waste situation offers a unique laboratory that may provide insights and models capable of application in wider contexts. This article seeks first to summarize the culture and history of waste in Bali, second to review a range of approaches to dealing with waste problems, and finally to examine in detail one project which offers a mid-level solution to waste problems with potential for

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replication elsewhere in tropical Asia. At the same time it argues that both problems and solutions can only be properly understood by taking into account the integration of social, cultural and political factors with technical and economic ones.

The cultural ecology of waste in Bali

Bali is a mountainous tropical island with rich volcanic soil and abundant rainfall. The pre-human ecology consisted largely of rainforest with a coastal fringe of mangrove swamps and coconut-lined beaches. Traditional subsistence ecology was based on progressive clearing of forest for cultivation of crops, mostly rice in irrigated fields, but also maize and sweet potato. Forest products, such as coconut trees, bamboo and banana palms were used for the construction of everything from tiny ritual offerings to large architectural structures. In this culture, surplus, unused or abandoned materials were simply left where they fell. 'Waste management' consisted of periodic sweeping of organic material out of the way, to be eaten by chickens, dogs and pigs or simply to decompose. Quantities large enough to cause inconvenience or of a kind to cause ritual pollution were burnt.

At the level of cultural meanings, a dichotomy of purity/impurity is a central idiom in contemporary Balinese religious thinking. Balinese religion may be viewed as a layer of Indic (Hindu/Buddhist) ideas and practices grafted onto older system of relationships with a host of invisible beings, especially ancestors and elements of the natural world. The resulting amalgam includes a pervasive symbology of pollutions created largely by biological processes such as leakage or excretion of bodily substances or waste, sexual activity, menstruation, birth, sickness and most of all death.

Religious practice occurs ceaselessly at many levels from the household to the community and is based on the production and placement of sacrificial offerings to these beings. The aim of much ritual, especially after polluting events (such as routine birth and death, or less routine bombings or volcanic eruptions) is purification of pollutions created by such events.

While natural cycles of birth, growth, death and decay are the primary model for this symbolism, it is manifest also in many other ways, including the geography and hydrology of the island itself, with the highest levels of purity in the mountains and especially the water of natural lakes in volcanic craters. These pure waters, and those of natural springs, flow downhill in streams, rivers and irrigation channels, through ricefields and villages, collecting impurities as they go, until, laden with pollution, they reach the sea, which functions as a kind of giant *niskala* (invisible, subtle) washing machine, absorbing and transforming impurities and sending purified water back to the mountains to begin its journey again.

These symbolic associations pervade all aspects of Balinese life including production, consumption and waste.

Waste of any kind, while its ingredients may not in themselves be inherently polluting, is at best material in a state of terminal decay. At worst it may contain substances of potentially very polluting nature. The aim of traditional 'waste management', is thus primarily a matter of 'pollution management' and only secondarily of dealing with waste material. The endless sweeping at the core of traditional waste management is as much about removing sources of pollution from human contact as about getting unwanted stuff out of the way.

In the 1970s Indonesia began to enter the global economy via exports of petroleum products, imports of consumer products and tourism. Population and prosperity increased as did levels of consumption, along with demands for resources, waste and pollution problems. By the late 1980s serious waste problems began to emerge, especially in densely populated urban areas.

Bali was both typical of this pattern and a special case. While tourism is in some respects a relatively 'clean' form of development, it requires high levels of amenities and consumption to service the needs of international tourists. These include imported foods and drinks, which often come in non-bio-degradable packaging. The prosperity from tourism led to the development of a local middle class with new tastes for consumption of similarly packaged goods. This packaging quickly became the major source of inorganic waste, especially in the more prosperous and touristed areas.

Cleaning up Ubud: early attempts

Ubud is a small town and a centre of both 'traditional' culture and tourism – a perfect case study of the contradictions referred to above. In 1981 an organization called Bina Wisata, was formed by concerned locals to guide tourist development in a direction compatible with local culture. Rubbish was one of their concerns. Their first solution, together with the local council (LKMD) was to borrow a truck from the district government, collect the rubbish from the main streets and market, and dump it into a river gorge around the corner – out of sight of the main street. Despite these efforts the problem grew apace through the late 1980s and early 1990s. By 1993 it was out of control, with rubbish lining the streets faster than it could be collected, unregulated dumping and burning at the edges of town, and tourists pointing out the contradiction between image and reality (Fleischman 1994).

In 1993 a group of educated, middle-class Indonesians, mostly Balinese and some of them living in Ubud, began meeting to discuss environmental issues. They formed an organization called Yayasan Wisnu (hereafter YW), named for the Hindu deity associated with preservation and maintenance of the universe (<http://baliwww.com/wisnuenviro-works/>). Solid waste was one of their primary concerns and

one of their first projects was to address Ubud's rubbish problem (Bali Post 1993).

At this stage LKMD was still collecting and dumping, but now on a disused site at the edge of the town, so YW decided to establish a recycling facility on the spot. They obtained funding and began discussions with local government. However it transpired that the land was privately rather than publicly owned, so the project was abandoned. YW moved on to other projects elsewhere. Three subsequent waste projects in Ubud likewise foundered for a variety of reasons, mostly to do with the Byzantine factionalisms of local community politics.

We will return to Ubud, but meanwhile, this road paved with good intentions illustrates the difficulties of establishing even a relatively simple project in a relatively small and cohesive community. It also suggests that the most intractable difficulties tend to be social/political ones rather than technical or even economic ones. The next sections zoom outward from Ubud to review a range of approaches that have been tried since then elsewhere in Bali with varying degrees of success.

Jimbaran Lestari: a small-scale commercial solution for hotel wastes

After their frustration in Ubud, YW shifted their focus to the big hotels on the coast, especially the resort complex of Nusa Dua, where waste management was no better than in Ubud, with much of it simply being dumped over a cliff, into a river, on disused roadside land or even into 'protected' mangrove forest (Mariani 2007). Some hotels were selling their food waste to local pig farmers, one of whom had a small business trucking the materials, but demand fluctuated and it was not always sufficient to keep up with the hotels' production of waste. By 1995, guests were complaining about waste problems so the hotels asked YW for advice.

YW tried to educate hotel managements and their local garbage contractor about better practices, at the very least by not dumping illegally, but preferably recycling and composting. This initially fell on deaf ears, but when the InterContinental found itself with a smoke problem from burning of illegally dumped rubbish and after fruitless complaints to local government, they turned to YW. This led to meetings between YW, InterContinental and the waste contractor and subsequently the formation, by the former contractor of the enterprise known as Jimbaran Lestari (JL). YW continued to assist with management and contract negotiations.

In 1996 JL began working with three hotels (Tang 2004: p. 53) who paid for their waste to be collected. It is now collected from more than 15 hotels in Jimbaran and nearby areas and trucked to a central facility in Jimbaran where it is sorted and processed.

These premises are compact, well organized, tidy and clean. The waste is trucked in by paid contractors in separate

batches: garden waste, wet waste and dry waste. Wet and dry are dumped on opposite sides inside a big shed. Dry waste is sorted manually by (mostly Javanese) labourers employed by the middlemen who buy the recycleables for shipping back to recycling plants in Java. Wet waste is drained and solids are sold to pig farmers. Liquids are processed in a septic tank. Garden wastes are dumped in a pleasant yard behind. Wood is separated and sold as firewood. Lighter materials are composted in big piles, sprayed regularly and turned manually. The resulting compost is sold back to the hotels. Only residual unrecycleable material (30%) goes to a landfill.

JL has been a relatively successful solution, but its success appears to be dependent on a number of factors. According to a consultant to the project and long-standing member of YW (Olivier Poullion; personal communication), the most important factors are its central location and its early start in the business, but three others are added here. First it began small and although it has grown gradually, it has remained manageable in scale. Second it was based from the start on a commercial model of financial sustainability, notwithstanding significant involvement of non-governmental organizations (NGOs) and some donor funding in the early phases. Third, this commercial viability is made possible largely by a waste stream relatively rich in recycleable materials and a well-informed clientele willing and able to pay for collection. These observations in no way detract from its success, but neither do they offer any reason to assume that it would be viable on a larger scale, or that it could be replicated elsewhere.

In 2009 JL entered into a contract with the local (*kelurahan*) government to process household waste, but this initiative collapsed soon afterward in a mess of mismanagement and corruption. Since then JL have had internal problems which threatened their survival.

This is an unfortunate note on which to end this story, but two points emerge from it. First, JL provides a fairly successful model, if somewhat limited in application and second the factors which enabled its success and also the subsequent problems have been ones of politics, management, communication and corruption: human factors rather than technical or even economic ones.

TPA Suwung/Sarbagita: an industrial approach to urban waste

Denpasar is the capital city of Bali, a few kilometres inland from the main coastal tourism areas, in the centre of the highest concentration of population. It produces some 1500 m³ of waste per day, weighing some 300–450 tonnes (Tang 2004: p.53, Bakken 2005). This figure has doubled over the past couple of decades and is expected to double again in the next couple (Tang 2004: p. 49, Boediwardhana 2003). Most of this, plus more from neighbouring districts, a total of around 800 tonnes day⁻¹, is trucked and dumped

into a landfill [TPA (*tempat pembuangan akhir*)] on an area of reclaimed coastal mangrove swamp known as Suwung (Bali Post 2008). The only recycling or 'management' of any kind is a small army of scavengers (*pemulung*) who collect metals, glass, plastics and paper for recycling. The remainder rots and festers in the tropical heat, releasing the malodorous and powerful greenhouse gas methane, and it is probably already leaching contaminants into the sea.

In 2003 the governments of the three adjacent districts (*kabupaten*, Badung, Gianyar and Tabanan), joined the city administration, under the acronym *Sarbagita*, to develop an 'integrated' plan for waste management for the whole of south Bali. They obtained funding, partly from the World Bank, to construct a plant at Suwung to process all the waste from all four districts for the next 20 years (Boediwardhana 2003). The basic idea was to convert waste (of which there is too much) into energy (of which there is not enough).

Waste-to-energy is an old approach that is revived periodically in response to new problems and technologies. Its latest incarnation, the conversion of landfill gases to electricity, is now well established globally, at least in principle, but because the concept is relatively new in Indonesia, *Sarbagita* sought design ideas and tenders for a public-private partnership formed from a number of international energy companies and contractors. They chose PT Navigat Organic Energy Indonesia (NOEI), a relatively new energy company, but a subsidiary of the large Manunggal Energi Group and supported by the UK company, Organics. The technical model is known as GALFAD, an acronym for 'gasification, landfill gas and anaerobic digestion'. Essentially this means intensification of methane production, capture of this gas for burning, but also high temperature burning of dry material, and using the heat from both to drive turbines to generate electricity (NOEI 2006, GE Energy 2007). Estimated production was initially 1 MW of power, enough to power the plant itself, growing to some 10 MW, which is enough to deliver electricity to around 700 local households. In 2004 a head contract was awarded to NOEI and survey, planning and public relations work began immediately (Bakken 2005). The economic viability of the project relies also on obtaining carbon-credit funding through the clean development mechanism (CDM). In 2007, NOEI's application for CDM funding was approved based on the processing of 800 tonnes of waste per day.

Three years later, neither gasification, digestion nor electricity production have begun. NOEI and *Sarbagita* remain silent about the problems, but it is likely that an attempt to increase the CDM funding by claiming a higher volume of waste has created delays. It is likely also that there are technical and environmental problems with both the site and the technology (Bali Post 2008). Critics claim the project is fundamentally flawed from the outset; that its sheer scale is neither efficient nor environmentally safe, it involves high

transport costs, takes any profits offshore and undermines the kind of local community-based approaches they believe are more appropriate (Gies 2009).

Small-scale local solutions: Bali Fokus

Yayasan Wisnu was dissolved in 2000 and its manager Yuyun Ismawati, formed a new NGO called Bali Fokus (www.balifokus.or.id). Its mission was initially sustainable development in general but it became focused mainly on sanitation and solid waste management. Since their involvement in one of the aborted projects in Ubud, they have initiated a number of other projects, mostly processing small-scale industrial and agricultural waste materials in Bali and Eastern Indonesia. Their approach is one of training, facilitation and consultation rather than actually setting up, let alone running projects, but their philosophy is clearly oriented to local community ownership and empowerment. While they have not transformed the waste management landscape of Bali, they do represent an alternative model at the opposite end of the spectrum from the *Sarbagita* one. Interestingly though, their preferred model is anaerobic digestion to produce methane for use as a fuel – also waste-to-energy, but on a smaller scale.

Scale and technology: a fundamental contradiction

As a recent media report points out, approaches to waste in Bali are split between proponents of large-scale industrial processing made possible by overseas funding and technology, and those advocating small-scale, relatively low-tech, local community-based solutions (Gies 2009). Proponents of large-scale approaches tend to begin with technical and financial analyses of the scale of the problem itself and assume the advantages of economies of scale and thus to be able to afford more sophisticated technologies (e.g. Morton 2005, Sutanto 2007). 'Human' factors such as the social, cultural and political contexts of projects form little if any part of their analyses. Those advocating small-scale approaches on the other hand emphasize social and community aspects and question dependence on foreign money and technology, as well as the environmental side effects of large projects. As a metaphor for this they point out that the economic viability of the Suwung project is dependent on increasing rather than decreasing the volume of the waste stream; in other words expanding rather than reducing the basic problem.

The following section relates the story of a project which appears to straddle this divide, in terms of scale and technological sophistication. It was conceived as a model for replication elsewhere in Indonesia and I suggest it is worthy of serious consideration as such.

Fasilitas Temesi: Intermediate scale and technology

Back in Ubud, the waste problem never went away and by 2001 the Ubud Rotary Club had become interested in the problem. Rotary Ubud consists mostly of western expatriates, and its president was David Kuper, a retired chemical engineer from Switzerland, who was also a founding member of Bali Fokus. He had some years experience working for the Swiss government aid agency in Indonesia, so he was well-equipped with technical and management expertise as well as local experience and knowledge. In 2003 Rotary and Bali Fokus together initiated one of the projects that had failed because of local politics.

In 2004 they started again, with the help of a successful local tourism entrepreneur, who had a network of political connections throughout the district. This man is from a village called Temesi, in a poorer area east of Ubud, where the main landfill dump for the district (of Gianyar) is located. He persuaded the Temesi community and district government to agree to a pilot project to recycle part of the waste stream to the existing landfill and arranged for the necessary consents to be processed in a matter of days (rather than the usual weeks or months). Rotary had sufficient funding for a facility to handle about 4 tonnes of waste per day. This was constructed quickly and was opened in mid-2004.

It consisted of a large open shed with access for waste at one end and egress for finished products at the other. Inside was a long conveyor belt on which the rubbish was sorted manually by workers from the local village. The recycleable materials (glass, metals, paper and plastics) were separated and packaged for sale to networks of *pemulung* who transported and sold them to recycling plants in Java. Despite minor problems, social as well as technical, the system worked well, but it was limited by two factors. First it was processing only a fraction (about 4 tonne/day) of the existing waste stream (more than 50 tonne/day) and it needed to process much more to achieve the economies of scale necessary to pay for itself. Second, less than 10% of the waste stream was recycleable, whereas more than 80% was organic material, as is typical for non-urban areas in tropical Asia.

The solutions were relatively straightforward: to enlarge the facility to process at least 50 tonne day⁻¹ and to shift the focus from recycling to production of high-quality compost for sale to the growing market for use in hotel gardens, public parks and private landscaping. David, now working with another NGO, Yayasan Gus, (www.gus-bali.org) had already started research and development to improve the quality of their compost. The site and waste stream were available, but to expand the facility, they needed significant capital.

At this point carbon-credit funding began to play an increasing part in the story. David was aware of the climate change advantages of aerobic composting, but a chance

meeting with a Swiss visitor provided a contact to a Swiss travel agency (Kuoni) who were interested in offsetting their emissions through the CDM. The project reduces emissions by taking organic material out of the waste stream entering the landfill, where it would otherwise decompose anaerobically (without oxygen) producing methane (CH₄). By composting it aerobically (with oxygen) instead, it produces only carbon dioxide (CO₂), a much less powerful greenhouse gas, leading to a net reduction of emissions. David was already convinced of the superiority of aerobic compost in nutritional and hygienic terms, and his research and development was focused on achieving this by forcing air through the material during the composting process. The new knowledge about CDM added a potential funding source, technical logic and public relations bonus to the existing direction of the project.

In response to this, the project was repackaged in terms of climate change to sell their emission reductions via CDM. This repackaging included a plan to transform the site from a typical malodorous tropical landfill into a landscaped 'Climate Change Theme Park' for visitors, especially school groups.

However, to obtain CDM funding they needed to quantify and certify their reductions, make an application to the United Nations Framework Convention on Climate Change (UNFCCC), obtain approval from the appropriate government agencies in both host and sponsoring countries and find businesses to buy their reductions. Although David was able to do parts of this work himself, much was even beyond his capacity and indeed that of anyone else in Bali or perhaps even Indonesia. So, they had to hire specialist consultants in Europe to do most of the measurement, calculation, certification, applications, brokering, etc. This too was paid for out of donor funding.

Eventually all these pieces came together and in early 2008 they were certified as taking methane equivalent to nearly 77 000 tonnes of CO₂ out of the atmosphere over the following 10 years, for which they expect to earn an income of over US\$1.5 million (<http://www.kuoni.com/EN/Feature%20Stories/Pages/myclimate,%20green%20seat.aspx>). They are also pursuing less rigorously assessed and less valuable verified emission reductions (VER) of a further 60 000 tonnes of CO₂ equivalent which they estimate will be avoided after the 10-year period of certified reductions (for more detail on the climate-change aspect of the project see MacRae (2010)).

This funding is however contingent on maintaining the agreed level of production and to achieve this, they still needed to expand the facility. In mid-2008 construction was complete and an advance CDM payment in addition to further donations had been received. They were, however, still struggling to meet production targets because of difficulties finding sufficient local labour for the critical process of manual sorting. Few Balinese are willing to work with waste

because of the cultural attitudes to pollution referred to earlier. An alternative plan to employ dozens of Javanese scavengers was also complicated and delayed by local concerns about the influx of a substantial number of Muslim outsiders into their community. A year later, the labour bottleneck had been largely solved but a new obstacle was the need for more covered workspace for the additional workers. This extension was finally finished in November 2009 and by January 2010 processing had increased to an average of 55 tonnes.

Although this project is still a short of economically sustainable operation, it has achieved an extraordinary amount in a short period and represents an alternative model between the industrial-scale and community-based approaches (as well as public and private ownership models) combining some of the benefits of both. While it began with considerable input of donor funding and outside expertise, as well as government contribution, it is firmly based in a local community and is now legally owned by that community.

What works and why?

While Bali is an extraordinary case in certain respects, its waste problems are, in technical terms, essentially common to most of tropical Asia as are the range of potential solutions. The evidence presented here suggests that that waste-to-energy (WTE) is emerging as the most appropriate approach in technical and environmental terms. However, the proposed applications of WTE range from industrial-scale ones based on sophisticated imported know-how and hardware as well as overseas capital; to local-scale, community-based ones based on relatively simple technologies utilizing local materials and skills.

Notwithstanding the technological and economic logic of large-scale WTE and the social and ecological appeal of community-scale WTE, neither has so far proved feasible in Bali. Although there are many WTE schemes in design or development stages, the only ones known to be actually in operation in Bali are very small ones processing human waste or animal manure rather than rubbish-based waste materials.

The solutions that have been most successful in Bali to date have been based on methods other than WTE, but more importantly for the present purposes, they are intermediate in scale. Jimbaran Lestari is based on recycling of a range of materials, whereas Fasilitas Temesi has focused on high-quality compost. Jimbaran Lestari has been successful in funding itself commercially, whereas Temesi has relied on a combination of government subsidy, donor funding and more recently CDM.

Despite these differences, they are in technical terms variants of the same model: (a little) recycling plus (a lot of) composting. Both also have the potential to incorporate WTE should appropriate technology become available. Jimbaran Lestari is a specialized variant responding to the unusual situation of resource-rich waste and producers

willing and able to pay. While such situations are not unknown in tropical Asia, for example in other tourist resort areas or expatriate enclaves, they are not typical. Much more typical is the kind of situation which Fasilitas Temesi deals with: high organic content, little capacity to pay for collection and an existing infrastructure limited to a primitive state-owned landfill site.

The point here is not technical critique of either the WTE principle, or of methane capture or digestion technology, let alone of specific projects. The logic of such approaches seems inescapable but, despite this, to date they have simply not worked well enough, at any scale.

The projects that seem to have worked best combine recycling with composting in various mixes. While it may be tempting to interpret this evidence in terms of the technologies used, such interpretations may be misleading and lead away from the rather more complex set of non-technical factors which have enabled the projects which do work.

Both Jimbaran Lestari and Fasilitas Temesi are at scales intermediate between the industrial and community ones. Both also target fairly clearly defined waste streams which they have analysed carefully and to which they have tuned their systems. While flows of materials, energy, labour and money in and out of the projects are relatively easy to map, flows of information are less so, but it is these flows of information that have enabled both projects to work so well. These flows originate in and are embedded in human relationships which are themselves embedded in cultural contexts and social networks. The more closely these human, social and cultural dimensions are looked at, the more subtle factors become evident.

At Jimbaran Lestari, the key relationships are straightforward – between the hotels and the waste contractor (Figure 1(a)). The former want their waste removed, cleanly, reliably and efficiently whereas the latter needs to meet his costs and preferably to make a profit. Their interests are largely complementary as both have a common interest in good waste management and compost production. The role of the third party, Yayasan Wisnu, has been primarily to facilitate the primary relationships, by helping define needs and good practices and by handling some of the negotiations between parties whose worlds are in many ways very different, despite their common interests. Other, more peripheral parties include the buyers of the various products of recycling and the local government, but again these are largely straightforward one-to-one business relationships between parties with common interests (Figure 1(a)).

At Temesi, the diagram is somewhat more complex (Figure 1(b)). At a formal level the project is owned by a foundation (*yayasan*) within Temesi village, on land leased from the district government, who also support the project in other ways through various departments and offices. Temesi provides some of the labour but so also do immigrants recruited by agents. According to project documents, it is

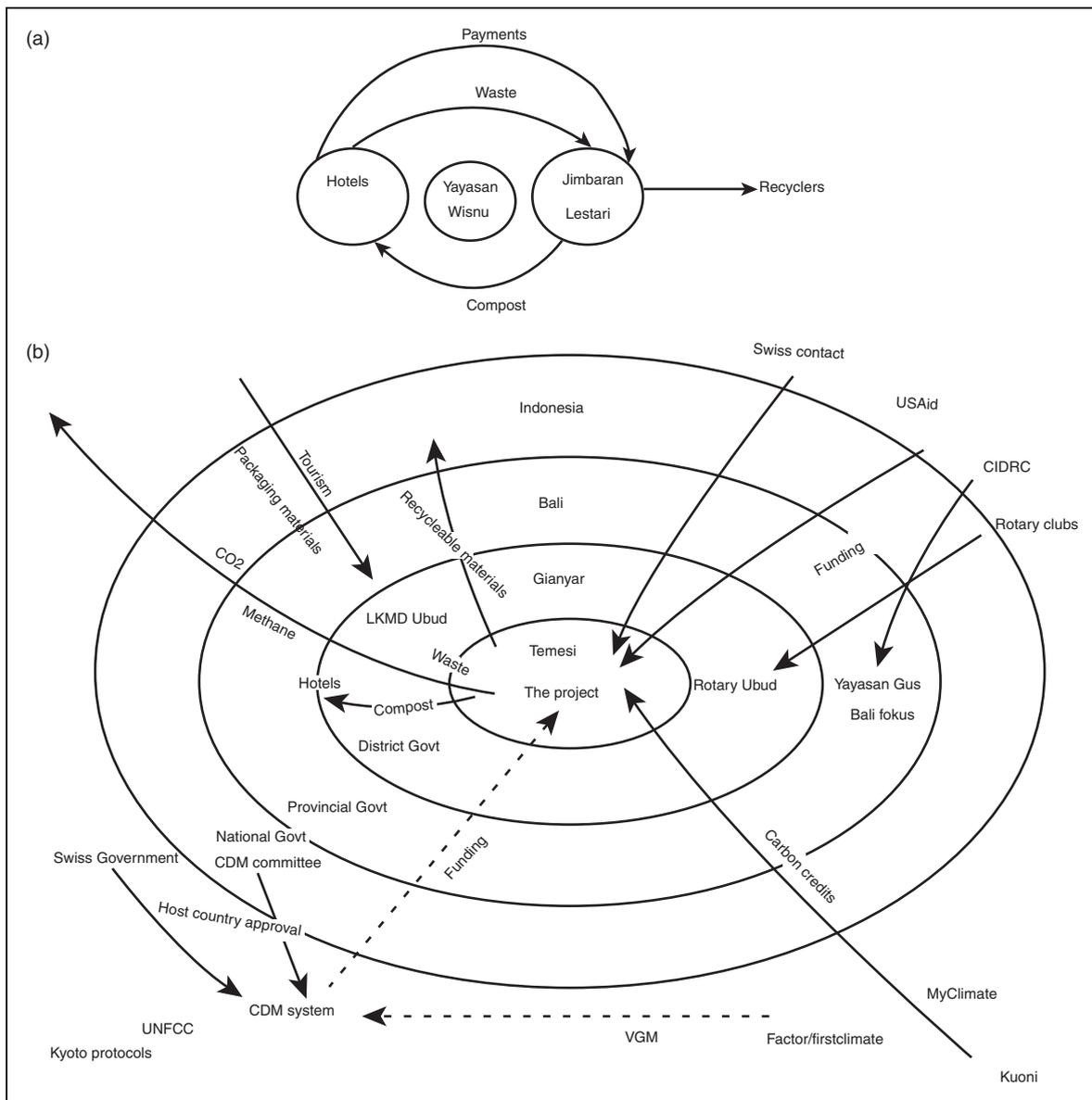


Figure 1. Diagrams of project relationships: (a) Jimbaran Lestari; (b) Fasilitas Temesi.

‘implemented’ by Yayasan Gus, with ‘support’ from Rotary. In practice this means that Gus has up till now provided most of the technical, administrative and public relations expertise and staff. This wording also obscures David Kuper’s role as the real driving force behind the project, in terms of his technical knowledge, development experience, contacts, and his extraordinary commitment and dedication to the project. Through him and to a lesser extent Yayasan Gus, there are links to networks, local, national and international, of friends, supporters, donors, agencies, consultants, and the CDM system.

Space does not permit an exhaustive analysis of the web of relationships at Temesi, let alone their embedment in the complexities of village politics, the niceties of local government procedures, cultural attitudes to dirt, labour practices and Muslim immigrants. It should, however, be clear that the

flows of information, money, carbon credits, permits, etc. at Temesi are more complex than at Jimbaran Lestari.

Conclusion

This article began with the problem of solid waste in tropical Asia – everyone has it, everyone is looking for solutions, but nobody seems to have got it entirely right yet, let alone has a standard model emerged. The evidence reviewed here, from the small but distinctive case of Bali, identifies two somewhat different models which suggest that, despite their theoretical logic, WTE approaches may not be the most viable, at least in the short term.

The two successful models are intermediate in scale between ‘industrial’ and ‘community’ models, essentially similar in technical terms, but different in economic ones.

However, it is only by shifting the analysis of them away from purely technical and economic dimensions to social and cultural ones, that it is possible to begin to understand the factors that enable their success. While these models are in themselves worthy of consideration, more importantly so also are the complex interactions of social and cultural factors with technical and economic ones which enable some projects to work better than others.

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