Waste Management 32 (2012) 2126–2133

Contents lists available at SciVerse ScienceDirect

Waste Management

journal homepage: www.elsevier.com/locate/wasman

# Determinants of sustainability in solid waste management – The Gianyar Waste Recovery Project in Indonesia

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ARTICLE INFO

*Article history:*
Received 31 August 2011
Accepted 10 January 2012
Available online 12 February 2012

*Keywords:*
Waste recovery
Project sustainability
Project assessment methods
Integrated solid waste management
Composting
Project success factors
Developing countries

ABSTRACT

According to most experts, integrated and sustainable solid waste management should not only be given top priority, but must go beyond technical aspects to include various key elements of sustainability to ensure success of any solid waste project. Aside from project sustainable impacts, the overall enabling environment is the key feature determining performance and success of an integrated and affordable solid waste system. This paper describes a project-specific approach to assess typical success or failure factors. A questionnaire-based assessment method covers issues of: (i) social mobilisation and acceptance (social element), (ii) stakeholder, legal and institutional arrangements comprising roles, responsibilities and management functions (institutional element); (iii) financial and operational requirements, as well as cost recovery mechanisms (economic element). The Gianyar Waste Recovery Project in Bali, Indonesia was analysed using this integrated assessment method. The results clearly identified chief characteristics, key factors to consider when planning country wide replication but also major barriers and obstacles which must be overcome to ensure project sustainability. The Gianyar project consists of a composting unit processing 60 tons of municipal waste per day from 500,000 inhabitants, including manual waste segregation and subsequent composting of the biodegradable organic fraction.



## 1. Introduction

Decision-makers in low- and middle-income countries are mainly confronted with rapid urbanisation and problems of dysfunctional solid waste management facilities and services. Urban policy makers and local governments therefore have to tackle this issue and find economically sustainable solutions to the urban waste problem without compromising environmental goals (Diaz et al., 2007; UN-Habitat, 2010). Integrated Solid Waste Management (ISWM) is a comprehensive approach to prevent, recycle and manage solid waste in ways that most effectively protect human health and the environment (Van de Klundert and Anschütz, 2001). This involves an appraisal of the local needs and conditions to facilitate selection of the most appropriate waste management activities to be applied in this specific context. It complements the purely technology-oriented approach as it includes: (i) waste system "elements" comprising the functional processes within the waste management stream (generation, on-site storage, collection, intermediate storage, transport, treatment, recovery & recycling, final storage), (ii) stakeholders and (iii) the dimensions of the enabling environment (environmental, social, financial, legislative, and institutional aspects) (Fig. 1). In the interaction between various forces of the enabling environment, the wide range of involved stakeholders (formal as well as informal) and the various waste systems elements, any solid waste management activity will cause an impact on the socio-economic and natural environment, be it positive or negative. This impact will alter the perceptions and interaction among stakeholders and the enabling environment.

An example for the consideration of various stakeholders in solid waste management is the role of the informal sector. These informal actors are often key in any change of waste management activities and thus should be excluded from a participatory process of planning towards upgrading of facilities or services. The enabling environment – as another element of sustainability – can be described as the set of interrelated conditions that bring about sustained and effective change (Eawag/WSSCC, 2005). Critical elements of the enabling environment should be identified at an early stage of a project (Lüthi et al., 2011). If feasible it might be necessary to also foster certain aspects (e.g. institutional support) to thus create a favourable environment for solid waste improvements. Furthermore successful projects need to be flexible in design, adaptable and operational in ways that best meet current social,

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0956-053X/$ - see front matter 
doi:10.1016/j.wasman.2012.01.011

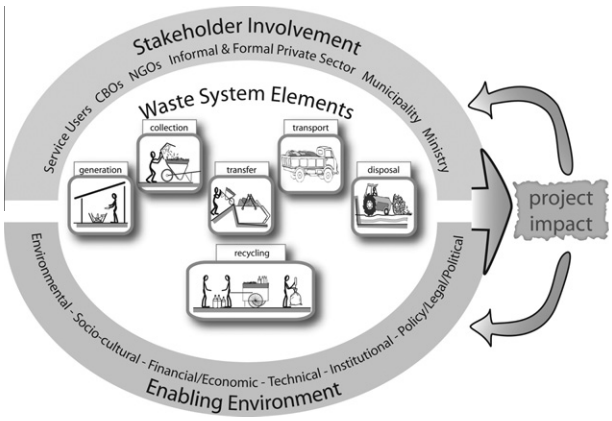


**Fig. 1.** Graphical representation of the Integrated and Sustainable Solid waste Management approach (adapted after Van de Klundert and Anschütz, 2001).

economic and environmental conditions, which are also likely to change over time and vary depending on the geographic area of the project. Since such projects must be inherently durable and robust to adapt to changing needs, they require careful planning not only at the outset of implementation, but also systematically throughout their operation. Finally, provisions for sustainable financing (covering investment, depreciation, operation &maintenance, and replacement costs) are key to ensuring a robust and reliable operation and maintenance.

### 1.1. Learning from best practice

Decision-makers are keen to learn from "success cases" to translate and apply them to their local contexts (Collivignarelli et al., 2007; Read et al., 2007; UNEP, 1996; UNEP and CalRecovery, 2005; Wagner et al., 2007). Since projects in high-income countries are often considered to be success stories, decision-makers in low-income countries strive to replicate them without paying particular attention to respective costs, required skills, education, and technical expertise. Gaining access to unbiased, well-analysed and clearly structured information is still a major challenge faced by decision-makers in developing country who are at high risk of being blinded by aggressive private sector "sales representatives". System vendors may present decision-makers with solutions containing biased information on the merit of a particular system. Decision-makers lacking a solid technical background or state-of-the-art knowledge and information are then uncertain what to believe (Predehirt & Walsh, undated). Also international or national NGOs, driven by their philanthropic approach, frequently initiate solid waste projects but know little of past experiences elsewhere and tend to thus repeat a similar learning process and make the same mistakes as others before them. To overcome this limited availability of knowledge sharing and transfer, the concept of knowledge brokerage shows an increasing trend in current sustainability discourses. A wide range of literature promotes the importance of knowledge sharing and transfer as a way of breaking down barriers that hinder sustainable development (Sheate and Partidário, 2010; Ward et al., 2009).

### 1.2. Solid waste project assessment

Yet, the question remains on how information can be assessed in a simple and rapid manner, and analysed and presented concisely to allow the respective stakeholders to make more informed decisions on how to push forward in their improvement objectives.

Traditionally, assessments of a waste facility or technology have mainly focussed on technical aspects such as plant performance in terms of service coverage, waste volume processed and associated environmental impacts. Often these elaborate on detailed analysis of mass flows technical specifications but provide limited information why the project performs as expected or not. Currently, however, experts agree that integrated and sustainable solid waste management goes far beyond the technical and environmental aspects (UNEP and CalRecovery, 2005). Drivers of success or failure can also be linked to:

- issues of social mobilisation and acceptance (social element)
- stakeholder, legal and institutional arrangements comprising roles, responsibilities, and management functions (institutional element)
- financial and operational requirements as well as cost recovery mechanisms (economic element).

Project appraisal can follow a multitude of well recognised approaches using a wide range of methods and tools. These are especially widespread in development work, where impact indicators relate to social development, poverty reduction and improved livelihoods (African Development Bank, 2003; Rietbergen-McCracken and Narayan, 1998). As regards environmental issues, the well-established and widely used Life Cycle Analysis (LCA) is often applied to solid waste projects. This technique addresses goods and services and their use of energy, materials and resources over their entire life cycle (i.e. cradle-to-grave system), including their potential environmental impacts. These particularly include energy consumption, production of solid waste and emissions of air, water or soil pollutants. Developed in the 1990s, the environmental Life Cycle Analysis (LCA) has currently reached a certain level of harmonisation and standardisation (Finnveden, 1999). Economic aspects, such as the Life Cycle Costing (LCC) method, have been integrated into the LCA to compile all costs related to a product or service over its entire life cycle, from production to use, maintenance and disposal. Social aspects were also included in recent years to evaluate social impacts (and potential impacts) that may directly affect stakeholders positively or negatively during the life cycle of a product or service (UNEP/SETAC, 2009). Yet, environmental impact assessment (environmental emissions) still remains in the centre of focus of the LCA method. Moreover, the LCA and associated methods do not reveal how product quality or project performance (i.e. success) is affected by the specific contextual conditions as summarised in Fig. 1 under the term "enabling environment".

The EU-FP7 coordination action project entitled ISSOWAMA (Integrated Sustainable Solid Waste Management in Asia) aims at developing appropriate assessment methods to improve analysis of waste management projects in Asia (www.issowama.net). The project thus addresses the issue of determining whether a project can be classified and assessed in a rapid manner and if specific factors can be identified that influence the success of various kinds of solid waste projects. This paper summarises selected project results and outputs and highlights the issues of multidisciplinary analysis and its use as a qualitative tool to improving our understanding of project success factors, drivers and impacts. It also explains the method of analysis developed and describes its application on one project example – a municipal waste composting facility in Bali, Indonesia.

## 2. Methods

The ISSOWAMA consortium developed a simplified method to assess solid waste projects through a series of questions, which will provide the basis for analysis of the "drivers of success" or "reasons of failure". The assessment questionnaire was designed jointly by all project partners and associated experts. The final questions compiled in the first version of the questionnaire are the result of an iterative exchange among all ISSOWAMA consortium members (totally 17 partners, of which 12 from the Asian region and 5 from Europe). This first version should be considered "work in progress" undergoing validation through its application in various case studies and subsequent adaptation. The first section of the assessment defines the goals of the project as is a necessary first step. The assessment then follows a guiding set of questions covering the different "sustainability elements" – which are thematic areas around issues of sustainability – which can be summarised as follows: technology, social aspects, economy, institutions, and environment. Qualitative indicators which influence project success or failure were defined using expert knowledge and overall case study experience. For each indicator one or more questions are thereafter formulated that can be answered with: "no", "rather no", "rather yes", "yes" or "not applicable" and also allow a descriptive answer (Table 1). Open questions are also included to allow respondents to raise other important aspects not covered elsewhere. Other questions assess information on project impact and typically relate to social aspects, health and environment.

The method of inquiry and data collection may differ from case to case. In general, the approach should combine a variety of research tools and methods such as:

- observations
- document analysis, comprising a systematic search for information, evidence or insight into documents directly or indirectly related to the project
- key informant interviews of selected individuals with unique knowledge/personal experience of the investigated issues
- historical analysis systematically seeking to understand the processes and events that led to a current situation or context, including methods such as historical narratives, timelines and time trend analysis, and
- interviews or focus group discussions with individual stakeholders or stakeholder groups, which may include a SWOT analysis used to understand the Strengths, Weaknesses, Opportunities, and Threats involved in a project, organisation or goal (Trochim, 2006).

The first version of the developed tool was applied to selected project cases in the Asian region and also at the Gianyar facility. In the case of the Gianyar composting unit, the assessment benefited from very comprehensive project documentation which was studied in detail. In addition to the document analysis two researchers conducted independent site visits and documented their observations following the aspects highlighted in the available questionnaire. During the first site visit, one researcher conducted semi-structured two hour interviews with three key informants. These were the initiator of the project, the chief technical officer and the marketing and communication specialist. About 4 months later the second researcher visited the site and held a semi-structured interview with the initiator of the project. Data from both researchers was compiled into one assessment as they did not differ significantly. Another six months later the first research was able to conduct an open interview with two consultants that had just recently visited the site. Their general views on success factors of this project were noted and compared to the previous assessments. The site visit, interviews, assessments and analysis were conducted in a period of approximately one year.

## 3. Introduction to the Gianyar Waste Recovery Project

Like many other developing nations, Indonesia also has to deal with major challenges in the field of solid waste management. Especially in the tourist destination of Bali, a tropical island with a population of approximately 3.9 million attracting annually over two million foreign tourists, pollution through indiscriminate dumping or dysfunctional management of solid waste can lead to detrimental impacts. These not only contaminate the environment but can also directly affect Bali's economy inherently linked to tourism and the amount of solid waste it generates. Yet, tourists also want to enjoy the Balinese pristine landscape and culture and not be disturbed visually or environmentally by mismanaged solid waste. Unfortunately, most waste is inappropriately managed and indiscriminately burned or dumped on unauthorised sites or into rivers. Concerned residents have launched campaigns to reduce the amount of garbage generated. A "Say No to Plastic" or "Bali Cantik Tanpa Plastic" initiative launched to reduce plastic waste was directed towards retailers in Ubud, a small town in the centre of the island. It offered affordable alternatives to plastic shopping bags and raised the awareness of customers about the plastic problem (Planet Mole – Indonesia in Focus, 2007).However, this commendable effort only targeted plastic, which amounts to only a small fraction of Bali's solid waste made up of more than 70% biodegradable organic material (Medina, 2009).

The ambitious Indonesia law "Number 18 of 2008 Regarding Waste Management" (Republic of Indonesia, 2008) requires all 504 regions of Indonesia to have: "Integrated waste processing sites where collection, sorting, recycling, handling and final waste processing takes place". The final waste disposal must be in sanitary landfills. The law also requires the avoidance of methane emissions from landfills. Although this law should be implemented by May 2013, the lack of funding and investment in waste management projects makes a timely implementation unlikely. However, in three out of nine regions of the province of Bali sanitary landfills exist or are currently being built. Investments are being made by the national Ministry of Public Works while the operating cost must be covered by the regional authorities.

The Gianyar Waste Recovery Project, which focuses on this biodegradable organic waste, aims at providing a sustainable system for integrated solid waste management, comprising waste separation and subsequent composting of the organic fraction. Based on a low cost, low tech and low risk approach, the project targets not only an improvement of the local situation but also likes to act as a model for replication in developing nations.

The project, launched in 2004 by the Rotary Club of Bali Ubud together with a local non-governmental organisation (NGO), Yayasan Bali Fokus, started with a small pilot plant on a 400 $m^2$ surface area. It tested and validated the operational conditions and parameters before scaling it up to a larger material recovery facility. During this time, "research & learning" was a fundamental objective and various joint research partnership projects with national and European universities were conducted to optimise the process and improve the quality of the final product while reducing its costs. In 2008, the first phase of a larger material recovery facility with a daily waste processing capacity of 30 tons of waste was completed together with another local NGO, Yayasan Gelombang Udara Segar (GUS) (translates to: Wave of Fresh Air). In the second half of 2009, the facility, was extended to handle 60 tons of waste per day, and became operational in January 2010. The now 4800 $m^2$ roofed facility allows processing of most waste collected in the Regency of Gianyar with its 500,000 inhabitants (Yayasan Pemilahan Sampah Temesi, 2009). The processing steps of the facility described in Fig. 2 include an outsourced manual separation of biodegradable and non-biodegradable waste and subsequent forced ventilated table composting step of the biodegradable fraction. After a 3–4 months composting period, the product is sieved and further matured for 1–2 months before the finished compost is sold.

**Table 1**
List of qualitative indicators and the respective questions in the assessment questionnaire.

| Indicator | Question as formulated in the questionnaire |
|---|---|
| *Technical functionality/appropriateness* | |
| Level of local skills for design and construction | Is there sufficient local availability of know-how and experience (skills) to design and build the technologies or equipment used in the case? |
| Level of local skills for operation and maintenance | Is there sufficient local availability of know-how and experience (skills) to operate and maintain the technologies or equipment used in the case? |
| Use of local materials | Is there sufficient local availability of material resources (supply of material and spare parts) for technologies or equipment used in the case? |
| Level of performance considering expected goals | Is the case and technology performing as it was designed to perform?<br>– Does the real amount of collected/treated waste correspond to the amount that was planned in the project planning document?<br>– Is the system mostly functional and in operation (e.g. down times are minimal)?<br>– Are measures taken to make the system work according to its design? |
| Level of flexibility to changing conditions (adaptability) | Can the case and its technologies easily cope with changing conditions/context?<br>– Is there sufficient availability or access to space and facilities to increase capacity?<br>– Is there sufficient availability of facilities & equipment to adapt to a changing characteristic of the waste?<br>– Do other changing conditions provide a barrier to the case and if yes what measure are taken to overcome this? |
| *Health and environmental impacts* | |
| Level of workers related health protection and health care services | Does the case safeguard workers' well-being and health?<br>– Is safety equipment and training provided to safeguard workers' health?<br>– Are measures to safeguard health used by the workers?<br>– Is health status of workers' regularly checked?<br>– Is health care and treatment provided for workers if needed? |
| Level of community related health protection | Does the case safeguard community well-being and health?<br>– Does the case take preventive measures to safeguard community health?<br>– Do hardly any accidents/diseases occur in the communities which are related to the solid waste management case?<br>– Are complaints minimal about any form of nuisance (noise, insects, rodents, malodours, etc.) caused by the case and are rectified through appropriate measures?<br>– Is serious environmental pollution (which may directly influence health of the community) avoided through appropriate measures? |
| Compliance with environmental legislation | Does the case comply with local environmental standards and regulations concerning emissions to the atmosphere, aquatic environments, soil and groundwater? |
| Compliance with perceived limits of emissions | Does the case prevent nuisances like bad smell, noise and insects? |
| Efficiency of natural resource and energy consumption | How efficient is the use of scarce natural resources and polluting energy sources? |
| Effectiveness and limitations on waste generation | Does the case pay attention to minimize waste generation?(only relevant if the case both "generates" and "handles" wastes) |
| *Costs, finances and economics* | |
| Level of cost efficiency | Does the case provide the service cost-efficiently |
| Level of cost recovery | Is cost recovery of the waste handling case functioning and sustainable?<br>– Do revenues outweigh the cost of providing the service?<br>– Are depreciation reserves to renew material/machines available?<br>– Is the dependency on time limited funding support minimal?<br>– Are beneficiaries of the service willing and able to pay the suggested tariffs to the case for the waste handling?<br>– Are sources of public funding (tax money) available to the case and provided in the long term (if required)? |
| *Social aspects* | |
| Level of social commitment | Have beneficiaries been informed about their duties towards and their benefits from the case? |
| Level of social acceptance/support | Are beneficiaries favorable to the case and support the case in different ways? |
| Level of institutional acceptance/support | Are authorities favorable to the case and support the case in different ways? |
| Level of social demand | Was the case developed through a strong community or public demand and support? |
| Level of social interaction | Do beneficiaries have the possibilities to give feedback or to complain to the management? |
| Level of social inclusion | Does the case take specific gender and child issues (of beneficiaries) into account?<br>Does the case provide equitable service (also for the poor)? |
| *Organizational strength and institutional support* | |
| Level of in-house staff skills and capacities | Have the employees, managers, operators working with the case/technology been sufficiently trained?<br>– Are operators of the system trained to guarantee smooth operation?<br>– Are employees trained to fix and maintain the equipment?<br>– Are managing staff of the case trained to guarantee smooth operation? |
| Level of influential leadership | Does the organization have a motivated, determined, technically competent and well connected (to experts, donors, government, politics) leadership? |
| Level of external knowledge sharing and exchange | Do the organization and its senior and management staff have links to knowledge centres and exchange to other specialists of the sector? |
| Level of organizational formality | Does the case study have a clear organizational and registered status (NGO, formal private enterprise, etc.)? |
| Level of employment standards | Do employee contracts conform to national and labour union recommendations (e.g. minimum salaries, work contracts, benefits, social security, insurance, etc.) |
| Level of performance and quality monitoring and evaluation | Is a monitoring system or benchmarking in place to evaluate performance of the case (audits, inspections)? |
| Level of interaction with staff and customers | Does the organisation address feedback from beneficiaries or employees effectively? |
| Level of political support | Does the case avail of political support? |
| Level of institutional support | Does the case have a well-functioning collaboration with local authorities (e.g. the municipality)? |

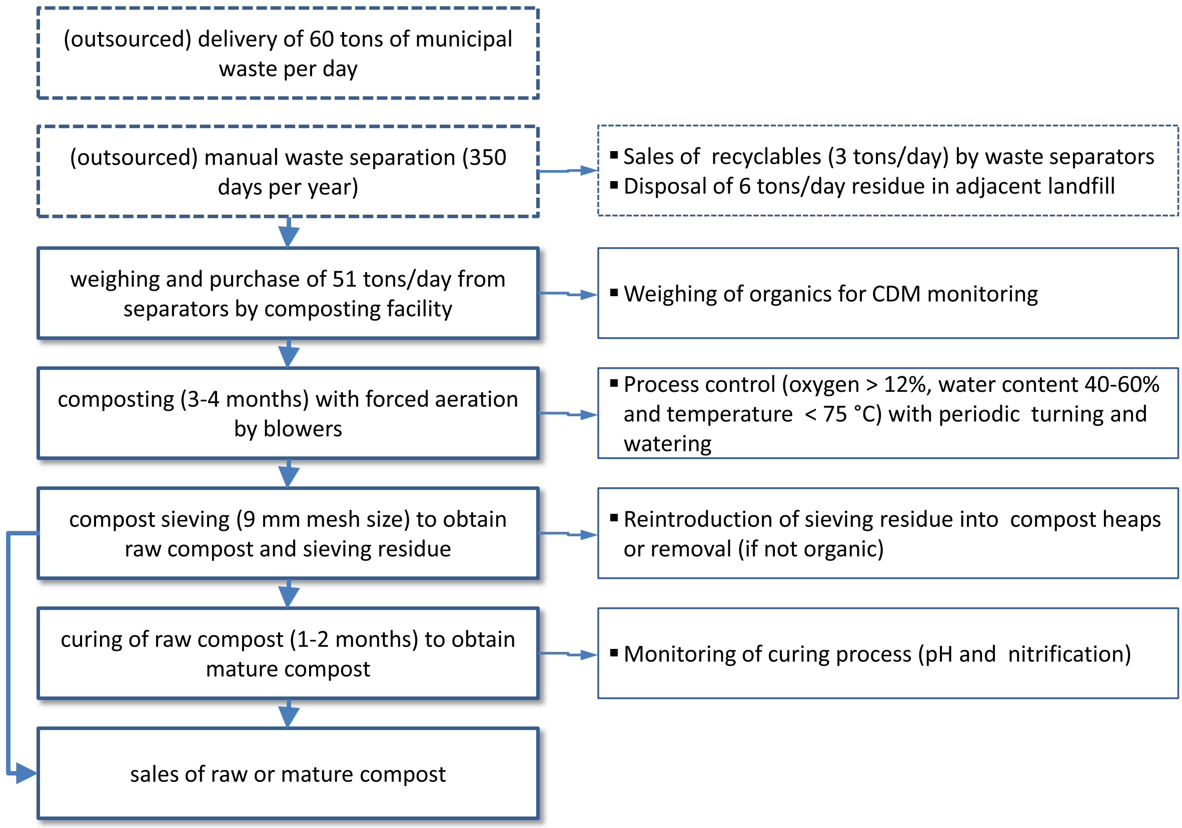


**Fig. 2.** Flow stream chart of the Gianyar waste composting facility. Tons, times and percentages are estimates. (Yayasan Pemilahan Sampah Temesi, 2009).

## 4. Success and sustainability factors

Based on the assessment protocol developed by ISSOWAMA, analysis of the Gianyar project is briefly explained in the following chapters and structured according to the elements of sustainability as listed in Table 1. A more detailed case study description is available from ISSOWAMA (2011).

### 4.1. Technical appropriateness

Project policy is to purchase only locally produced equipment, thereby reducing costs and problems associated with importing equipment, as well as allowing easy local modifications and repairs. Locally produced equipment and installations include:

- *Waste separation:* Conveyor belts have proven to be inefficient and were abandoned. Local custom is to squat while working and thus separation is carried out directly from the waste heaps deposited on the ground by the waste trucks.
- *Shredding of organics:* An improved and less energy consuming method of shredding organic waste prior to composting is being developed further by using vertical shredders and minimising abrasion of the shredder knives.
- *Turning of compost tables:* As imported systems may cost up to USD 500,000 and the project is still not availing of any local reliable solution, turning is performed by an excavator on loan from the government. Since this is not an ideal solution, negotiations are underway to obtain a wheel loader to be made available by the Ministry of Public Works in early 2011.
- *Forced aeration system and monitoring:* Radial blowers and locally constructed and very cheap butterfly valves are used to regulate airflow for each table, and a whole range of flow meters, temperature sensors and oxygen sensor tubes for research are manufactured at the facility at a fraction of the cost of a commercial product.

The Gianyar case thus adheres to the principles of appropriate technology in design, construction and maintenance by considering local expertise and if feasible local available materials. Furthermore the facility shows flexibility and has continuously adapted to the increasing waste amounts delivered. The performance of the facility is considered good also in terms of compost quality. The Indonesian National Standard SNI 19-7030-2004 (Badan Standardisasi Nasional, 2004) provides the specifications for compost from organic waste. Unlike other countries, Indonesia however does not restrict the use of the term "compost" for products of aerobic decomposition. The Gianyar compost product fulfils the Indonesian standards for all parameters (Table 2). Also the measured concentrations of heavy metals (not listed in Table 2) are far below the standards.

**Table 2**
Comparison between Indonesia standards for compost and Gianyar compost from organic waste.

| Parameter | Unit | Indonesia compost standard | Compost of Gianyar |
|---|---|---|---|
| pH | | 6.8–7.5 | 7.1 |
| C/N ratio | | 10–20 | 11.2 |
| Organic matter | % | 27–58 | 45.5 |
| Nitrogen (N) | % | >0.4 | 2.4 |
| Phosphorous ($P_2O_5$) | % | >0.1 | 1.1 |
| Potassium ($K_2O$) | % | >0.2 | 1.1 |
| Carbon | % | 9.8–32.0 | 20.8 |
| Fecal *Escherichia coli* | MPN/Gram[a] | 1000 | 0 |

[a] MPN: Most probable number.

### 4.2. Health and environment

Waste recovery and composting at Gianyar reduces by 90% the disposable waste volume. About 85% of these diverted wastes are biodegradable and thus composted, whereby 1 ton of raw biodegradable waste produces 300 kg of sellable compost. Furthermore, 5% of the waste is segregated on-site by the sorters and sold as recyclables to middlemen and subsequently to the local industrial sector. Proper control of the composting process through forced ventilation ensures aerobic conditions and avoids methane (greenhouse gas) production and odour emissions. Since the organic fraction is responsible for the organic pollution of leachate and methane generation, removal of biodegradable waste from the waste stream to be disposed of in the landfill also reduces the emissions at the landfill. Finally, the benefits of compost application on soils are well documented in literature (Rothenberger et al., 2006) increasing their organic matter content, water retention capacity and nutrient content, and providing a protection layer from erosion.

The project pays particular attention to minimising exposure of employees to dust (fine particulate matter) which as described in many studies (Harrison, 2007) may contain a predominance of spores resulting in a respiratory tract illness with compost workers. At Gianyar all labour intensive tasks like separation and sieving are located upwind from the prevailing wind direction. Furthermore, dust is minimized by keeping the composing material sufficiently wet and hygiene masks are provided to workers.

As the segregation process has been outsourced, the composting facility is no longer empowered to apply health protection measures to workers during the sorting process. Yet, sanitation and washing facilities are provided to enhance hygiene practice and gloves, hygiene masks and shoes are distributed to the workers sorting waste.

On community level there has been no incidence of health risk and nuisance. Community members are supportive of the project as it follows a period of uncontrolled dumping with severe impacts on the environment and the project has also rehabilitated the old disposal site. The Gianyar project complies with the Indonesian law "Number 18 of 2008: Regarding Waste Management" (Republic of Indonesia, 2008). No leachate leaves the composting site and given the strict control to ensure sufficient aeration odour emissions are not of concern.

### 4.3. Economic aspects

The initial investment capital of 150,000 USD to launch the project was obtained through grants. Expansion of the facility to a 60-ton plant was budgeted at approximately 180,000 USD. This high capital investment is a critical factor when developing a strategy for replication. According to the business plan, the project will become sustainable and profitable from the sale of compost. However, this has yet to be proven. Composting 51 tons of organic waste per day yields about 15 tons of compost per day that must be sold to achieve financial sustainability. However, the sale of compost poses a challenge and the sale of all the compost still presents a major challenge. Table 3 shows the project team is well aware of this situation and has increased its effort and energy on boosting the sale of compost by penetrating existing markets and addressing new outlets. Landscapers, hotels, golf courses, and reclaimed land along the seaside are typical local bulk markets. The Gianyar compost is sold for Indonesian Rupiah (IDR) 1000/kg in 20 kg bags and for IDR 500/kg as bulk (1 USD = 9000 IDR). Selling to farmers proves very difficult as the government subsidizes chemical fertilizer up to a level of 92%. The overview of the annual cost and revenues are listed in Table 3 and show an annual loss of 636 million IDR. Nevertheless the Gianyar team is confident that by 2013 they shall be able to sell the full production as:

**Table 3**
Expected yearly profit & loss statement for 2011.

| Accounting period 2011[a] | Million IDR[b] | Cost distribution |
|---|---|---|
| *Income* | | |
| Total compost revenues | 1158 | |
| *Expenses* | | |
| Personnel cost for waste separation | 576 | 32.1% |
| Personnel cost for composting | 546 | 30.4% |
| Diesel fuel (shredder, wheel loader, transport) | 122 | 6.8% |
| Electricity (lights, sieves, convey or belts) | 48 | 2.7% |
| Material (tools, equipment, safety, etc.) | 72 | 4.0% |
| Equipment service | 31 | 1.7% |
| Administration & community contributions | 37 | 2.1% |
| Sales & marketing cost | 62 | 3.5% |
| Depreciation | 300 | 16.7% |
| Total expenses | 1794 | 100.0% |
| Balance | −636 | |

[a] Months of October to December 2011 were estimated by using figures of September 2011.
[b] 1 USD = 9000 Indonesian Rupiah (IDR).

- A current state company client has been identified that produces organic fertilizer pellets and can access to fertilizer subsidies.
- Land reclamation projects are ready for greening and require large quantities of compost.
- The golf courts of Bali cover an area of 200 hectares and progressively buy more bulk compost.
- The "Bali Clean & Green" program launched by the Governor of Bali targets the replacement of all chemical fertilizers by 2013. To achieve this will require more compost than is currently produced in Bali.

To further support the financial business plan, the Gianyar project pursued registration as a Clean Development Mechanism (CDM) project (CDM registration in 2008). During ten years, the aerobic composting shall reduce greenhouse gases by 153,000 tons $CO_2$-equivalents, whereof 72,000 of these are eligible for carbon credits and become payable after verification. The fact that payments for carbon credits occur "after" verification implies that funding sources need to be obtained upfront before the carbon credits can be cashed in. The project is registered under the CDM methodology AMS-III.F. – Avoidance of methane production from biomass decay through composting, version 05 and the estimation of the baseline emissions for this methodology refer to III.G. Landfill Methane Recovery using the First Order Decay model (FOD).

To optimise cost efficiency at the facility, aside from developing appropriate equipment, the separation process was reorganised and an outsourcing (subcontracting) approach was pursued. A self-organised group of waste pickers now separate the delivered waste. Recyclables are sold by the separator to local agents and middlemen, and the composting facility buys the biodegradable organic fraction from them at an agreed price per ton.

### 4.4. Social aspects

The rather poor rural village of Temesi embraced the project as it clearly met the priority and demand of the village. Upon project implementation, the former disposal site of Temesi was restored and its environmental emissions reduced. Restoration of the problematic landfill was welcomed by the population and did not meet the usual resistance encountered when implementing waste projects. The village also benefited from the project as it provided about 150 new employment opportunities, particularly to the needy such as marginalised women. Many community meetings were held during project implementation and still continue to date. The issues vary from general information exchange and debate sessions on project progress and development to strategy development and decision making – for instance when the project decides to subcontract more waste workers for waste sorting. All interactions with the community always include the leaders of the Temesi village and their support proved to be helpful in disseminating project information to the local communities of Temesi and minimising any potential social conflicts. Also the foundation board members fulfil a similar role by conveying information in a formal way and thus prevent the spreading of rumours and conflict. The local stakeholders therefore act as a bridge between the waste facility and the local community.

### 4.5. Organisation and institutions

First experience with waste recovery projects in Bali were acquired from composting activities by Denpasar municipality (the main city of Bali) with local NGOs and from NGOs projects in 1995 on waste recovery from hotels (Medina, 2009). The initiative for a composting project in Ubud (located in the Regency of Gianyar) pursued by the Rotary Club of Bali Ubud, was systematically promoted and led by an extremely dedicated and motivated person regarded as the "driving force" of the project. The project was subsequently implemented by an NGO, the Bali Fokus Foundation. The interest in composting, the enthusiasm in optimising the management and composting processes with regard to quality of the final product while reducing its costs, and the unfailing commitment to the project are considered major factors to achieving enhanced performance and on-going success. However, even a committed individual or an NGO must adhere to administrative and legal requirements. The Gianyar (local government authority) was involved in the project at an early stage and provided administrative and legal support including the required land for the facility. This support was clearly fostered by the project team using the pilot plant as demonstration unit to show that the approach actually works and has minimal negative environmental impacts. The Regency of Gianyar and a newly established village-based foundation, the Yayasan Pemilahan Sampah Temesi (Temesi Waste Separation Foundation), took over the project in December 2008 and now manages it on a public–private basis. This foundation, which is firmly anchored in the Temesi village where the facility is located, is embedded in the village administration. A "Memorandum of Understanding" (MoU) was signed between the village of Temesi as project host, the Regency of Gianyar and the Foundation. The foundation board members maintain a valuable network, intensive exchange with institutions and also ensure continuing public relations with the residents of Temesi.

At project level, the staff is trained in quality and process control after introduction of the Quality Assurance System ISO 9000, which was a major endeavour in capacity building. The specifically drafted "Quality Manual and Operating Procedures" is available in Indonesian and used as a basis for training and continuing education. Individual research staff have benefited from special training in in-house microbiological analyses, proper use of monitoring equipment and laboratory analysis. Managerial training to facility staff is also provided.

## 5. Conclusions and outlook

The Gianyar project, comprising waste segregation and composting of biodegradable waste, is a good example of a highly integrated approach accounting for the different elements of project sustainability. Attention was paid already during the planning stage to both technical appropriateness and to involving the local authorities (regency and village).This gradually led to a more comprehensive approach and finally to an organisational involvement of these institutional actors as well as a hand over of responsibilities to the respective entities.

Since technical appropriateness was not optimal from the start, it offers potential for improvement. Yet, the assessment also revealed that the motivating factors to achieving improvement are on going and continuous.

Finding the necessary investment capital was not an easy task due to the limited "best practice" experiences required to convince prospective funders.

The dedication of a "driving force" with his/her excellent network of contacts and abilities to advocate and convince people is certainly a major factor contributing to project success and improvement. However, this issue must also be considered as a significant obstacle when planning for replication, as such individuals as main "driving forces" are not easily found and cannot be appointed but become involved for reasons of personal motivation, commitment and interest.

A still open question and unresolved challenge relates to attaining cost recovery through good marketing strategy of the compost products.

Registering the project with the Clean Development Mechanism is helpful but unfeasible due to initial cash-flow problems, since credits granted after verification are low at the start and only increase over time (due to the "avoidance of methane production from biomass" method). Furthermore, the CDM registration under the UNFCCC is regrettably very burdensome and unaffordable for many projects, even if the project qualifies for "simplified modalities and procedures for small-scale project activities".

Finally, the assessment conducted with the ISSOWAMA method reveals that this tool allows to structure data collection and analysis and to foster a more integrated assessment. Yet, scope for improving the tool has also been identified.

A clear distinction should be made between how the enabling environment influences performance and outcome of the project, and how the project impacts on the social, economic and ecological environment.

Furthermore the study was not able to determine the relative importance and contribution of each individual indicators to the success of the composting project. In a next step the questionnaire shall be complemented with a tool using the method of Analytical Hierarchy Process (AHP). This can then be used in stakeholder focus groups to determine weights of the indicators.

Finally, the questionnaire should be slightly amended to better account for development and changes over the project period to prevent a momentary snapshot assessment.

## Acknowledgements

We are grateful to all the members of the ISSOWAMA consortium for contributing to the development of this assessment tool and for allowing to collate all the wealth of shared knowledge and experience into this method. All our project partners are listed under www.issowama.net. We would especially like to thank Yayasan Pemilahan Sampah Temesi for allowing us to analyse its project and for providing all the necessary information and documentation. Moreover, the authors wish to express their gratitude to Prof. C. Collivignarelli at the research centre CeTAmb at the University of Brescia, Italy for his continuing support. Finally we thank the Swiss Agency for Development and Cooperation (SDC), the Swiss National Centre of Competence in Research (NCCR) North-South, the Swiss Federal Institute of Aquatic Science and

Technology (Eawag) and the EU-FP7 for financial backing of the project.

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