# Lessons Learned by the Gianyar Waste Recovery Project

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## Introduction

The Gianyar Waste Recovery Project was started in 2004. Since 2008 it processes 50 tons of waste per day, 7 days a week. Organic waste (85 %) is processed into compost. Suitable waste (5 %) is recycled and the residue (10 %) is deposited in the adjacent managed landfill. The percentage for recycled waste is so small, because scavengers remove most valuable recycles from waste before it reaches the Gianyar facility. The original amount of organics in waste is in the 70 to 80 % range.

Composting is not rocket science and operating a waste recovery facility requires only common sense. The only challenge is fulfilling the complicated CDM requirements (see 3.2.).

The crux in establishing successive waste recovery lies in the logistics and marketing. Unfavorable logistics lead to illegal dumping and the pollution in developing countries is proof of this. Therefore, in these lessons learned, special emphasis is given to logistics and optimal facility size.

## 1. Logistics issues

The logistics are the most crucial element to make a solid waste management project successful. To be successful a waste recovery project must contribute to a visible reduction of environmental pollution in the area it covers. In the Gianyar Waste Recovery Project, the most important lesson learned concerns logistics. In this document, logistics include the location and the ideal number of waste recovery facilities in relation to managed landfills, which are interdependent.

There are many viable design and operational options and, if mistakes are made, they usually can easily be remedied. However, when the design of the project logistics is flawed and investments for waste recovery facilities are made at the wrong location, corrections are expensive and not always possible. In other words, logistics must be right from the beginning, which requires careful planning.

There is an economic and a compliance component in logistics, both are equally important:

### 1.1. Economics of waste transport

Waste trucks should be able to achieve at least two rounds per day. This is only possible with short distances between the collection points and the waste recovery facility/facilities. Long distances require more trucks and generate more operating cost. They are also create a motivation to "cut corners" as explained below in paragraph 1.3. A one way trip should not exceed 30 minutes.

Waste collection, processing and deposition in managed landfills are the duty of the Sanitation and Park Service (Dinas Kebersihan dan Pertamanan or DKP) in each region (Kabupaten) or municipality. It is regulated by Law 18 of 2008 regarding Waste Management that also promotes the 3 RE.

### 1.2. Compliance with waste transport

When the distance between the collection points and waste recovery facilities is too far, there is a high risk that the waste is dumped in nearby illegal unmanaged landfills. Unfortunately, this kind of hazardous waste dumping is an undisputable fact in developing countries. The reasons for not complying are saving time and fuel cost. As law enforcement is low and sanctions are not efficient, the only remedy is a pragmatic approach of eliminating the incentives for illegal dumping.

The lack of concern for the environment of the population contributes also to a low compliance. Even the Balinese government has a very low priority of environmental protection in spite of the complaints of tourists and the considerable dependence on the tourism income. Its priorities are:

1. Assure stable macroeconomics
2. Increase investments for development of education, health and economy
3. Increase the poor population's share in the economic development
4. Assure preservation of religion and culture
5. Preservation of the environment

(from RAD-GRK Provinsi Bali – 2012 or Regional action plan for climate change mitigation)

### 1.3. Illegal waste dumping

To have a truly comprehensive solid waste management system, the rampant illegal waste dumping in most developing countries must be addressed. There are two reasons for illegal waste dumping:

The first factor is illegal dumping by individuals over the fence or into the next waterway due to the lack of a collection network that covers also houses in small alleys. Often waste is only collected where there is access for dump trucks. This needs an improvement of the collection infrastructure by the government as it is beyond the capabilities of most non-governmental waste projects.

The second factor is the large scale illegal dumping by governmental and private waste trucks. If the distance to the waste recovery or landfill facility becomes too big, waste will be disposed in illegal locations to save money and time, both for the personal benefit of the waste collectors.

Illegal waste dump sites near Gianyar and Denpasar in Bali, Indonesia

Illegal dumping in mangrove forest. The tidal hub pollutes the sea

A valley being filled with illegally dumped waste within our project area

1.4. Designing "compelling logistics"

The illegal waste dumping is best addressed by designing "compelling logistics". Crucial for such compelling logistics are short distances between the waste collection and the waste recovery facility.

This is best accomplished by having a sufficient number of decentralized smaller waste recovery facilities or "satellites" instead of only a large one at the site of the managed landfill. To avoid illegal dumping, the delivery time to such decentralized facilities should not exceed 15 minutes. The increasingly popular local Waste Banks (Bank Sampah) are a good option. In these local Waste Banks that serve a neighborhood or at most a village, recyclable material is readied for sale and the organic fraction is composted as in a large centralized facility. The waste separation must be finished daily to avoid unpleasant emissions. The 10 % residue is best collected by landfill based trucks, preventing illegal dumping. Because of the short distances and with only residues having to be transported to the managed landfill, considerable cost savings are achieved. For more details about ""Waste Banks" refer to paragraph 2.3 below or section "Waste Banks" on the project's website: www.temesirecycling.com

There are no significant economies of scale in building large waste recovery facilities. On the opposite, they create significant challenges while decentralized facilities offer win-win situations (see below). Choosing decentralized waste recovery facilities is not more expensive. \

Only one central managed landfill for one or even for several Indonesian regions (Kabupaten) is necessary as the waste is reduced to only 10 % residue (about 500,000 people lives in a region). Contrary to waste recovery facilities, building managed landfills offer sizeable economies of scale.

Short distances between waste collection points and decentralized waste recovery facilities (e.g. a Waste Bank) provide win-win situations:

- Short distances avoid illegal dumping and reduce logistic cost
- Small decentralized facilities cause less public resistance than big ones
- Villages with waste recovery facilities will take ownership of them
- Decentralized facilities create peer pressure which reduces individual illegal dumping
- Easier compost sales to local customers with little transport cost while large compost orders can be consolidated with other facilities

**In view of above reasoning, a decision to have only one central waste recovery facility should only be taken, if all mentioned adverse factors do not exist or can be neutralized.**

## 2. Centralized or decentralized solutions?

### 2.1. A missed chance of the Gianyar Waste Recovery Project

The importance of logistics was not realized during the project planning and implementation. We reasoned that one centralized waste recovery facility next to the official managed landfill of the region of Gianyar (our project area) would be the ideal solution. However, several illegal waste dumping sites within our project boundaries prove the opposite. The reason for the existence of these illegal sites is the long delivery time. The rational of the waste truck crews is: "Why should we drive 30 or more minutes, if we can dump the waste easily after a 10 minute drive?" They might even get money from the scavengers working on the illegal dump instead of paying a tipping fee.

If we could redesign the Gianyar Waste Recovery Project, we would create at least 12 decentralized waste recovery facilities which can be reached by the waste trucks in no more than 15 minutes. There the waste would be separate and the organics be composted. The 10 % residue would be collected by trucks of the managed landfill.

### 2.2. What is the ideal size for a waste recovery facility?

There is no ideal size. The size of each facility is determined by the amount of waste that can be collected in an area where the distance between the closest waste collection points and the waste recovery facility does not to exceed 15 minutes. Another consideration is feasibility. Often the top down approach is politically not feasible or too slow. Usually bottom up approaches are easier to implement. There are many success stories of such small scale "satellite" waste recovery and composting facilities in neighborhoods or villages (dusun/banjar or villages) driven by committed personalities.

### 2.3. Waste Banks (Bank Sampah)

Waste Banks are a new concept for waste management and a very good one. They offer many win-win situations and one would be hard pressed to find arguments against them. They are mushrooming all over Indonesia, because they are easy and cheap to implement. In only a few years over 10,000 Waste Banks opened in Indonesia by 2014, based on private initiative and ownership.

The Ministry of Environment of Indonesia promotes Waste Banks as the new strategic program. According to the ministry, garbage management with a lot of positive impacts through the Waste Bank development program is inseparable from the participation of people, especially from the informal sector on grassroots level.

Waste Banks are set up in neighborhoods typically for about 1000 residents and are usually run by poorer people who wish to increase their income. Bank customers bring all non-organic waste to the banks where it is treated like a deposit. Transactions are recorded preferably in a bank book that the customer holds or alternatively in lists kept by the bank. Many banks also accept organic waste while the rest promotes composting at home. The Waste Banks sell the deposited material to mobile agents for reuse or recycling. Thus the waste deposits are transformed into money that can be withdrawn when needed after a contribution of about 15 % is deducted for the bank's operating costs.

For more details about ""Waste Banks" refer to the section "Waste Banks" on the project's website: [www.temesirecycling.com](http://www.temesirecycling.com)

## 3. Economic issues

### 3.1. Separation at source

About 70 % of all the people working in the facility separate waste, which accounts for about 42% of all operating cost. Separating waste is outsourced for reasons explained below. Further 34 % are for our own staff and 24 % for other expenses like energy etc. With the high cost of separating waste it would be highly desirable that waste is separated at source i.e. at household, hotel, institutional etc. level. This would cut the operating cost by 42 % and improve the financial situation significantly.

Already during the pilot plant phase, when we separated only 2 tons of waste per day, efficiency problems became evident when the waste separators received a fixed salary. Efficient and diligent workers adapted quickly to the pace of lazy workers, because there was no incentive to work hard. A trial with a bonus system was quickly abandoned, because perceived (and maybe real) injustice created unrest.

The solution was outsourcing the waste separation. The facility purchases the separated organic fraction at a fixed price from the waste separators, who can sell the separated recyclables on their own account to several onsite agents. The competing agents guarantee the waste separators a fair price. The combined income from selling organic waste and recyclables assures even less efficient waste separators the legal minimal salary. This system rewards efficient workers and relieves the facility from many management and administrative tasks. It also turns financially undesirable fixed costs into variable costs.

### 3.2. CDM carbon credits

Indonesian greenhouse gas reduction projects can register under the Clean Development Mechanisms (CDM) of the UNFCCC or the local equivalent, the Nusantara Carbon Scheme (NCS) of the National Council on Climate Change of Indonesia (Dewan Nasional Perubahan Iklim or DNPI). Both systems allow bundling, if decentralized waste separation and composting is chosen (see 3.4.). A new mechanism has been launched by a Japanese – Indonesian partnership called Joint Crediting Mechanism (JCM) that offers simplified procedures. This is necessary because Indonesia as the fourth most populous country hosted only 2 % of all worldwide CDM projects by 2014.

Due to the stringent requirements to obtain carbon credits under the CDM scheme it is important, project employees and not the outsourcees control the entire composting process from weighing the organic fraction to the sale of compost. If carbon credits are sought, it is strongly recommended to introduce a quality control system. Our ISO 9000 type quality system has helped us to pass the stringent CDM verifications without undue problems. Our project was registered with a crediting period of 10 years from November 4, 2008 to November 3, 2018.

### 3.3. Financial sustainability

The project was very lucky to find a buyer for its greenhouse gas reductions that pays a far higher price per certified emission reduction (CER) than the average price in the voluntary CDM market. Without this generous compensation by a company who likes the project, it would presently not be possible to cover the 68 % operational loss as described below.

The reason is that the project has no access to the largest market, the rice farmers, because they can buy chemical fertilizers that receive up to 90 % subsidies to keep the rice price low. Without this market, the project so far is not able to sell all compost it produces, which would be prerequisite for sustainability without CDM compensations. We are in process to obtain the necessary licenses to compete for subsidies, but even with them increased sales are not guaranteed. However, opening the farmer’s market is a necessity to replace the CDM carbon credits which cease after the last payment in 2019.

The Temesi Profit & loss statement:

| Average per month cost (average Jan 2015 - Jun 2016) | Million Rupiah per month | Percentage |
|---|---|---|
| Operating cost | | |
| Separating waste (outsourced) | 50 | 42% |
| Employee salaries | 37 | 31% |
| Other costs | 33 | 27% |
| Total | 120 | 100% |
| Income | | |
| Compost sales | 38 | 32% |
| Loss | 82 | 68% |
| | | |
| CDM subsidies until 20) | 82 | 68% |
| Recyclables are part of salary of waste separators | | |

Separating the incoming waste burdens the operating cost with 42 %. Thus, separation at source would save the project 42 % and allow a lower selling price for compost.

Compost sales cover only 32 % of our operating cost. Thus we incur a loss of 68 %. Until the end of 2019, the reduction of greenhouse gases under the Clean Development Mechanisms of the UNFCCC generates enough income to pay for this loss. As mentioned above, compost sales are low because our compost cannot compete with fertilizers that are subsidized up to 90 % for rice farmers. This leaves us with private customers and landscapers. Because the compost sales are so low we accumulated an inventory 2000 tons of compost by 2016.

This situation is not sustainable. For this project and other similar projects to become sustainable:

- Composting facilities must have a level playing field with competitors. This means same subsidies for all or no subsidies for all.
- Waste must be separated at source.

Therefore it is important to plan cost considerations early in the project implementation. This includes early pushing for separation at source and put emphasis on compost sales after the implementation. Also early in the project cycle, possibilities should be explored to obtain subsidies and thus get access to the large rice farming market.

### 3.4. Compost supply and demand considerations

In 2016 it is estimated that Indonesia generates 65 million tons of organic waste per year that emit huge amounts of the greenhouse gas methane in landfills, equivalent to 3 million tons of methane. The methane from landfills amount to 11 % of Indonesia's greenhouse gas emissions (or even 21 % if forest fire and peat emissions are not taken into account).

With a collection rate of about 50 % or 32.5 million tons, potentially 12 million tons of compost can be produced.Compost as fertilizer is a very beneficial product for rice farming and was already so before the 1970s. Since then, a heavy use of chemical fertilizers was promoted by the government to boost rice production. Compost contains beneficial organisms and minerals that restore depleted soils. Pesticides whose use increased 30-fold from 1998 to 2008 and chemical fertilizers killed beneficial insects, spiders as well as pathogens. Nowadays, the brown plant hopper and the stunt viruses it spreads lack natural predators are responsible for increasing catastrophic harvest failures.

Chemical fertilizers are sold as granules and farmers like this easy to handle application form. The amorphous texture of compost has a competitive disadvantage. However, compost can be formulated into granules with water and the use of a 4 mm sieve and a disk fertilizer granulating machine that can be locally manufactured for less than 1,000 USD.

### 3.5. An important role for international donors

With 90 % subsidies for chemical fertilizers, it is impossible to successfully sell large amounts of compost to rice farmers, which represents by far the biggest market in Indonesia. To take advantage of this potential, there must an equal opportunity, i.e. similar prices or subsidies.

Equal opportunity can only be pushed in a concerted action by all waste projects in Indonesia, led by donors for waste projects (like KfW and SECO). There best possibility is to include a "conditionality clause" in contracts with the government – or amend contracts accordingly – that requests a level playing field.

**Without a level playing field, all larger waste projects yielding compost or soil conditioners form biogas production will inevitably fail.**

## 4. Research in to composting and alternative decomposing methods

### 4.1. Research conducted

Cooperation with the Swiss Institute of Technology in Zurich and other academic institutions as well as with large scale Swiss composting facilities significantly improved the quality and result of the R&D carried out since 2004. The cooperation consisted of mutual visits and the fielding of students, who did their thesis in the research facility, which also comprises an analytical laboratory.

Extensive research with over 100 research batches was conducted in the research facility. Besides research on compost, the project also investigated the feasibility of using organic waste for the production of biogas or proteins with the black soldier fly larvae as well as vermiculture and silage making. The research has shown that composting is most likely the only viable method to process large quantities of organic waste with the prevailing waste. Biogas, vermiculture, larvae protein processes are hardly viable with the waste mix we receive in Temesi, because of its low content of high nitrogen and easily digestible kitchen waste. Silage making yields only second rate feed stock.

Specific research topics were assessing the permissible range of C/N ratio; the (un)usefulness of commercial inoculants (starters) like EM; the necessity of a roof over the decomposing organics; decomposition speed; impact of shredding; impact of temperature and humidity; influence of the prevailing salt content; suitability of composting food processing residues; plus other parameters of interest.

### 4.2. Composting

In the Gianyar Waste Recovery Project, compost production has the highest potential profitability. The monitoring during composting should focus on oxygen and water content. The temperature is not easy to control and may exceed 80 centigrade in large piles, more than the desirable 65 to 70 centigrade. This is not optimal for the quality but unavoidable in large composting piles. The advantage is that the resulting compost is guaranteed free of pathogens, insect eggs and weed seeds, an advantage for most applications. At 80 centigrade plus, we suspect some chemical oxidation. We call it cold combustion or caramelization. This changes somewhat the texture of compost.

The desirable water content of 40 to 60 % is controlled by strongly pressing the processing material in the fist. If more than a few drops can be pressed out, the water content is too high and if the hand stays more or less dry, it is too low. Forced aeration removes a considerable amount of humidity so that turning and watering is required about every 2 weeks.

The oxygen should be kept at least at 6 %. It is important that the sensor of the oxygen meter has an acid medium to avoid neutralization by carbon dioxide. Greisinger electronic www.greisinger.de , is one of the few companies that sells sensors with an acid medium. To regulate the airflow, the project had simple butterfly valves constructed by the local supplier of the aeration ducts.

In literature much attention is given to the C/N ratio. However, in large scale composing of organic solid waste adjusting this ratio is not feasible. Research with additions of urea for nitrogen or saw dust for carbon did not yield a significant difference.

All essential microorganisms needed for composting are already in the waste and the composting process stars on its own. Our research has clearly proven that starters - also called inoculants - like activated EM1, EM4 and other magic broths have no influence on composting whatsoever.

### 4.3. Beyond compost – are there other feasible decomposition methods?

The waste collected in Denpasar and the more rural region of Gianyar contain both over 85 % of organic waste. The percentage of food remains is low, while the content of garden and other organic waste is high. The tropical organic waste is very different from waste in developed countries with a moderate climate.

Composting is a very viable method for processing organic waste. This is not without reason as the results from 10 years research station have shown. About 100 batches that tested composting and other decomposition methods revealed significant weaknesses in alternative decomposition methods. Even composting takes longer than normal in Indonesia due to slow decomposing components like palm leaves. All other alternative decomposition methods are less feasible due to the unfavorable waste composition that decomposes slowly, has a deficiency of high nitrogen compounds or, last but not least, requires high investments per ton processed. High nitrogen compounds like food remains are crucial for all alternative decomposition methods.

- Biogas generation from organic waste in developing countries is problematic in spite of the higher temperatures. The natural decay with a regressive decomposition rate yields a process that can take 60 years. Efficient industrial methods like KOMPOGAS are very expensive and would be a maintenance nightmare in developing countries. However, the uncomplicated BEKON method might be a viable alternative.
- Silage making does work well with selected components like the common elephant grass and banana leaves and stems. Other leave and especially palm leave silage were shunned by cows.
- Vermiculture and protein production with the larvae of the black solder fly work well with household waste. However they are problematic with mixed organic waste and scaling up such processes to over 1 ton per day is extremely difficult.

## 5 Design issues

A low cost, low risk and low tech facility was deemed to be the appropriate approach for a developing country. A high tech facility would have led to maintenance and spare part problems.

### 5.1. Facility layout

When planning the facility layout, care should be taken that the waste separation area is on the side where the prevailing winds come from in order to expose workers as little as possible to the emissions of the composting piles, although they are small and harmless.

Aerated composting hardly smells and if the water content is kept above 40% no dust will be emitted. Composting dust is a potential health hazard and masks should be worn if exposed to dust, e.g. during turning.

## 5.2. Table composting

Due to lack of space, capital and the assumption that the composting process has to be protected from tropical rain, we have chosen table composting under a roof. Table composting allows processing a maximum amount of organics on a given area. Windrow composting has at best only half the capacity of table composting. See Annex 1 for a schematic presentation of table composting.

## 5.3. Facility surface

A promise of the project to the local population was to restore the unmanaged landfill of the Gianyar Regency in Temesi, which was plagued by unpleasant and hazardous emissions. This was achieved by covering the old landfill with soil and building the waste recovery facility on top of it. However, a surface that is not solid like as example a concrete slab poses operational problems:

First decomposing organic waste is very dense and interlaced, making it hard for front loaders to scoop it up unless its teeth can be inserted on a solid surface below the organics. Because of our soft surface, the facility has to use a more expensive excavator for the necessary periodic turning of the composting piles.

Second, because we have up to 4 meter high composting piles, forced aeration is required. The easiest way to accomplish this is with screen covered channels in a concrete slabs that allow not only aeration, but also collecting the leachate. The leachate can be collected in a closed tank or led through a 30 cm U-trap in an open tank (the backpressure of forced aeration usually does not exceed 20 cm water column). On our soil covered landfill we had to resort to wooden racks as plastic pipes collapsed due to the weight of the piles and generated heat of up to 80 centigrade.

## 5.4. Facility roof

Because of the rainy season in our tropical area, it was deemed necessary to cover the whole facility with a 5000 square meter roof, which was the most expensive investment besides the excavator. However, preliminary tests runs with composting in the open during the rainy season as it is usually done in Europe and the USA, showed no detrimental influence on quality or processing time. This indicates that only the waste separation, sieving and finished compost areas need to be covered, which require only about half the roof size. However, further tests runs are recommended before designing open composting.

## 5.5. Shredders

Our research has shown that palm leaves are the slowest decomposing fraction of the incoming organic waste. The composting process is only finished when these palm leaves are decomposed. Bali waste contains a lot of palm leaves in the form of Hindu offerings. Shredding of palm leaves hardly increases the surface that is exposed to decomposing microorganisms. First we reduced shredding to coarse material and later altogether ceased to shred as it was a major cost factor and did not shorten the processing time. Wooden waste is used by employees for fire making.

## 5.6. Compost sieves

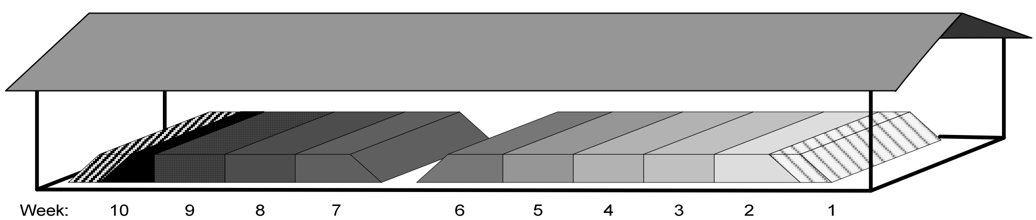
In Europe mesh sizes of 2.5 or 4.0 cm are usually chosen for compost bulk use. Our facility uses only 0.9 cm mesh size, which is also suitable for nursery applications. To produce granules, 0.5 cm sieves are used. Granules are the preferred application form of rice farmers who do not like the amorphous compost. The sieve residue consists of particles that are not completely decomposed and of non-organic impurities like small plastic that were too time consuming to remove during the separation process. Depending on the amount of non-organics, the sieve residue can be added to the beginning of the process or better finished separately to avoid a buildup of the non-organic compounds.

## 5.7. Forced aeration

Reducing back pressure and thus operating costs is essential for a low cost operation. Therefore the air delivery ducts should be dimensioned to have air speeds below 20 km/hour. It is important to use radial (centrifugal) blowers which can build up pressure when the resistance (backpressure) increases. Axial blowers cannot build up pressure when the backpressure increases. Instead their airflow to the compost piles decreases due to a back surge (reversed airflow at the outside of the rotor blades). Forced aeration warrants aerobic conditions and avoids the unpleasant odors that would develop with an anaerobic decomposition of organics.

Adjusting the airflow is essential in forced aeration composting. The project developed flow meters for a wide range of air flow that can be manufactured and calibrated locally at about 3 % of the cost of imports. To adjust the airflow, the project developed very low cost butterfly valves that cost a fraction of commercial valves.

## Annex 1: Table composting




Schematic depiction of turning table composting piles. Aeration is effected by lateral perforated pipes.
- In this schematic depiction (above after turn 4), the shrinking volume is not taken into account.
- The number of turns can be adjusted by increasing or decreasing the amount of turned material.