Final Report

Resource Augmentation by Tapping Renewable Resource and by Utilizing Waste

Rainwater Harvesting, Wastewater Reuse and Composting/biogas

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Preface

Resource augmentation is becoming one of the most important challenges for developed and developing countries alike to support economic activities and to improve the living standards. Natural resources are under intense pressure due to rapid increase in the demand in the wake of urbanization and industrialization. Rainwater harvesting can reduce the stress on freshwater resources. Natural resources are also being affected due to discharge of untreated wastewater and solid waste. By recycling wastewater, one the one hand, demand for freshwater could be decreased. On the other hand, by avoiding the discharge of untreated wastewater into water reservoirs, the risk of polluting freshwater sources could be lowered. Similarly, compost and biogas from biodegradable waste can increase the availability of these resources to support agriculture and industrial activities. This also reduces the costs, which are otherwise incurred for managing the waste.

To assist developing countries to initiate resource augmentation by tapping renewable sources such as rainwater and by utilizing waste such as wastewater and biodegradable waste, UNEP-DTIE-IETC implemented a project in sugar industry in Viet Nam. The aims of the project were to raise awareness, build local capacity for designing and implementation of similar systems and demonstrate resource augmentation by designing and implementing rainwater harvesting system, wastewater reuse system and composting at a sugar company.

This report provides the details of all the activities of this project. This report aims to raise the awareness in other developing countries for undertaking similar initiatives on resource augmentation. This report also highlights the important issue of stakeholder participation, as the sugar company implemented the system without taking any financial support from UNEP-DTIE-IETC.

This project was a success mainly due to strong support from UNEP and UNEP-DTIE top management in Nairobi and Paris. The strong and continuous support from national and provincial governments in Viet Nam played a vital role. Active participation of all the local partners and other stakeholders made this project a good example of local capacity building for scaling up and replication of similar initiatives.

The queries and comments on this report are highly appreciated, as these will be very useful to plan for the future projects.

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Executive Summary

In the recent years, there has been a lot of emphasis on sustainable development in terms of linking economic development with sustainable use of natural resources. Many developing countries have seen rapid economic growth through industrialization. This has resulted into rapid urbanization and improved living standards. These countries are facing a major challenge to sustain their economic growth rates. One of the vital considerations would be the availability of resources to support industrialization and improve living standards. Water and energy are crucial resources in this regard. Many developing countries are already water-stressed and their increasing population base requires essential water resources to support drinking water supply and to support agriculture. Rapid industrialization is having double impact on water resources. Firstly, freshwater is required to support industrial activities. Secondly, they discharge wastewater that pollutes the reservoirs. Rainwater harvesting and wastewater reuse by industries could reduce the pressure on freshwater resources. Similarly, energy is another vital resource as developing countries usually spend huge sum of foreign exchange to import energy. By converting organic waste into an energy source such as biogas, energy security could be increased and some precious foreign exchange could be saved. Biodegradable waste from industries could also be converted into fertilizer to support agriculture activities.

UNEP-DTIE-IETC assists member countries on application of environmentally sound technologies (EST) under its three pillars: water and sanitation, production and consumption, and disaster prevention. The aim is to build local capacity and provide technology support under Bali Strategic Plan for Capacity Building and Technology Support. This project, "Resource Augmentation by Tapping Renewable Resources and by Utilizing Waste" was planned to raise awareness of key stakeholders such as governments and industries, to build the capacity of local partners for designing and implementing rainwater harvesting, wastewater reuse and composting/biogas in industrial sector, and to disseminate the lessons learned. The capacity building is aimed to enable local partners to scale up and replicate similar initiatives on their own. This project was focused to create active partnership with industries, so that they implement EST for rainwater harvesting, wastewater reuse and composting.

The first activity for this project was to identify an appropriate country and then an industry. It is evident from global statistics that Southeast Asian region has seen a rapid economic growth due to rapid industrialization. This region faces enormous challenges to make sure that natural resources and energy are available to sustain these economic growth rates and improved living standards. This region has seen a rapid increase in demand for water resources and energy over the few decades. Within this region, Viet Nam is one of the countries, where demand for resources is increasing rapidly. Keeping in view the large number of people who do not have access to safe drinking water, rapid industrialization requiring water for industrial activities, and traditional agriculture base, freshwater augmentation has become priority for the government. Similarly, energy and compost are other key issues for the government to sustain rapid industrialization, agriculture and living standards.

Within industrial sector in Viet Nam, sugar industry is a traditional industry using huge amount of water and discharging it back to reservoirs. Sugar industry also produces a large amount of biodegradable waste that could be converted into compost/biogas. There has been a growing demand in sugar in domestic and international markets, leading to formation of many more sugar companies in Viet Nam. To make these efforts sustainable, there was an urgent need to address water demand, wastewater discharge and biodegradable waste from these companies. This project on resource augmentation was a timely answer for these efforts.

The project was planned with the following objectives:

1 Awareness raising on resource augmentation by tapping renewable resources (rainwater harvesting) and by utilizing waste (wastewater and organic waste)
2 Identification of potential for resource augmentation at a sugar industry – baseline

study
3 Identification of environmentally sound technologies for rainwater harvesting, wastewater reuse and composting at industry level
4 Design and implementation of project related technologies/systems: rainwater harvesting, wastewater reuse and composting at a sugar industry with local support

To achieve the above objectives, following activities were designed:
1 Three awareness raising and capacity building workshops for local partners (sugar industry and Viet Nam Cleaner Production Centre) and stakeholders (national and local government, industry representatives and community representatives) on policy framework for resource augmentation, rainwater harvesting, wastewater reuse and composting
2 Development of detailed designs for rainwater harvesting, waste water reuse and composting at a selected sugar company
3 Capacity building of local partners to design similar EST for other industries
4 Implementation of project components at a sugar company

Following outcomes were expected to be achieved:
1 Enhanced availability of resources (water and compost) from renewable resources and from waste
2 Demonstration of environmentally sound, techno-economically viable and socially acceptable technique and technologies for resource augmentation for rainwater harvesting, wastewater reuse and organic waste composting.
3 Enhanced capacity of local partners to design and implement technologies and system for rainwater harvesting, wastewater reuse and organic waste composting
4 Demonstration of 3R principles and ESTs in sugar industry which can serve as model for other industries in the region for replication and adoption.

To implement the project, an MOU was signed between UNEP and Viet Nam Cleaner Production Centre (VNCPC). The local partners, VNCPC were required to provide local support to carry out all the project activities. It was aimed that UNEP would assist VNCPC to develop in-house capacity to design rainwater harvesting, wastewater reuse and composting systems, so that VNCPC continue to support the implementation of these systems at other industries. After reviewing a few candidate sugar companies, Binh Dinh Sugar Company was selected as their top management was very committed and made an upfront commitment for installation of rainwater harvesting system, wastewater reuse system and improved composting plant through a MOU with VNCPC. They provided all the local support including local technical staff. However, after designs for EST were completed, Binh Dinh Sugar Company was sold to an international private company that kept all the commitments on hold till institutional and financial restructuring. VNCPC again reviewed other candidate sugar companies and selected Song Con Sugar Company for the implementation of project components. VNCPC modified the designs as per the local conditions.

For activity to promote awareness raising on resource augmentation by rainwater harvesting, wastewater reuse and producing compost/biogas, following four workshops were held, two in Ha Noi and two in Binh Dinh respectively:

1. Enabling Policy Framework for Resource Augmentation
2. Environmentally sound Technologies for Composting
3. Rainwater Harvesting
4. Wastewater Reuse

For data collection and designing EST for project components (rainwater harvesting, wastewater reuse and composting/biogas system), international consultants were invited for their expert support to assist local partners. The local partners were trained on-site to design the specific systems. The salient features of each project component at Binh Dinh Sugar Company are as under:

Rainwater harvesting:

1. It was estimated that about 12000m^3 of rainwater would be harvested during rainy season over the six months per annum.
2. Flow: Rainwater collection and distribution system was designed based on the gravity to save energy required for pumping
3. Treatment: Simple inline filtration technology was considered in order to save costs and due to the good quality of rainwater
4. Intended use: The harvested rainwater was supposed to be used for industrial processing and not for potable purposes.
5. Maximum rainfall: Peak flow design criteria was based on 40% of maximum daily cumulative rainfall intensity is could be reached in 15 min.
6. Currently available freshwater tank, with a capacity of 600m^3, was considered to be appropriate for collection of rainwater due to its connection with distribution system
7. The system was designed based on locally available materials and fabrication capacity. Total cost was estimated at about US$ 15,000.

Wastewater reuse:

Based on the data collection, as shown in the following table, attention was focused on areas where treated freshwater is used. For freshwater consumption, Ash Filter and Dust Filter had highest tolerance values for suspended solids and are also high consumption areas. Accordingly, it was decided to target these two application points for using wastewater.

	Wastewater Stream							
	Source of Generation	Quantity m^3/hr	Quality (as given by Sugar Company)					Discharge into
			COD	BOD_5	SS	Temp	pH	
1	Vacuum Water	63912	5 to 12	2 to 10	20 to 27	33	NA	River
2	C.W for equipment	531	150	0	≤50	40	NA	WWTP
3	Sanitary	280	4000	2400	>100	50	10 - 11	WWTP
4	Cloth Cleaning	200	1500	NA	1800	80	NA	WWTP
5	Ash filter	300	29	0	≤20	35	NA	Sedimentation tank
6	Dust filter	400	0	9	>100	25-27	NA	Sedimentation tank
7	Treated wastewater	1000	≤50	0	≤30	≤35	6.7	

NA: Not Available

Composting:

1. Mixing pressed mud with dry organic waste and proper aeration
2. Removable roof during rain season for press mud, which is kept outside to get dry
3. Leachate collection and treatment system
4. To control odour through proper mixing of materials, turning piles and avoiding seepage of water

Once designs were ready, the sugar industry was privatized and Song Con Sugar Company was selected for the implementation of the project components. It was a great achievement of capacity building activities during the earlier design phase, that VNCPC designed the project components for this sugar company on its own. For rainwater harvesting, the expected amount is 448m^3/year. The system would cost about 4 million VND or USD 2,500. For wastewater reuse, currently company was recycling about 280m^3/hour of wastewater and additional 50m^3/hour or 1,200m^3/day would be recycled with the installation of cooling tower at a cost of 234 million VND or about USD15,000. For composting, the current capacity would be improved from 10,000 tons/year to 20,000 tons/year and environmental improvements would also be introduced at a cost of about 1 billion VND or about US60,000.

After the implementation of the project, following impacts and results were achieved:

1. Capacity building – A very important objective of the project – capacity building at local level – has been very well achieved and amply demonstrated, thanks to an unexpected problem (backing out by the management of the first company) which came as a boon in disguise. The partner technical institution VNCPC (including its host institution – Institute of Environmental Science and Technology) developed the designs for the new

partner industry (Song Cong Sugar Company) almost on its own thus demonstrating that the capacity has actually been built.

2. Technology Support – The information and technical knowledge provided by UNEP through specially prepared manuals and training programmes resulted in a better understanding of Environmentally Sound Technologies for resource augmentation. The technology support component was further strengthened by involving international experts with intensive knowledge and experience in the field. Technology support activities were even extended beyond the project focus area and the partner industry was provided information and knowledge on sugar manufacturing technology also.

3. EST Implementation – The ESTs developed and designed for rainwater harvesting, wastewater reuse and organic waste composting were all implemented at Song Song Sugar Company. The results are as follows:
   - A pilot rainwater harvesting system has been designed and implemented at the Administrative Building. With a total catchment area of 280m^2 the system has the potential of harvesting approx. 448 m^3 of rainwater in an average rainy year. The implementation of the system was completed in August 2007 and in the consequent two month the RWH system enabled the company to collect 150m^3 of rainwater. Encouraged by the success of the pilot system the sugar company is keen to expand the rainwater harvesting to other buildings during the next off-season period.
   - A pilot wastewater reuse system has been designed and implemented. A 50m^3/h cooling system was designed and implemented to recycle wastewater from vacuum tuyars. The system is in continuous operation since its commissioning in September and has enabled the company to recycle 36,000m^3 of wastewater in the first month of its operation. The company has spent VND 240 million (US$15,000) towards fabrication and implementation of the system. The investment is likely to be paid back in 3 months due to reduced freshwater levy and even after accounting for additional cost towards operated cost of the system. The company is already making additional investments for expanding the pilot wastewater cooling and reuse system and is also keen to identify and implement other wastewater reuse operations.
   - Designs for modification in the existing composting system as well as design for a new, bigger and more scientific composting systems have been prepared. The company has already implemented the removable roof design in the existing system. It will soon implement the leachate collection and treatment system. The total investment will be in the range of VND 1.0 billion (US$60,000). The operating practices have been improved which is expected to result in improved quality of product. The company has committed to implement the new scientifically designed composting system. The land has already been procured. It will take at least 1 year to built the plant and put it into operation. The total investment for composting plant is expected to be in VND 2.0 mission (US$ 125,000). Additional investment of VND 8.0 billion (US$ 500,000) will be required for leachate treatment plant to treat the leachate from composting plant.

4. Dissemination and replication – The partner technical institution (VNCPC) organized a Dissemination Workshop on12 December 2007 to disseminate the experience gained and lessons learnt. It was a good surprise that Binh Dinh Sugar Company also made a presentation on their wastewater reuse system, which was implemented by the new management as they got impressed with this project and they utilized their own technical capacity, which was built during the design phase of this project. The partner technical institution has conveyed its willingness to include resource augmentation related achieving in its programme of work. The support to the partner industry was provided on the premise that the company will disseminate with knowledge to other industries and invite them to its premises to see the solution implemented. It is therefore reasonable to expect that this demonstration project will have an extensive dissemination and replication – UNEP-DTIE-IETC will continue to support and build further capacity in Viet Nam, and will also develop and implement similar projects in other countries.

Acronyms

BISUCO	Binh Dinh Sugar Joint Stock Company
DONRE	Department of Natural Resources and Environment (Provincial Government)
DOST	Department of Science and Technology (Provincial Government)
DTIE	Division of Technology, Industry and Economics
ETP	Effluent Treatment Plant
EST	Environmentally Sound Technologies
HUT	Hanoi University of Technology
IETC	International Environmental Technology Centre
MONRE	Ministry of Natural Resources and Environment (National Government)
MOU	Memorandum of Understanding
PPP	Purchasing Power Parity
UNEP	United Nations Environment Programme
VNCPC	Viet Nam Cleaner Production Centre
VND	Viet Nam Dong (Currency)

1. Introduction

Many developing countries are facing the uphill task of achieving and/or sustaining the targets of economic growth and better living standards without putting enormous pressure on the natural resources. The depletion and deterioration of natural resources can hamper the economic growth rates and can drastically affect the quality of life. This brings in the whole spectrum of sustainable development – ensuring that economic growth and improved living standards are in harmony with natural environment.

Various strategies at international, national and local level are being pursued to promote sustainable development. There is an increasing momentum to promote concepts like circular economy and eco-towns, where economic activities and living standards can be improved without putting a lot of pressure on the natural resources. The resources, required for economic growth, could be generated by tapping renewable resources such as rainwater harvesting, and by utilizing waste such as wastewater reuse, waste recycling and converting waste into energy. This would reduce the burden on the natural resources and also reduce amount of wastewater and solid waste that requires to be treated and disposed.

Tapping renewable resources and converting waste into a resource requires application of environmentally sound technologies (EST) supported as appropriate policy framework. These technologies are designed to minimize waste generation and secondary contamination during production processes. Enabling policies may include regulatory and fiscal policies that encourage use of alternative sources as well as to build institutional capacities for implementation and sustainable operation of such systems.

International Environmental Technology Centre (IETC) of Division of Technology Industry and Economics (DTIE-UNEP) promotes the application of EST. Drawing upon the mandate provided by the Bali Strategic Plan for Capacity Building and Technology Support, UNEP-DTIE-IETC assists member countries by raisins awareness and providing technology support to strengthen local capacity.

2. Resource Augmentation

Fresh potable water is fast becoming a scarce resource in many developing countries. Intensive agriculture based on use of chemical fertiliser is depleting the humus content in the soil. Of course, the climate change issue related to use of fossil fuels for generating energy are pretty well known. Freshwater augmentation by tapping rainwater and by reusing wastewater is emerging as an attractive means for mitigating water scarcity. Conversion of waste into a resource, for example production of compost and biogas from organic waste, is another way to maximize the resource recovery and to minimize waste. Accordingly, the major focal areas for this project were:

Water: Increasing water consumption and pollution, due to rapid growth in population and economic activities, is putting severe pressure on the freshwater resources. One of the possibilities, for minimizing this pressure, is to promote freshwater augmentation through alternative practices based on EST. Freshwater augmentation through rainwater harvesting and greywater reuse may help in releasing the pressure on the existing freshwater resources. There could be different strategies for freshwater augmentations for the various sectors, i.e. domestic, commercial, industrial, and agriculture. Furthermore, combined approach of rainwater harvesting and greywater reuse helps in overcoming the limitation of rainwater harvesting alone (due to its dependability on the rainy season).

Waste: In developing countries, the major portion of overall waste comprises of organic wastes. Most of the countries lack appropriate resources to collect, treat and dispose the waste. On one hand, recycling the organic waste may help to reduce the overall volume of waste; thus, enabling the authorities to more effectively collect, treat and dispose the remaining waste. On the other hand, converting organic waste into a resource helps towards resource augmentation and also towards closing the loop as local as possible. Manure obtained from composting of organic waste helps in building the humus content of soil.

Energy: Rapidly developing countries are facing enormous challenges to sustain their economic growth rates by meeting the demand for natural resources and energy. Moreover, the increasing energy prices are making it difficult to sustain the economic growth rates and to support the improved living standards. Hence, the national and local governments, in partnership with private sector and communities, are trying to implement alternative energy plans mainly focusing on renewable energy sources. In this regard, waste could be converted into an energy source such as biogas and fuel. Enormous amount of biomass and biodegradable waste is generated in developing countries, which could be converted into an energy source to increase energy security and to reduce the economic burden of energy imports.

3. Selection of a Country and Industry

3.1 Overall Selection Analysis of South East Asia

The rapid economic growth in Southeast Asian region, is leading to rapid urbanization and higher living standards. This, in turn, results in increasing demand of resources including water and energy.

Although, most of the countries in this sub-region are not water-stressed (the availability of water in Southeast Asia exceeds 5500 cubic kilometers per year); however, the unequal distribution of water resources within the countries, the changing climatic patterns, depletion of ground water resources, and increasing pollution of water resources are hampering the availability of water to support industrial, agricultural, and household demand for water. Furthermore, the total population of the region exceeded 550 million at the end of the 20th century and is expected to increase by around 50% or by an additional 250 millions by year 2025. By 2025, per capita natural water availability will decrease from 27 to 18 cubic meters per person per day.

The rising oil prices and increasing demand for energy is creating a major bottleneck to keep up with the current pace of industrialization. The changing lifestyles are also putting pressure on the energy. Asia Pacific Energy Research Center suggests that Southeast Asia is forecast to experience the fastest economic growth (a 2.5 fold increase) in coming years.

Therefore, there is an urgent need in this region to chalk-out and implement strategies for resource augmentation by adopting alternative practices based on environmentally sound technologies (EST). Freshwater augmentation through rainwater harvesting could be one of the better options, as the climate is generally tropical, and the region is blessed with abundant rainfall - 1600 mm to 3000 mm as annual averages. However, to safeguard the consistent availability of water, especially with changing climate patterns and unequal rainfall in different locations within the countries, wastewater reuse could be another option.

3.2 Selection of Country – Viet Nam

There is a rapid economic growth in Viet Nam and substantial foreign direct investment is targeted for the industrial sector. GDP per capita (at PPP) has seen a substantial growth from US$ 2,006 in 2000 to US 2,490 in 2003, while the real change in GDP has been on an average of 7% per annum. There is rapid expansion and restructuring in industrial sector to meet the international as well as local demand. During five years from 2000 to 2004, the industrial sector continued to grow at 15.8% (in production value). The industrial production in 2003 was 5.6 times that of 1990.

There are major challenges with regards to freshwater supply. The water demand from various sectors is increasing. The water demand for urban areas is estimated to be 4.5 million m^3/day and for industry 3.3 million m^3/day. By the year 2020 total demand for urban and industry will reach at 15.94 million m^3/day and out of that industrial water demand will be 8.35 m^3/day. Meeting this demand is becoming difficult due to increasing scarcity and/or pollution of fresh water resources coupled with insufficient infrastructure and treatment facilities.

Water pollution is becoming a crucial environmental and health issue in Viet Nam. Municipal wastewater is the main cause of water pollution and this problem is increasingly becoming worse. Industrial wastewater is most often discharged without appropriate treatment, which contributes towards increasing water pollution. Therefore, there is an urgent need to explore the possibilities of freshwater augmentation from alternative sources including wastewater reuse that also helps to reduce the water pollution.

Solid waste management is another major challenge and improper management does not only create public health and environmental impacts but opportunity for turning waste into a resource is also lost. Organic waste can be converted into compost, biogas or ethanol. This helps economic growth and also reduces burden on environment. Viet Nam was therefore selected for implementating the pilot project on Resource Augmentation.

3.3 Selection of Industry Sector

In Viet Nam, there is a rapid industrialization as both domestic and international companies are setting up new industries. Food and beverage processing industries still make the largest share in Viet Nam. Seafood processing industries are mainly export based, while coffee and tea industries serve both domestic and international markets. The other major industries include cement steel and chemical specially fertilizer. The domestic and international demand and high prices for cement, fertilizer, and steel make them the greatest contributors to the country's economic sector. In addition to these industries, garment and textile industries are expanding and silk production was revived in the 1990s. Industries for electronic equipment and motorcycles are also expanding, and in the early years of the 21st century automobile manufacturing has been Viet Nam's fastest growing industry. Other important manufactures include footwear, tobacco products, paints, soaps, and pharmaceuticals. Most of these industries are new; thus, their technology and operations in compliance with environmental regulations. The traditional industries, such as sugar industry, require technical and financial support to convert their technology and operations in line with the national regulations. These traditional industries also consume enormous resources and generate waste that goes untreated. Hence there is an urgent need to address these traditional industries.

3.3.1 Resource Augmentation Challenges in Sugar Industry in Viet Nam

In Viet Nam, the rapid growth in sugar production is putting enormous pressure on the natural resources including water. The current trends in the region show that water will no more be an abundantly available resource. This is also evident from the falling production of sugarcane (Table 1) despite higher demand and price.

Table 1 Sugar cane production and prices, 2001 – 2005

Year	Planned acreage, ha	Harvested acreage, ha	Acreage in implementation of Decision 80, ha	Sugar cane purchasing prices, thousand dong/ton
2000 – 2001	230,000	201,863	121,476	220 – 230
2001 – 2002	240,000	212,887	125,381	250 – 260
2002 – 2003	255,000	238,000	149,030	270 – 280
2003 – 2004	264,000	258,000	194,811	320 – 340
2004 - 2005	221,491	208,139	175,275	350 – 370

The technologies used for sugar production are old and inefficient. Sugar yield are up to 20%

less than that in modern industries. Apart from sugarcane, water is the other major input in sugar industry. The industries, located near the water sources, pump huge quantity of water for cooling (vacuum water) and discharge it back to the source. Sugar factories also require treated water for other industrial and domestic uses including for dust filter, ash filter, equipment cooling and cleaning, cloth cleaning, sanitary uses and for offices. The wastewater requires proper treatment due to a high concentration of pollutants. The current law requires industries to also pay levy on wastewater. Hence, to save the costs, industries may reuse wastewater to reduce the amount of wastewater as well as to reduce the demand for freshwater.

In addition to waster and wastewater, organic waste is another major challenge for sugar factories. Bagasse is mostly used as fuel in boilers to meet the steam and electricity demands of the sugar factory. Another organic waste – press mud – is composted and converted into manure as it is rich in Potassium and Phosphorus. The production of compost is stable and profit making but present production levels meet only 55% of the demand for the sugar-cane belt. Therefore, improvements in composting plants can increase the output levels and can provide a useful resource while reducing the environmental impacts.

4. The Project

To promote resource augmentation with the help of environmentally sound technologies (EST), the project was aimed to tap rainwater harvesting and reuse wastewater for freshwater augmentation and to bring improvements in composting plant at a sugar factory in Viet Nam and simultaneously raise awareness and build local capacity for replicating such projects in other industries.

The project was planned with the following objectives:

1 Awareness raising on resource augmentation by tapping renewable resources (rainwater harvesting) and by utilizing waste (wastewater and organic waste)
2 Identification of potential for resource augmentation at a sugar industry – baseline study
3 Identification of environmentally sound technologies for rainwater harvesting, wastewater reuse and composting at industry level
4 Design and implementation of project related technologies/systems: rainwater harvesting, wastewater reuse and composting at a sugar industry with local support

To achieve the above objectives, following activities were designed:

1 Three awareness raising and capacity building workshops for local partners (sugar industry and Viet Nam Cleaner Production Centre) and stakeholders (national and local government, industry representatives and community representatives) on policy framework for resource augmentation, rainwater harvesting, wastewater reuse and composting
2 Development of detailed designs for rainwater harvesting, waste water reuse and composting at a selected sugar company
3 Capacity building of local partners to design similar EST for other industries
4 Implementation of project components at a sugar company

Following outcomes were expected to be achieved:

1 Enhanced availability of resources (water and compost) from renewable resources and from waste
2 Demonstration of environmentally sound, techno-economically viable and socially acceptable technique and technologies for resource augmentation for rainwater harvesting, wastewater reuse and organic waste composting.
3 Enhanced capacity of local partners to design and implement technologies and system for rainwater harvesting, wastewater reuse and organic waste composting
4 Demonstration of 3R principles and ESTs in sugar industry which can serve as model

for other industries in the region for replication and adoption.

5. Project Partners

For smooth implementation of this project, three partners were required in addition to continuous support from national and local governments. UNEP-DTIE-IETC as the first partner to provide technical assistance for all the activities including data collection, awareness raising, designing of project components (rainwater harvesting, waste water reuse and composting systems) and implementation. The second partner would be a local organization with technical expertise in environmental areas. While working with this local partner, UNEP-DTIE-IETC would build their capacity in designing resource augmentation systems, so they can scale-up or replicate similar projects in other industries in Viet Nam. The third partner would be a sugar company, where the project components would be implemented. This sugar company would provide technical staff and also implement the systems with their own funds.

5.1 Identification of Partner Technical Institution – Viet Nam Cleaner Production Centre

The Viet Nam Cleaner Production Centre (VNCPC) was established in 1998 within the framework of the UNIDO/UNEP NCPC programme. The centre is located at Hanoi University of Technology (HUT) at the Institute for Environmental Science and Technology and employs currently 18 people. The vision of the VNCPC is to play a catalytic and coordinating role as national focal point for the promotion and implementation of eco-efficient industrial production techniques in small and medium sized enterprises (Cleaner Production or CP), but also in the education of consultants and students. Furthermore the VNCPC actively participates in policy advice to the government for strengthening CP aspects in environmental strategy of Viet Nam. This makes VNCPC an ideal partner in Viet Nam to assist traditional industries, such as sugar industries, for resource augmentation by tapping on renewable resources and by utilizing waste.

5.2 Identification of a Partner Sugar Company

The emphasis, in identification of a sugar company for project implementation, was that the selected sugar company should be genuinely interested in the project by agreeing to implement the systems with its own funds. Based on a nation-wide assessment, VNCPC identified two sugar companies, which were interested in the project and in promoting their “environmentally friendly” image. After meetings with the management to get the firm commitments, especially for self funding to procure and operate EST for rainwater harvesting, wastewater reuse and composting, Binh Dinh Sugar Company was selected.

5.2.1 Binh Dinh Sugar Joint Stock Company (BISUCO)

This sugar company is one of the 9 best sugar companies in Viet Nam. It is located in Binh Dinh province in southeast Viet Nam. It has a sugarcane crushing capacity of 1800 tons/day. It also produces 9 million litres/year of alcohol, 5000m^3/year of hardboard, and 5000 tons/year of compost. The company has a workforce of 800 people and it has a plantation area of about 6,460 ha.

The sugar factory was set up in 1995 and commissioned in March 1997. The technology and equipment in use now are of Chinese origin based on sulfitization method.
The factory needs 54,000m^3/day of water with average sugarcane crushing of 1500 tons/day. It is expected that water demand will increase up to 82000m^3/day when its capacity will be enhanced to about 3000 tons/day of sugarcane. The factory is paying following costs for water and wastewater:

1. Clean water supply: 200 VND/m^3 * 54,000m^3 = 10,800,000 VND/day

2 Wastewater treatment: 640 VND/m^3 * 1,500m^3 = 960,000 VND/day
3 Environment fee: 10 VND * 54,000m^3 = 540,000 VND/day
Note: 1 USD = 1,600 VND)

Major source for water supply is Con river, which also receives back the discharged wastewater from the industry. Since 2005, water level in Con river has dropped. The factory discharges vacuum water without any treatment, while it has built a wastewater treatment plant with activated sludge system for treating wastewater from other processing and sanitary sources.

Binh Dinh Sugar Company was a joint stock company and the then management was fully supporting the project, and showed their commitment by allocating human resources and committed for financing rainwater harvesting and wastewater reuse systems as well as improvements in the composting plant. However, during the course of the project, Binh Dinh Sugar Company was sold to an international private company just after the completion of designs for rainwater harvesting, wastewater reuse and composting. The new management wanted to keep all the commitments on hold till they make institutional and financial restructuring of the company. Thus, VNCPC again searched for a new partner. After the short-listing and detailed assessment, VNCPC recommended Song Con sugar Company.

5.2.2 Song Cong Sugar Company

Song Con Sugar Company is located in Tan Ky district, Nghe An province, which is on the East-North side of Truong Son mountain range with a diversified and complex topography. Mountainous area occupies 83% of total area of this province. This province is located in the monsoon tropical climate and directly effected by the West-South monsoon which is dry and hot from April to August, and by East-North cold and humid climate from November to March.

Song Con Sugar Company is a State-owned enterprise which belongs to Nghe An's Department of Agriculture and Rural Development. The company was built under the National program of "One billion tons of sugar". In 1997, with the support of Nghe An People Committee, Song Con Sugar Company extended its capacity to 1250 tons/day by investing in advanced technology from Spain. This modern and automatic technology can produce 19,000 - 20,000 tons of refined sugar per season.

The company was facing environmental challenges as during the production season, a huge amount of waste from factory was discharged to the adjacent lake causing pollution in this area. The company was also wasting a large amount of vacuum water from the Tuyer equipment. This water is clean and it could be reused in cooling system. However, the company had no solution so far to treat and reuse this wastewater. In addition, the molasses and bagasse from the production are also not properly and effectively treated - only a small part of it is used as raw material for composting.

6. Project Activities

6.1 Activity 1: Raising Awareness and Capacity Building

This activity was designed to promote the use of environmentally sound technologies (EST) for resource augmentation (rainwater harvesting, wastewater reuse and converting organic waste into compost/gas), and to secure support from national and local agencies for project implementation.

First two workshops were held in Hanoi on "Enabling Policy Framework For Resource

Augmentation" and "Environmentally Sound Technologies (ESTs) for Composting" on November 16th and 17th, 2005 respectively. The workshops were co-chaired by Director UNEP-DTIE-IETC and Director General, Department of Environment. The workshops were attended by high-level officials including Vice Director, Viet Nam Environment Protection Agency, Ministry of Natural Resources and Environment (MONRE), high-level officials of sugar company, VNCPC and other relevant organizations. The workshop highlighted the important issues regarding policies, including regulations and fiscal policies, and their enforcement to create an enabling environment for resource augmentation by utilizing waste and by tapping renewable resources. The workshop provided a platform to the government, industries and local partners to understand each other's point of view for supporting policies to promote resource augmentation through environmentally sound technologies (EST). The discussions on composting were very intensive as Viet Nam is an agricultural country and demand for compost is very high, especially to maintain the soil productivity and to provide cheaper options to the farmers. The sugar companies usually maintain their land to make sure the sugarcane would be available; thus, they provide all the inputs including compost to the farmers.

The other two workshops were held in Quy Nhon city, Binh Dinh Province on "Rainwater Harvesting" and "Wastewater Reuse" on January 12th and 13th, 2006 respectively. These workshops were co-chaired by Deputy Director UNEP-DTIE-IETC and officials from Department of Natural Resources and Environment (DONRE) and Department of Science and Technology (DOST) of Binh Dinh local government.

During the workshop on rainwater harvesting, most of the participants were interested in knowing the techno-economic aspects of rainwater harvesting system at industrial scale. There are some experiences for household rainwater harvesting; however, industry level rainwater harvesting is quite rare due to technical complexity in design and construction of the system.

The workshop on wastewater reuse also created great interests, as the technical staff from various industries came up with various questions on the reuse and recycling of wastewater within an industry. The technical inputs provided during the workshop were appreciated and the participants showed keen interest in the project.

6.2 Activity 2: Designof Environmentally Sound Technologies at Binh Dinh Sugar Company

An important aim of the project was to build local capacity, hence VNCPC and technical staff of Binh Dinh Sugar Company were fully involved from the beginning, starting from the data collection and survey to on-site systems design with the help of international experts. The designs of ESTs were developed for all the three components namely rainwater harvesting, wastewater reuse and organic waste composting.

6.2.1 Component 1: Rainwater Harvesting

Binh Dinh Sugar Company is spread on an area of 10.2 ha. There are 34 buildings occupying an area of 7.8 ha. Some of the buildings do not have suitable roofing for rainwater harvesting. However, those buildings, which will get suitable roof structures in near future under the renovation plan, were also considered for rainwater harvesting. After a detailed survey, it was estimated that 74% of total roof area could be considered as a potential rainwater catchment area. Potential rainwater amount was calculated based on the monitoring data at meteorological station Binh Tuong, Tay Son, Binh Dinh. Highest per day rainfall is 100 mm while average annual rainfall is 2000 mm. It was estimated that about 12000m^3 of rainwater would be harvested during rainy season over the six months per annum.

The salient design features of rainwater harvesting system were as follows:

1 Runoff Coefficient: A runoff efficiency of 90% was assumed based on the slope and material of the roofs
2 Flow: Rainwater collection and distribution system was designed based on gravity flow to save energy required for pumping
3 Treatment: Simple inline filtration technology was considered in order to save costs and due to the good quality of rainwater
4 Intended use: The harvested rainwater was supposed to be used for industrial processing and not for potable purposes.
5 Maximum rainfall: Peak flow design criteria was based on 40% of maximum daily cumulative rainfall intensity is could be reached in 15 min.
6 Pipe Details:
- Material of Construction: Un-plasticized Poly Vinyl Chloride (UPVC) with pressure rating of 4 kg/cm2.
- Manning's Roughness Constant (n): 0.01 (assumed)
- Commercially available diameters of UPVC pipes (mm): 63, 75, 90,110, 140, 160, 180, 200, 225, 250, 280, 315

7 Layout of piping: Pipeline network was designed to be constructed above ground level at minimum height of 3.5 meters and maximum height of 6 meters to ensure gravity flow and avoid any dead pockets
8 Down take pipes: Existing down take pipeline network was considered to be utilized
9 Screens needed to be provided in the gutter at each down take pipe entry
10 Pipe supports: Design for simple and cost effective MS angle supports were developed
11 Annual duration of flow in pipeline system: Rainy season (6 months/year)
12 Pipeline network was assumed to be running ¾ full on gravity system
13 Some gutters were to be replaced and roofs sections were to be repaired and painted as per actual requirement during implementation based on damage and leakage identified during the detailed survey
14 Currently available freshwater tank, with a capacity of 600m^3, was considered to be appropriate for collection of rainwater due to its connection with distribution system
15 The system was designed based on locally available materials and fabrication capacity. Total cost was estimated at about US$ 15,000.
16 The detailed design calculations for rainwater harvesting system is given in Annexure 1.

6.2.2 Component 2: Wastewater Reuse

Firstly, the quantity and quality of wastewater from different streams, within the industry, was established (Table 1). Secondly, the water quantity and quality requirements for different water consumption points were assessed (Table 2). To save the costs and energy requirements, the water consumption points and wastewater streams were matched according to their quantity and quality. Table 3 shows this match for wastewater reuse for non-potable uses. Based on the analysis of different areas of water consumption and discussions with managements of Sugar Company it was first decided that although vacuum water is the largest consumption area, it need not be considered for wastewater reuse as only untreated water is used here and thus the cost-benefit will not be attractive. Attention was therefore, focused on areas where treated freshwater is used. For freshwater consumption, Ash Filter and Dust Filter had highest tolerance values for suspended solids and are also high consumption areas. Accordingly, it was decided to target these two application points for using wastewater.

Table 1 Wastewater streams

	Wastewater Stream							
	Source of Generation	Quantity m^3/hr	Quality (as given by Sugar Company)					Discharge into
			COD	BOD_5	SS	Temp	pH	
1	Vacuum Water	63912	5 to 12	2 to 10	20 to 27	33	NA	River
2	C.W for equipment	531	150	0	≤50	40	NA	WWTP
3	Sanitary	280	4000	2400	>100	50	10 - 11	WWTP
4	Cloth Cleaning	200	1500	NA	1800	80	NA	WWTP
5	Ash filter	300	29	0	≤20	35	NA	Sedimentation tank
6	Dust filter	400	0	9	>100	25-27	NA	Sedimentation tank
7	Treated wastewater	1000	≤50	0	≤30	≤35	6.7	River

NA: Not Available

Table 2 Water consumption points

	Use of Fresh treated water						
	Purpose	Quantity m^3/hr	Quality Requirements (as given by Sugar Company)				Source
			COD	BOD_5	SS	Temp	
1	Vacuum Water (Fresh untreated)	63912	≤50	NSR	100	<30	River
2	Imbibation water (Recycled)	540	NSR	NSR	≤50	>55	Distilled water recycled from 2,3,4 effect of evaporator
3	C.W for equipment (Fresh treated)	531	NSR	NSR	≤50	≤30	Clean water storage tank
4	Sanitary water (Fresh treated)	280	NSR	NSR	≤50	≤30	Clean water storage tank
5	Cloth Cleaning (recycled)	200	NSR	NSR	≤50	≤80	Same as 2
6	Ash filter (Fresh treated)	300	NSR	NSR	≤100	≤30	Clean water storage tank
7	Dust filter (Fresh treated)	400	NSR	NSR	≤100	≤30	Clean water storage tank
8	Boiler feed water (Fresh treated)	735	NSR	NSR	≤50	≤30	Clean water storage tank
9	Water for irrigation (Fresh treated)	60	NSR	NSR	≤100	≤30	Clean water storage tank
	Total of fresh treated water (3+4+6+7+8+9)	2306	NSR	NSR			
	NSR: No Specific Requirement						

In the process of identification of appropriate wastewater stream for using at above identified application areas, the premise was to first use wastewater streams which require little or no treatment and can be reused directly. This would avoid any additional operation cost for reusing wastewater (except may be pumping cost) and thus the entire freshwater treatment cost would be saved. An analysis of different wastewater streams and discussions with management led to conclude that the following wastewater streams could be directly used for the earlier identified application areas (Ash Filter and Dust Filter):

1. Equipment cooling water (compressor cooling)
2. Equipment cooling water (sulphur burning)
3. Mill cooling water
4. Cooling water from boiler house

The balance requirement will be met by using treated water from effluent treatment plant (ETP). The actual quantity of cooling water available and the intended reuse is given in Table 3.

Scheme 1:

The cooling water from compressor cooling and sulphur burning will be conveyed to dust filter of plywood shop through gravity flow using the natural slope of the ground. The existing water requirement of dust filter is 400 m^3/day and the total supply of cooling wastewater from compressor and sulphur burning is 510 m^3/day. Taking the entire quantity of wastewater (510 m3/day) to the dust filter enables avoidance of any control mechanisms. Since the storage tank has an overflow connection, the excess water (110 m^3/day) will overflow and will be conveyed to the wastewater treatment plant through the existing channel system.

The existing set up of storage tank/pump/piping will continue to be used thus no additional investment is required towards this. The dust filter outlet water will be discharged through the existing wastewater treatment system.

Scheme 2:

The cooling water from the mill cooling, cooling water from boilers and treated water from Effluent Treatment Plant (ETP) will be conveyed to ash filter near boiler house. The existing water requirement of ash filter is 300 m^3/day. The sequence of usage of wastewater will be; first use up all the cooling wastewater from boilers, followed by mill cooling wastewater. The cooling wastewater from mill cooling is 100 m^3/day, from boiler house is 80 m^3/day and balance 120 m^3/day will be taken from ETP. In case of any problem from mill cooling or boiler house, the ETP will be capable of supplying 300 m^3/day of water to ash filter.

The cooling water and ETP treated water will be collected into new collection tank of 10 m^3 capacity. The sizing of tank is 2.5m x 1.75m X 2.5m. New ash feed pump of capacity 15m^3/hr will be installed on the new cooling water collection tank. The ash filter outlet will be conveyed through existing channels to the ash ponds. In both the cases, the existing supply system from fresh water tank through the central pump will be retained as stand by setup.

Table 3: Wastewater Reuse

Wastewater Streams	Quantity available m3/day	Intended Reuse	Quantity required m3/day
Equipment Cooling water (Compressor cooling)	300	Dust Filter	400
Equipment Cooling water (Sulphur burning)	210		
Mill cooling water	100	Ash Filter	300
Cooling water from Boiler House	80		
Treated Water from ETP	120		

With this wastewater reuse system, the sugar company will be able to reduce their treated water consumption by 35% (from 2000 down to 1300 cubic meter per day). The costs, with design details of wastewater reuse system would be about US$2,300. The detailed design calculations and system drawing are given in Annexure 2.

6.2.3 Component 3: Composting

The Composting plant under Binh Dinh Sugar Company is 10 km away from Tay Son Town, and is about 20 km from the Sugar Company. The company was using pith and press mud from production processes, ash and other additives to produce compost. The capacity of the plant was 5,000 tons per year with a non-mechanized process. The input materials for composting in the plant were as follows:

+ Pith: 9% of cane x1.800 tons/day x 150 days = 24.300 tons/year
+ Press Mud: 3% of cane x1.800 tons/day x 150 days = 8.100 tons/year
+ Ash: 25 tons/day x 150 days = 3.750 tons/year
+ Peat: 2.5%

The major challenges were quality of the compost, odour, and delays due to high moisture content of the materials. The press mud was stored under the open sky to reduce its moisture content by natural drying, but during rains it became more wet thus worsening the situation. There was no proper leachate collection and treatment system, which was leading to the contamination of soil and water sources.

Picture 1: Situation Analysis outside Composting Plant

The following measures were designed to improve the quantity and quality of compost as well as the process of composting, including leachate collection and treatment, to minimize its negative impacts.

Measure 1: Mixing press mud with dry organic waste and proper aeration

Mixing the organic wastes with the press mud will produce a material with appropriate C/N ratio, porosity and moisture content. Dry organic waste materials are locally available. These include tree leaf, hay, straw, sawdust, bagasse, coconut fiber, etc. These materials provide the first base layer. The second layer is of nitrogen rich materials such as press mud from sugar factory, animal droppings or sludge from municipal wastewater treatment. The third layer could be of carbon rich materials. This mixture should be stacked in heaps of 2 m width, 1.5 m height, 10 m length and 1.5 m side slope. The heaps are covered with plastic to keep them warm and to protect them from insects. The piles should be turned periodically to increase the amount of aeration. This type of composting process is suggested for the dry season and it takes about 3-4 months to convert organic waste in compost without using any mechanized or continuous aeration system.

Measure 2: Removable Roof during Rainy Season

During the rainy season, the press mud, which is stored in open to get dry, turns wet and a lot of leachate is produced. To avoid this problem, a removable roof was designed with locally available materials to prevent ingress of rainwater. This would also reduce the time required for drying.

Measure 3: Leachate Collection and Treatment

A leachate collection system for the water run-off from composting plant was designed. The leachate is formed due to moisture content of press mud and in other organic waste. A concrete bed will protect direct seepage of leachate into the ground. A drainage channel and a leachate collection pond were designed. Biological treatment method was proposed for leachate treatment. The average content of leachate was measured as: BOD = 10,000 mg/l, COD = 16,000 mg/l, total nitrogen 250 mg/l, and organic acid, aliphatic acid which is formed due to fermentation and aeration/disintegration processes. The quantity of leachate is not high, so it can be collected and treated in the aeration digestion tank with biological filtration tower for deodorization. Wastewater has to meet national standards (TCVN-5945, column B). Additionally, a buffer zone needs to be built around the composting plant to protect the water resources getting contaminated with any leachate leakage and prevent odour, noise and dust affecting the nearby areas. The buffer zone can be built by planting more trees and building fences with locally available materials.

Measure 4: Controlling Odour

To control odour, the sources of odour were analyzed. Odour is generated mainly from press mud and compounds containing sulphur. The current composting practices, especially inappropriate mixing of organic waste infrequent (or no) turning of piles were found to be the main causes of odour generation. The following practice was recommended to improve the situation:

- Thorough mixing of organic materials
- Increase height of piles from 1.2 to 1.5 m with proper air ventilation
- Moisture content to be kept at around 55%
- Turning piles 2 times/week
- Preventing penetration of water
- Minimize dust (odour carrier) emissions
- Composting piles in a dry place
- Keep the composting plant tidy, avoid spillages

Picture 2: Inside view of composting plant

7. Change of the Project Partner Industry

Unfortunately, by the time the project designs were completed, the Binh Dinh Sugar Company was taken over by a private overseas company. The new management suspended all the current commitments and conveyed their priority of management restructure and making improvements in the industrial processing technologies. It was difficult to foresee the time required by the new management to re-start the project. It therefore became imperative to identify and select another sugar company and redo the entire designs for the new project partner industry.

VNCPC assessed the potential of three interested sugar companies (two in the Central, one in the South of Viet Nam and recommended Song Cong Sugar Company, based on its commitment as well as easy access from Hanoi. VNCPC also agreed to redo the designs and complete the project without any additional costs.

8. Project Achievements at Song Cong Sugar Company

8.1 Raising Awareness and Capacity Building

Due to intensive training and involvement during the design development at Binh Dinh Sugar Company, the local partner – VNCPC- was able to develop the design of project components for the new partner industry – Song Cong Sugar Company – mostly on their own with very little expert support demanded from UNEP. Thus the basic of objective of the project – to build capacity in local partners – was truly demonstrated. VNCPC also carried out on its own awareness raising and training at the company level.

8.2 Designing and Implementation of Project Components

Component 1 - Rainwater Harvesting System

Nghe An province is located in the monsoon tropical climate and directly effected by the Southwestern monsoon climate which is dry and hot (from April to August) and Northeastern monsoon climate which is cold and humid (from November to March).

The data of hydrometeorology 2005 -2007 shows that:

- The average temperature is 24.2^{o}C
- Rainfall: The data of hydrometeorology measured in Tan Ky indicates that the total annual rainfall of province is about 2000mm per annum, the lowest rainfall is about 1110.1mm at Tuong Duong district. Total rainy days per year in 2006 were about 153 days and 2003 was the worst with 33 rainy days.

Table 4 Rainfall in Nghe An area 2006

Month	Raining days	Average rainfall per month (mm)	Highest Average raining day (mm)
1	11	27	8
2	18	53	10
3	19	51	16
4	11	44	33
5	8	100	53
6	8	57	35
7	9	171	116
8	18	552	160
9	12	254	65
10	15	518	162
11	9	106	45
12	15	72	21
Total	**153**	**2005**	**60**

Table 5 Rainfall in Nghe An area 2007

Month	Raining days	Average rainfall per month (mm)	Highest Average raining day (mm)
1	11	33	8
2	7	35	21

(Sources: Viet Nam Institute for Hydrometeorology)

Song Con Sugar Company consumes about 26,400m^3 of water per day. Water is pumped directly from nearby river. With the new regulations and levy system, the company has to pay fees for 26,400m^3 per day. The increased production costs, due to water levy, makes it difficult for the company to compete with others.

Song Con Sugar Company comprises of many buildings and most of these buildings have appropriate roof to be utilized as catchment area for rainwater harvesting. However, to build the confidence of the company in rainwater harvesting, a small scale pilot system for a roof area of 280 m^2 was designed (Figure 1). This pilot system includes 1 pipeline running along the boundary of administration building roof to collect and convey the rainwater into a treatment tank. From this treatment tank, rainwater flows into the clean water tank behind the company's canteen. The design details are as follows:

- The highest average daily rainfall: 100mm
- Average annual rainfall: 2000mm
- Rainwater harvested: 80%
- Roof area for collecting rainwater: 280m^2
- Expected amount or rainwater harvested: 448m^3/year
- Rainwater will pass through a filtration system and will be stored in the 12m^3 existing tank by gravity
- Diameter of the pipe increases on the sliding scale from start to end (D = 90 mm to D = 150mm) and it is made of UPVC with a strength of 4kg/cm^2
- The inline filter is designed to use locally available materials

Table 7 Rainwater harvesting at administration building

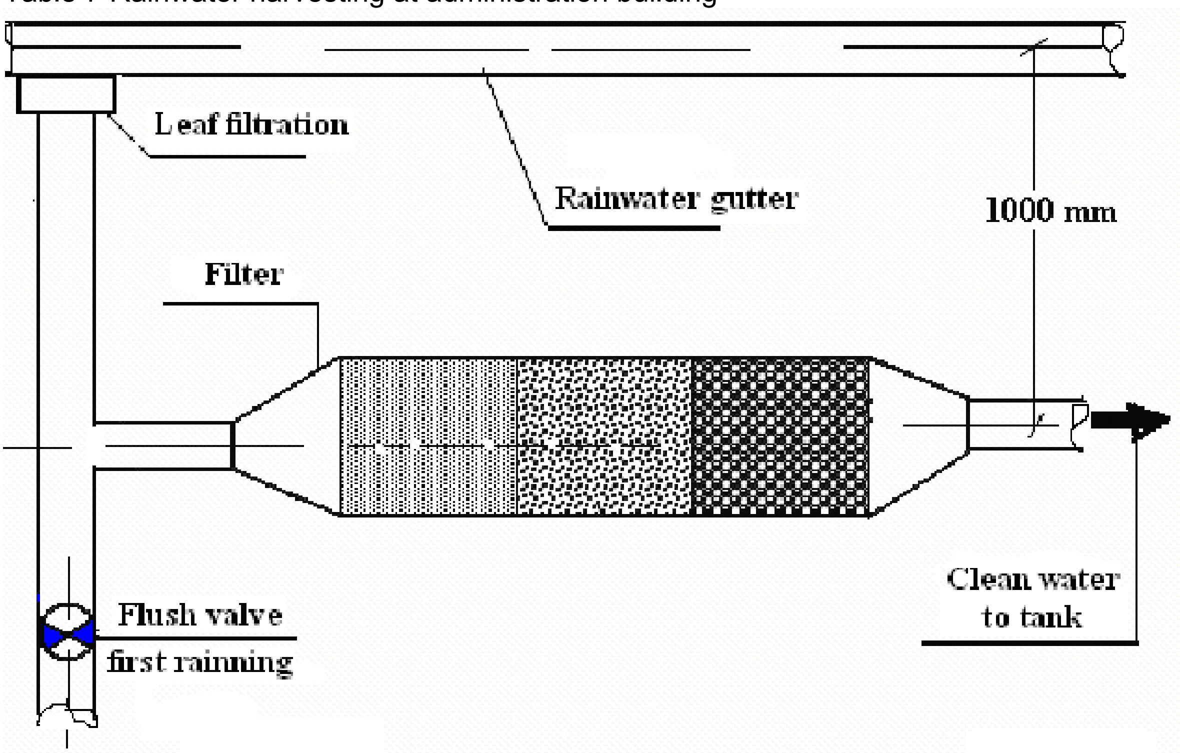


Figure1 Rainwater harvesting system for Song Cong Sugar Company

A valve is provided to flush out the water from the first rain of the season. The roof should also be cleaned twice a year. An inline filter is provided to completely remove the suspended particles from collected rainwater (Figure 2). The filter is positioned at 1.0 meter elevation difference with the gutter so that adequate water head is available. The design of the filter is very simple and it can be fabricated in-house.

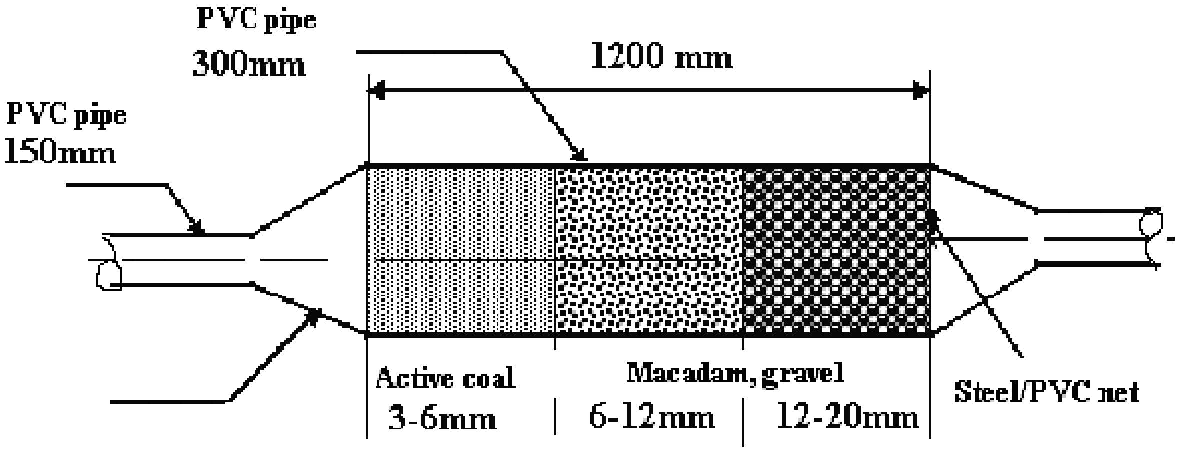


Figure 2 Inline filter

Total cost of material and labour was estimated based on the local prices in Nghe An province:

Table 6 Estimated cost for rainwater harvesting system

Pipe	Unit price (VND)	Quantity (m)	Total (VND)
Pipeline cost (I)			
Ø90	24,400	100	2,440,000
		Sub-total (I)	**2,440,000**
Expenses for auxiliary materials: elbow, T:10%			244,000
Installation cost			1,500,000
		Sub-total (II)	**1,744,000**
Total			**4,184,000**

Based on 2000mm of rainfall per year, the highest daily rainfall level at 100mm and with a system efficiency of about 80%, the payback period works out to - about 3 years (448m^3/year x 2000 = 896.000 VND/year).

Picture 3 Installation of rainwater harvesting system at the company

Component 2 - Wastewater Reuse System

The sugar company discharges wastewater into freshwater bodies without systematic treatment. Furthermore, the company is wasting a large amount of water from the Tuyer equipment which is used to create vacuum.

An analysis of water quality requirements at different application points vis-à-vis quality of wastewater, revealed that, in fact, the quality of single largest stream of wastewater – Tuyer wastewater – is good enough for reusing. The requirements for Tuyer include the clean water without any particles which may accumulate and block the pipe or have an impact on the pump. The water temperature should be less than 40^o C.

Currently, the company is recycling 280 m^3/hour of wastewater. In addition to that, the wastewater from Tuyer could be reused as its quality is fine and only it has to be cooled down. Fort this purpose, a cooling tower of 50m^3/h capacity was designed. The tower is 3m wide, 6m long and 4.6m high. The diameter of pipeline for wastewater is 150 mm and for treated water is 200 mm, and length of fan wing is 2300 mm (Figure 3)

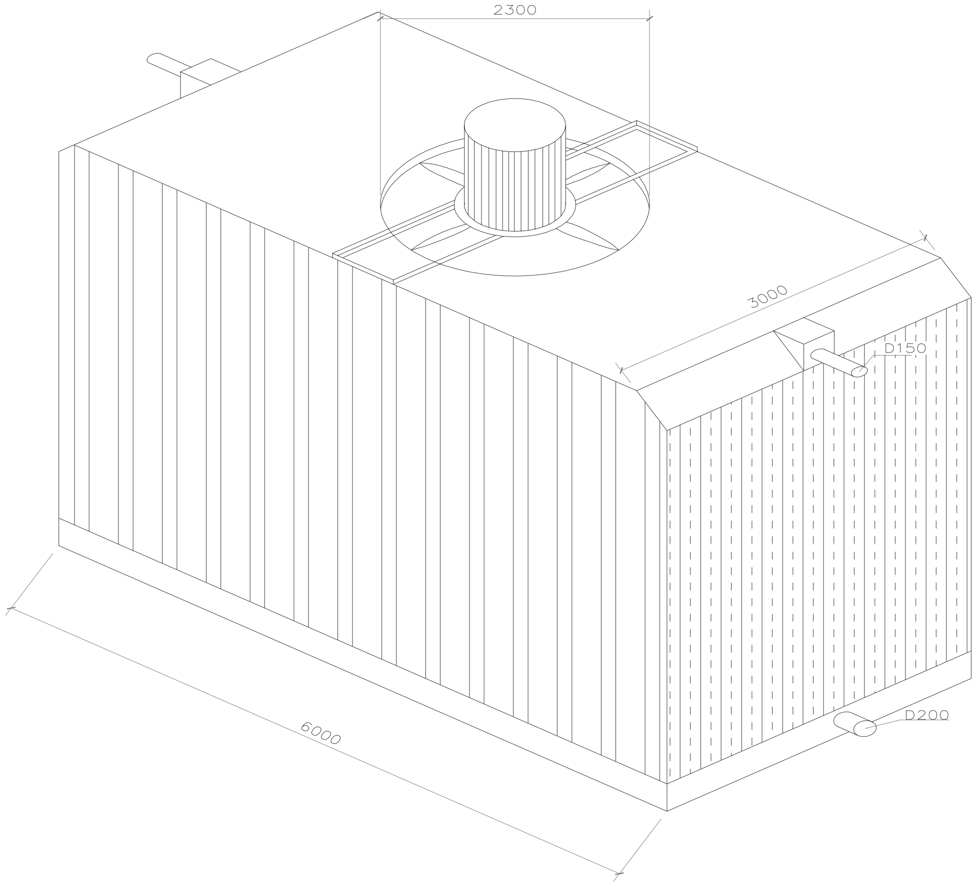


Figure 3 Cooling tower

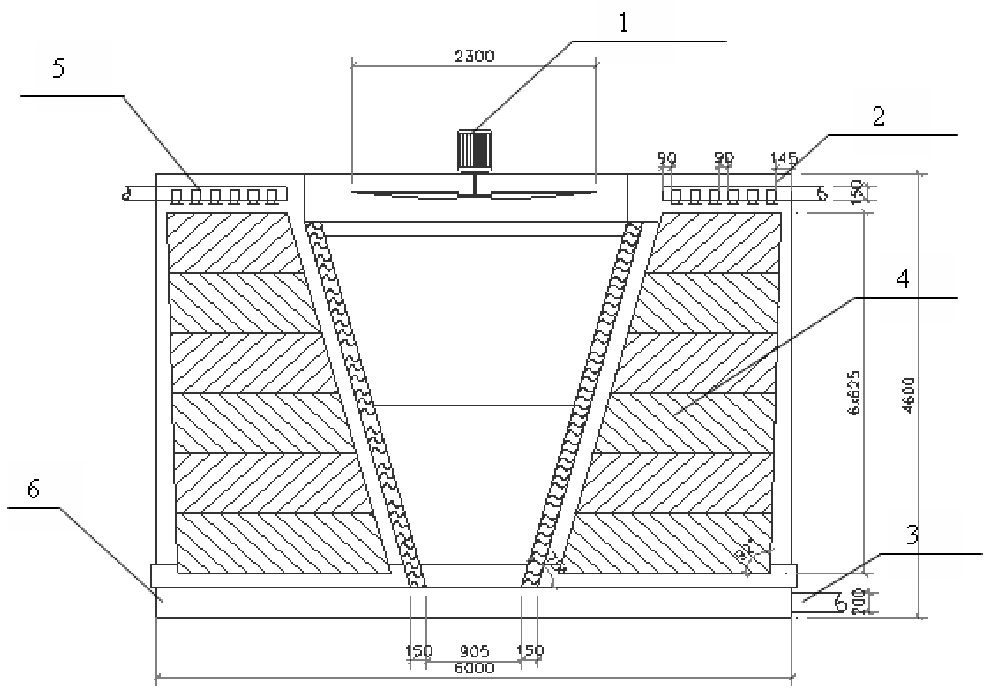


Figure 4 Details of cooling tower

1. Fan 2. Inlet water pipe 3. Outlet water pipe
4. Water distribution frame 5. Water distribution nozzle 6. Collected cool water gutter

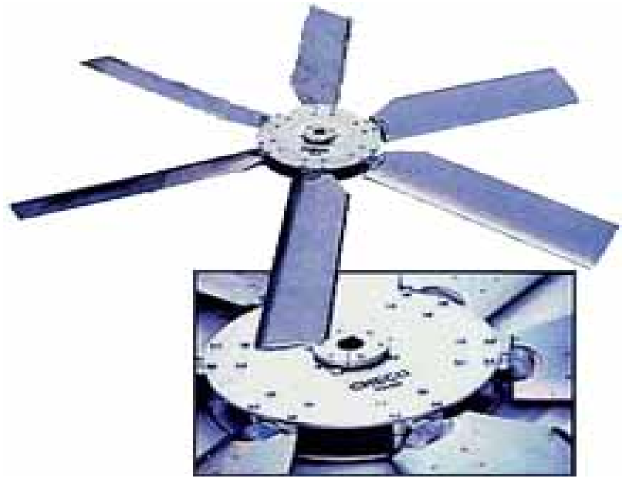


Figure 5 Fan wing of cooling tower

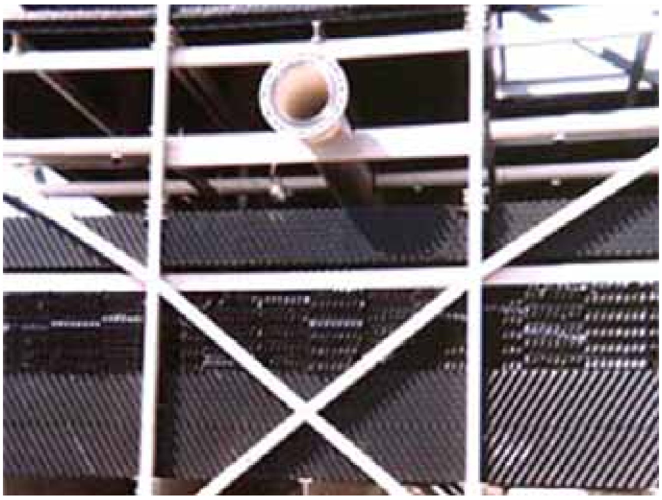


Figure 6 Water spraying frame and contact buffer

Table 7 Main parameters of cooling tower

No	Name – Symbol	Technical parameter
1	Water flow	$50m^3/h$
2	Inlet water pressure	0,5 - 1 kg/cm^2
3	Inlet water temperature	≤ 50^0C
4	Outlet water temperature	Meet the desired quality and utilizing purpose ≤ 37^oC
5	Water loss by evaporation	0,2%
6	Air suction fan (Japanese technology) - Capacity - Quantity - Suction pressure	 $15.000m^3/h$ 1 (diameter 1,6m) 20m H_2O
7	Tower frame	Shape steel
8	Cover	PVC plastic
9	Net weight	4,000 kg
10	Water distribution pipe, inlet and outlet water pipe	Steel

Cost breakdown is as under:

Manufacturing cost	170,000,000 VND
Transportation cost	4,500,000 VND
Installation and test operation	4,000,000 VND
Total	**178,500,000 VND**

Savings include reduced freshwater fee and wastewater fee. The capacity of tower is $50m^3/h$ equivalent to water flow $1200m^3/day$. Therefore, water charges saved in lieu of freshwater fee is $1200m^3/day$ x 150 days x 1300 VND/m^3 = 234,000,000 VND. The additional savings will be in terms of savings in wastewater fee for $1200m^3/day$. The payback period is 8 months based on savings in freshwater charges.

Picture 4 Installation of cooling tower

Component 3 - Composting

Song Con Sugar Company generates about 50,000 tons of solid wastes every year including bagasse, boiler ash, and sludge from sedimentation system. The company utilizes some of this waste to produce compost. The compost (Commix) plant is located 3 km away from Tan Ky town, 1.5 km from the sugar factory. It is located quite far from nearest residential (Picture 3) areas.

Picture 5 Komix compost factory

Currently, the plant uses press mud, ash, and other additives as raw materials to produce compost. The plant uses a synthetic bio-chemical technology in its production process comprising of pile composting with cover for anaerobic decomposition. There exist problems of odour and leachate discharge, and the quality of compost is not good. Therefore, designs were developed to introduce piles of 2m x 10m x 1.5m size with aeration system by turning the piles. During the rainy season, the company should use covers to avoid the penetration of external water into the piles. Furthermore, the materials should be well blended in appropriate proportion. The lowest layer often consists of carbon-rich materials like leaves, weeds, rice straw, sawdust, sugarcane bagasse, or coconut leaf midribs. The next layer is nitrogen-rich materials like press mud and animal manure. The carbon-rich layer is 20cm thick, and nitrogen-rich layer is 10cm thick. The layers should be stacked alternately until the compost piles reach 1.5m high. The piles should be covered to allow the temperature to rise and to provide protection from insects. The piles should be turned up side down or rotated, or mixed after 6-12 weeks. If the nitrogenous materials are not available, then animal manure can be added or legumuinous plants can be grown on the piles at the first turning, the grown plants will be buried at the second turning as a source of nitrogenous materials.

To reduce the environmental pollution including odour, noise, dust, and leachate, various measures were designed. Firstly, buffering areas were designed to isolate the composting activities to avoid water, noise and air pollution in the neighboring areas. A concrete bed with proper covering was designed to prevent seepage of leakage. The concrete base should have bearing capacity of not less than 1 kg/cm^2 and have a slope to drain the leachate. The walls and floor should be waterproof with minimum thickness of 60 cm. In order to further prevent the possibility of rainwater wetting the piles, a rainwater conveyance system was designed to directly connect the roof drains with the nearby lake.

Secondly, a proper leachate collection and treatment system was designed. The leachate from current composting activities contains 10,000 mg/l of BOD, 16,000 mg/l of COD, 200 mg/l of Nitrogen, and some organic aliphatic acids generated due to the fermentation and anaerobic decomposition. Generally, during the dry season, the water amount is small and can be recovered and treated in an anaerobic decomposition tank with bio-filtration to eliminate odours. The treated water should meet the Viet Nam Standard 5945. For leachate collection, the floor bed is comprised of three layers. The first layer is made of macadam of 30 cm thickness, the second layer is made of rough sand of 20 cm thickness, and the third layer is made of concrete or waterproof material. The leachate recovery system is comprised of the two parallel drainage pipes running along the pile with a slope. A biogas hole is located at every 20 metres of the drainage pipes to avoid blockages inside the pipes. The holes are built with brick having water resist layer with the dimensions of 800mm x 800mm x 800mm. Diameter of the pipe is 100mm with 20mm holes occupying 15% of the pipes' surface area. The lining for pipes should be resistant to any chemical and physical situations. The floor slope of compost pile is 2%.

Thirdly, to minimize odours during composting activities a system was designed to reduce odours. Odour is generally produced from press mud, organic wastes, NH_3 from Nitrogenous substances, mostly under effects of sulphur during anaerobic decomposition, and due to improper organization of composting activity, passive fermentation without forming piles with aeration. To improve the situation, a good mix of materials in proper layers is required as mentioned above. The materials should be retained for a short time by introducing aerobic decomposition. The piles should be 1.2 to 1.5 meter high with good porosity and moisture level should be maintained at 55%. The piles should be turned twice a week and any external water getting into the piles should be avoided as wet residues may cause anaerobic decomposition.

Picture 6 Passive compost piles at the factory

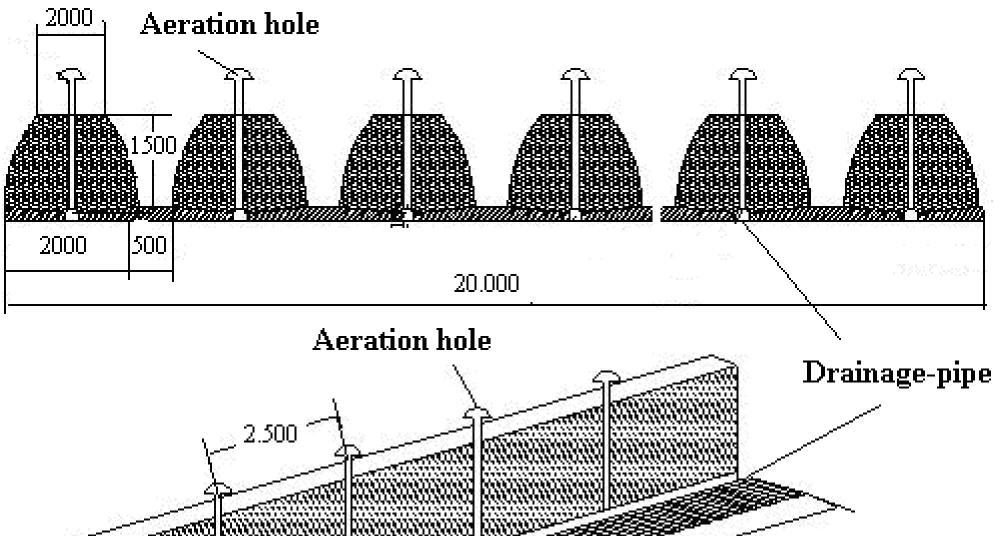


Figure 7 Piling with covers

The company cultivates about 4,000 hectares of sugarcane in the adjacent areas with production capacity of 12 tons/ha/year. Organic fertilizer demand is12 tons/ha x 4,000 ha = 48,000 tons/year. With the current composting capacity of 10,000 tons/year, only 20% of the demand is being met. To improve the production capacity, a new layout was designed to build a new plant of about 20,000 tons/year with an estimated investment of 2,000,000,000 VND. The improvements in rainwater collection system, leachate collection and treatment plant, etc. would cost about 1,000,000,000 VND. Figure 8 shows a layout for the new compost plant. Leachate collection and treatment is crucial to avoid environmental impacts.

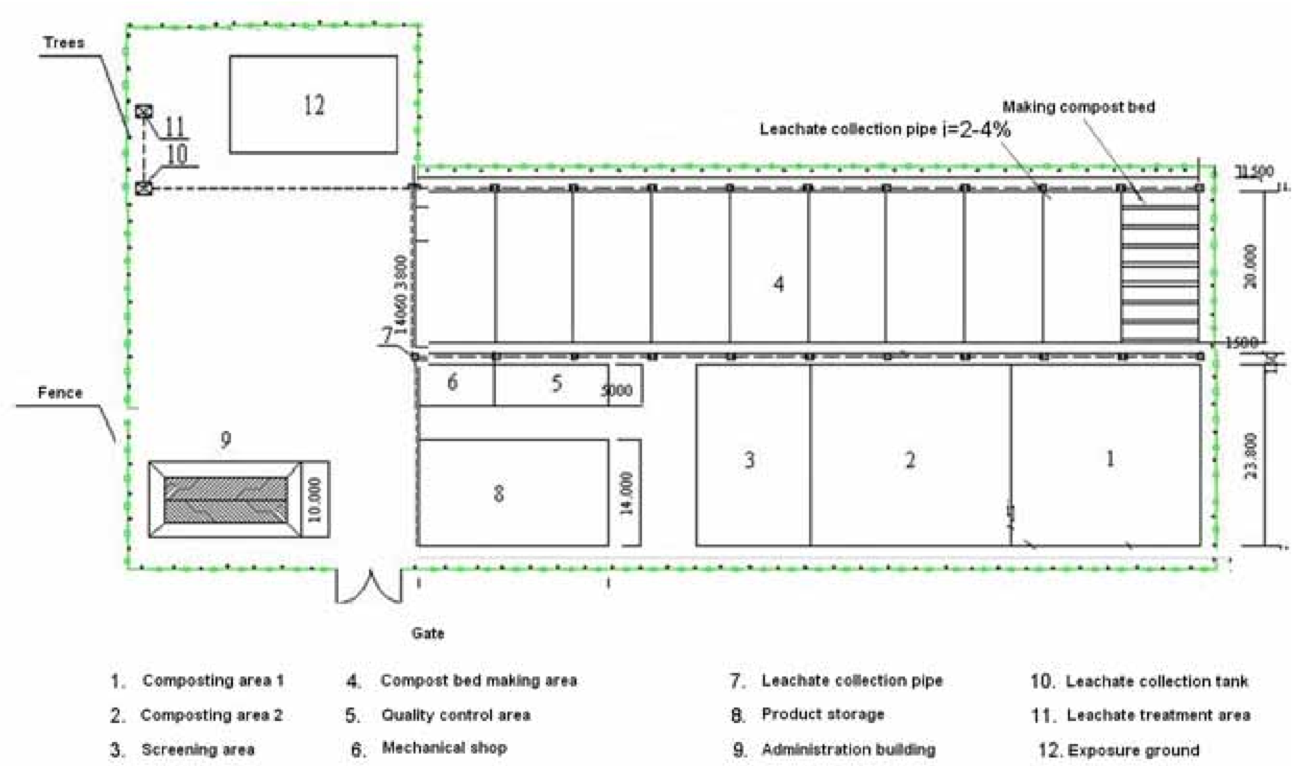


Figure 8 Layout of Composting Plant

Base on the leachate analysis and rainfall data for 2005 and 2006, a leachate collection and treatment system was designed as shown in Figure 9.

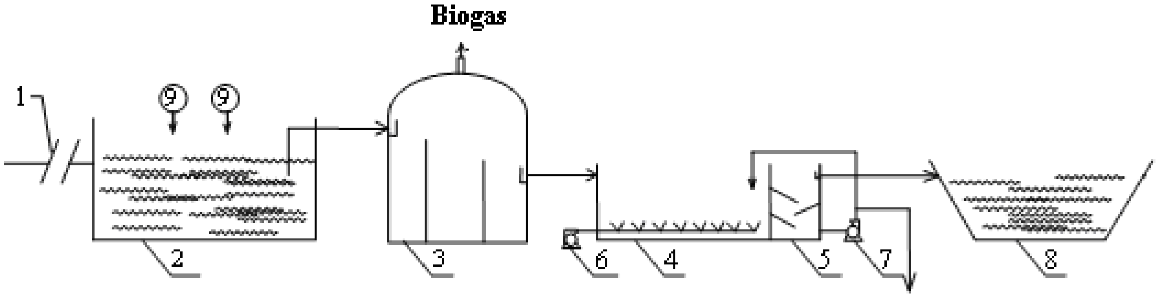


Figure 9 Leachate collection and treatment

1. Garbage screening net	2. Harmonizing tank	3. UASB tank	4. SBR tank
5. Sludge sedimentation	6. Air pump	7. Sludge pump	8. Facultative lagoon

Total investment on construction and equipment is estimated as 8,000,000,000 VND, and operational cost is estimated as 1,420,000,000 VND per year. Total earnings from sale of compost would be 20,000,000,000 VND per year (1000 VND/Kg).

The company has already implemented the removable roof design in the existing system. The implementation of leachate collection and treatment system will be soon underway. The operating practices have been improved and it is expected to result in better quality of product (the results will be known only after the next bash of compost becomes ready). The total investment is expected to be in the range of VND 1.0 billion.

Picture 7 Pile composting with cover avoiding the rain

8.3 Results Achieved

The project has been implemented at Song Cong Sugar Company. The results achieved are;

1. Rainwater Harvesting

A pilot rainwater harvesting system has been designed and implemented at the Administrative Building. With a total catchment area of 280m^2 the system has the potential of harvesting approx. 448 m^3 of rainwater in an average rainy year. The implementation of the system was completed in August 2007 and in the consequent two month the RWH system enabled the company to collect 150m^3 of rainwater. Encouraged by the success of the pilot system the sugar company is keen to expand the rainwater harvesting to other buildings during the next off-season period.

2. Wastewater Reuse

A pilot wastewater reuse system has been designed and implemented. A 50m^3/h cooling system was designed and implemented to recycle wastewater from vacuum tuyars. The system is in continuous operation since its commissioning in September and has enabled the company to recycle 36,000m^3 of wastewater in the first month of its operation. The company has spent VND 240 million (US$15,000) to work implementations the system and with reduced freshwater levy and even after accounting for additional cost towards operated cost of the system. The investment is likely to be paid back in 3 months. The company is already investing in expanding the pilot wastewater cooling and reuse system and is also keen to identify and implement other wastewater reuse opportunities.

3. Organic waste composting

Designs for modification in the existing composting system as well as design for a new, bigger and more scientific composting systems have been prepared. The company has already implemented the renewable roof design in the existing system. It will soon implement the leachate collection and treatment system. The total investment will be in the range of VND 1.0 billion (US$60,000). The operating practices have been improved which is expected to result in improved quality of product. The company has committed to implement the new scientifically designed composting system. The land has already been procured. It will take at least 1 year to built the plant and put it into operation. The total investment for composting plant is expected to be in VND 2.0 billion (US$ 125,000) and additional investment of VND 8.0 billion (US$ 500,000) will be required for leachate treatment which is far beyond the company's ability to fund from its own resources. It will therefore approach financial institutions and government to raise the funds.

9. Overall Impacts and Results

1. Capacity building – A very important objective of the project – capacity building at local level – has been very well achieved and amply demonstrated, thanks to an unexpected problem (backing out by the management of the first company) which came as a boon in disguise. The partner technical institution VNCPC (including its host institution – Institute of Environmental Science and Technology) developed the designs for the new partner industry (Song Cong Sugar Company) almost on its own thus demonstrating that the capacity has actually been built.

2. Technology Support – The information and technical knowledge provided by UNEP through specially prepared manuals and training programmes resulted in a better understanding of Environmentally Sound Technologies for resource augmentation. The technology support component was further strengthened by involving international experts with intensive knowledge and experience in the field. Technology support activities were even extended beyond the project focus area and the partner industry was provided information and knowledge on sugar manufacturing technology also.

3. Dissemination and replication – The partner technical institution (VNCPC) organized a Dissemination Workshop on12 December 2007 to disseminate the experience gained and lessons learnt. It was a good surprise that Binh Dinh Sugar Company also made a presentation on their wastewater reuse system, which was implemented by the new management as they got impressed with this project and they utilized their own technical capacity, which was built during the design phase of this project. The partner technical institution has conveyed its willingness to include resource augmentation related achieving in its programme of work. The support to the partner industry was provided on the premise that the company will disseminate with knowledge to other industries and invite them to its premises to see the solution implemented. It is therefore reasonable to expect that this demonstration project will have an extensive dissemination and replication – UNEP-DTIE-IETC while on one side will continue to support and build further capacity in Viet Nam, on the other will develop and implement similar projects in other countries.

As part of the Project on Resource Augmentation, rainwater harvesting system and waste water reuse system have been designed for implementation at the Binh Dinh Sugar Industry (BISUCO), Qui Nhon, Viet Nam. The design has been developed by International Environmental Technology Centre, Division of Technology, Industry and Economics, United Nations Environment Programme in partnership with Viet Nam Cleaner Production Centre and Binh Dinh Sugar Industry and with support from experts from Environment Management Centre, India. This report gives the detailed design of both systems along with relevant drawings and implementation aspects.

Baseline Information at Binh Dinh Sugar Factory

Binh Dinh sugar factory is located in Qui Nhon District of Viet Nam and about 45 km from city center. The factory processes 2,000 TPD of sugarcane and employs about 800 people. The industry is located on the banks of the river Kon. It is a perennial river and supplies water to industry throughout the crushing period. The factory withdraws fresh river water for production and processing and operates an Efficient Treatment Plant (ETP) which discharges treated water back to the river. At present the factory does not have to pay for the river water abstraction and bears only the pumping and treatment costs.

However, the factory management envisages a change in the regulatory policies and expects a water charge to be levied in the coming years.

Part I: RAINWATER HARVESTING SYSTEM

1.1 Determination of Rainfall Catchment Area

Rainfall data was procured for Qui Nhon and neighbouring region in Viet Nam to understand the hydrograph patterns and establish the baseline for RWH design. The monthly and cumulative hydrographs for Qui Nhon are presented in Figures 1 and 2.

As there was no daily rainfall data available, information for a nearby station Binh Fhuong was considered along with the data at Qui Nhon and an average maximum value of 100 mm/d was arrived at. This was used in designing the piping for RWH. Based on the cumulative rainfall in Qui Nhon, the total rainfall harvest potential was estimated on the basis of 2,000 mm and this value was considered while determing storage requirements.

Keeping in view the local hydrogeological factors, the need to keep the cost of RWH low, availability of large roof area, problems associated with harvesting of rainfall incident on ground, it was agreed with the management of BISVCO that only the rain incident on building roofs will be considered for harvesting. The factory has 34 buildings. The details of roof area of each building is given in Table 1. Some buildings (Building No. 1, 10, 17, 18, 19, 20 and 24) have no roof and were obviously out of consideration. Some buildings (Building No. 5, 6, 13, 22 and 23) have asbestos roof, but since the management has already planned to change them with metal roof, there were also considered for RWH. After studying the feasibility of connecting the harvested rain water with the rainwater conveyance system, the potential of RWH in view of the size of roof (roofs with small areas were not considered due to high cost/m^3 of water harvested) and other parameters, 17 out of 34 buildings were considered for RWH. The total roof area of these selected buildings is 7,815 m^2 which is 74% of the roof area of all the buildings put together.

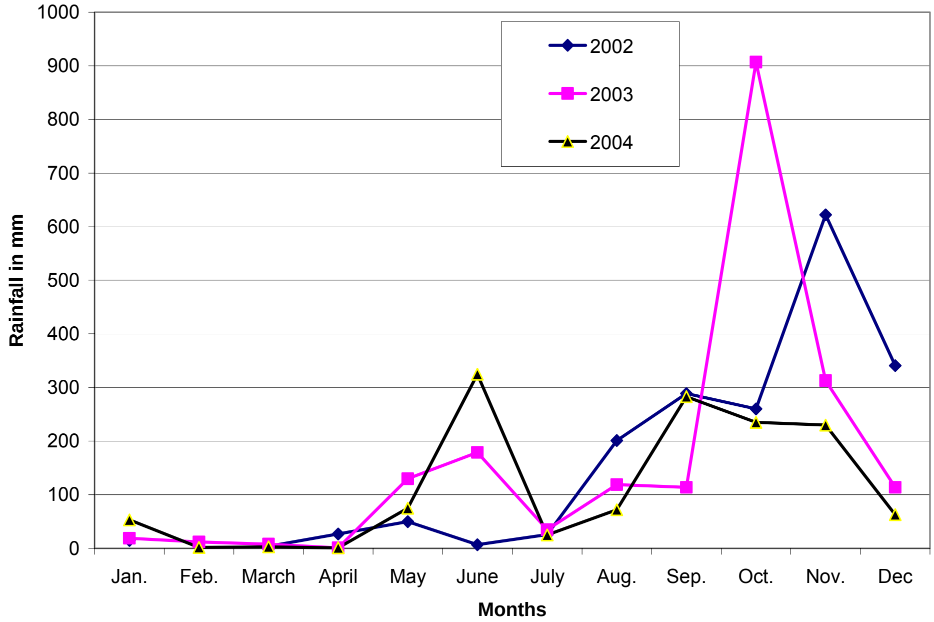


Figure 1 Monthly Rainfall Hydrograph – Qui Nhon (2002-04)

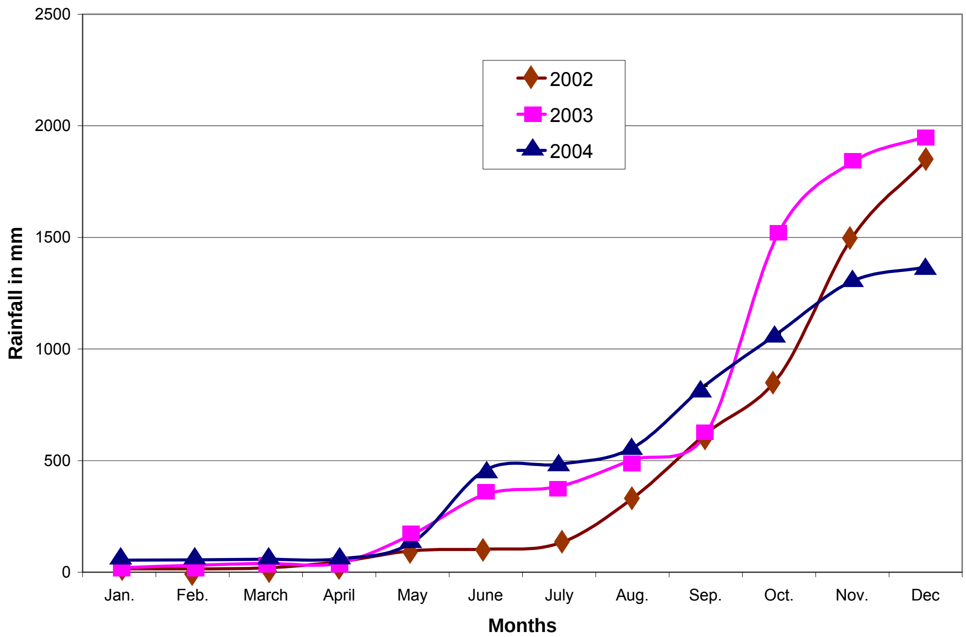


Figure 2 Cumulative Rainfall Hydrograph – Qui Nhon (2002-04)

1.1. Determination of rainfall catchment area

Table 1: Building Roof Area Statement for RWH

No.	Structure	L in m	W in m	Total Area	Area Covered in RWH	Reasons if not covered
1	Sugarcane store	83	19.5	1618.5		no roof
2	Transformer	38.5	9	346.5	346.5	
3	Milling crane	44	21	924	924	
4	Production Area	1900.73	1	1900.73	1900.73	
5	Sugar store	38.5	10	385	385	asbestos roof
5A	Second Sugar Storage			300	300	
6	Burning Sulphur	186.3	1	186.3	186.3	asbestos roof
7	Balance of Sugarcane	4.2	5	21		small
8	Balance of Sugarcane 2 structure)	8	3	24		small
9	Syrup Pumping Station	5	4	20		small
10	Syrup Tank 2 structure			76.93		no roof
11	Boiler	30	21	630	630	
12	Turbine House	30	15	450	450	
13	Electric and transfer Station	30	15.5	465	465	asbestos roof
14	Bagasse feed	15	21	315	315	
15	Oil Tank			12.8		small
16	Oil Pumping Stn	4	3.3	13.2		small
17	Equalisation tank	12.5	6	75		no roof
18	Stack			2.0096		no roof
19	Sedimentation Tank	19.03	6.2	117.986		no roof
20	Filter Tank	10.4	9	93.6		no roof
21	Clean Water Tank	21.04	10.72	225.5488		not possible
22	Pumping stn II	18	5	90	90	asbestos roof
23	Overhead Tank			30.1754		not possible
24	Wastewater tank	10.9	3.7	40.33		no roof
25	Chemical Centre	36	9	324		roof is at lower level
26	Repaired Mechanical House	30	12	360	360	
27	Metal Store	18	12	216	216	
28	Garage	7.2	12	86.4	86.4	
29	Main Admin bldg			234	234	
30	Canteen			170	170	asbestos roof
31	Main gate	6	4	24		small
32	Additional gate	4	3	12		small
33	Toilet	12	3	36		small
34	Sugar Storage House				756	
	Total Area (m2)			**10582**	**7815**	**m2**
	% of area considered for RWH	**74%**				

1.2 Design Basis for RWH System

- Runoff Coefficient: Roof tops are sloped roof structures and in some cases RCC terraces – a runoff efficiency of 90% is assumed to arrive at harvest potential.

- Flow: The rain water will be collected through gravity; the existing pumping set up will be used to supply collected rainwater to application areas.
- Treatment: Simple inline filtration technology is considered in order to save costs. Complicated treatment systems are not required in view of absence of contamination in rainwater.
- Intended use: The harvested rainwater will be used for industrial processing and not for potable purpose.
- Maximum rainfall: It is assumed that, 40% of maximum daily cumulative rainfall intensity is incident in 15 min. as peak flow for pipe design. This works out to 40 mm/d. To be on the safer side, runoff efficiency of 90% is considered in the pipe design.
- Pipe Details:
    - Material of Construction: Un-plasticized Poly Vinyl Chloride (UPVC) with pressure rating of 4 kg/cm^2.
    - Flow through pipes: Gravity Flow.
    - Manning's Roughness Constant (n): 0.01
    - Commercially available diameters of UPVC pipes (mm): 63, 75, 90,110, 140, 160, 180, 200, 225, 250, 280, 315
- Layout of piping: Pipes will be laid above ground at minimum height of 3.5 meters and maximum height of 6 meters.
- Down take pipes: Existing down take pipes were considered while designing the RWH system.
- Screens need to be provided in the gutter at each down take pipe entry
- Pipe supports: MS angle supports
- Present Distribution of water consumption: *Refer to Table 1*
- Duration of flow: Rainy season (6 months/year)
- Pipes are running ¾ of full on gravity system
- Joints, elbows, T junctions will be hot welded, FRP joints
- Some gutters to be replaced and roofs sections to be repaired and painted as per actual requirement during implementation based on damage and leakage
- Existing treated fresh water tank (capacity 600 m^3) will be used for collection of rain water

1.3 Overall Design of RWH System

Based on the design basis as mentioned in 1.3, the overall design for RWH was developed. The pipe routing and configuration have been optimized to achieve maximum rainwater harvesting with minimum costs and simplicity in operation and maintenance. The RWH consists of three routes of conveyance piping system to cover the buildings as selected under 1.1.

The route 1 covers partly roof tops of transformer, milling crane and production area and cover complete roof tops of sugar store, second sugar storage and sugar storage house. This route is selected with objective of minimum intervention into existing pipe layout of sugar plant. It will collect rainwater from approx. half roof top area of buildings 2, 3 and 4 and complete roof top area of buildings 5, 34 and 5.

The route 2 covers remaining parts from roof tops of transformer, milling crane and production area and cover complete roof tops of mechanical house, metal store, Garage and sulphur burning room. This route is selected in order to cover the remaining buildings from route 1 and with minimum intervention into existing pipe layout and process flow of sugar industry.

Route 1 and 2 will be joined near collection tank.

The route 3 will cover entire and proposed roof tops of boiler house, turbine house and electric & transfer stations. The route is selected in such way that, rain water conveyance pipes can easily incorporate the future expansion of boiler and turbine house.

The route 3 will have a separate rain water conveyance line to the RWH tank.

1.4 Detailed Design of RWH System

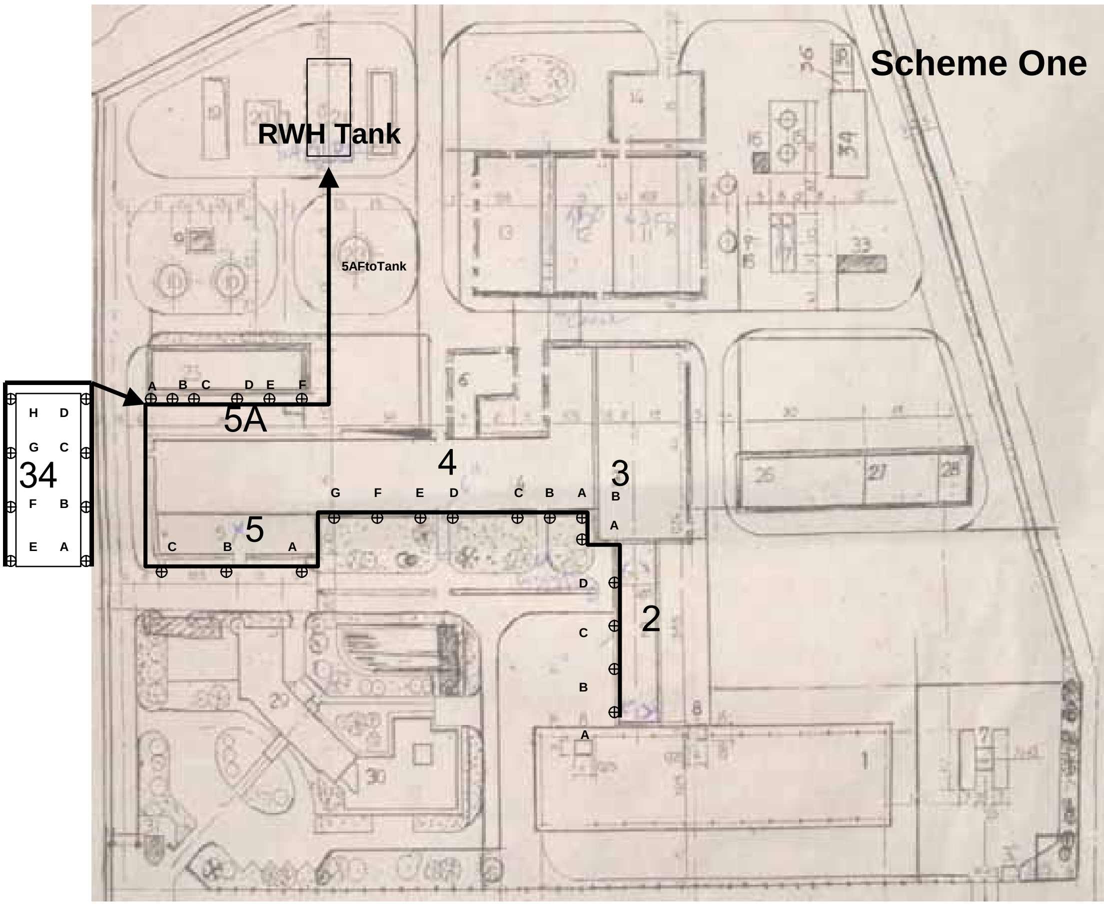
The detailed design of conveyance piping system (of different sizes), joints, elbows, in-line filters etc were prepared. The summary of material requirement is given below in Table 2.

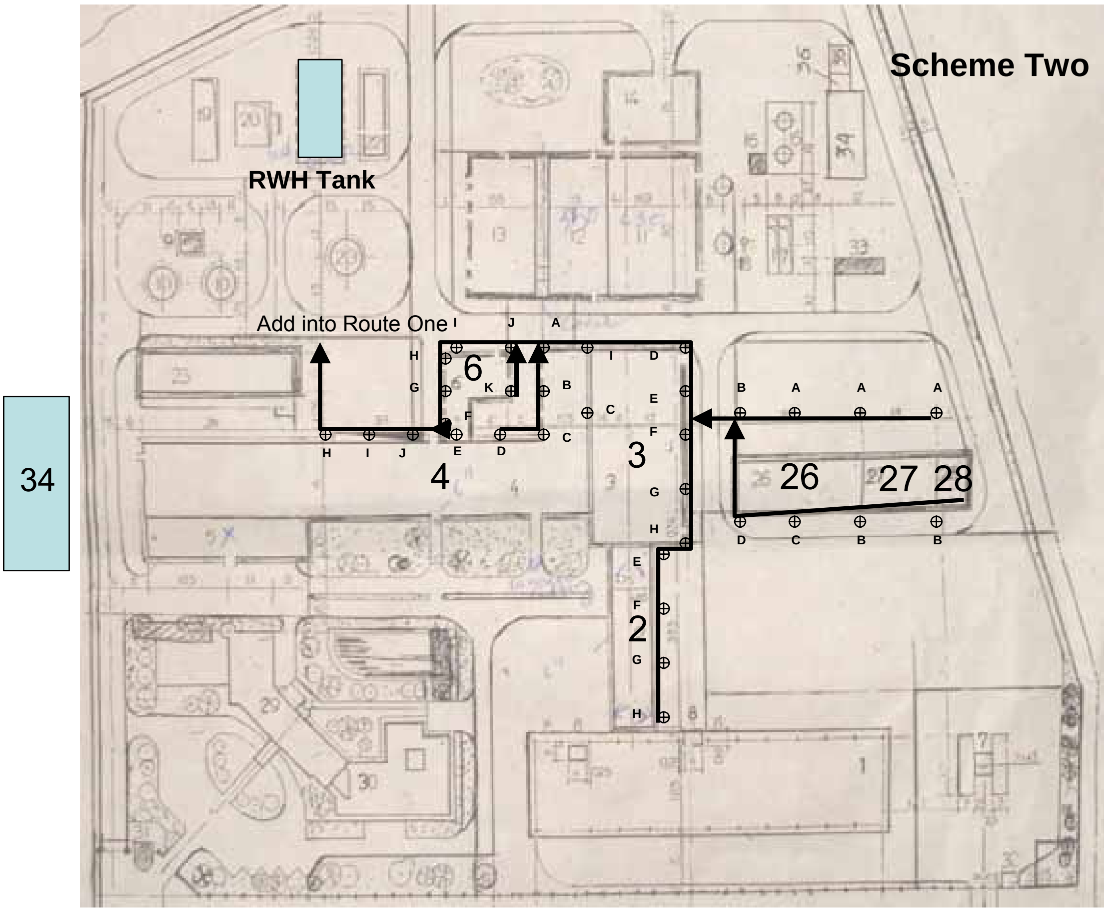
Table 2: Summary of Materials Required

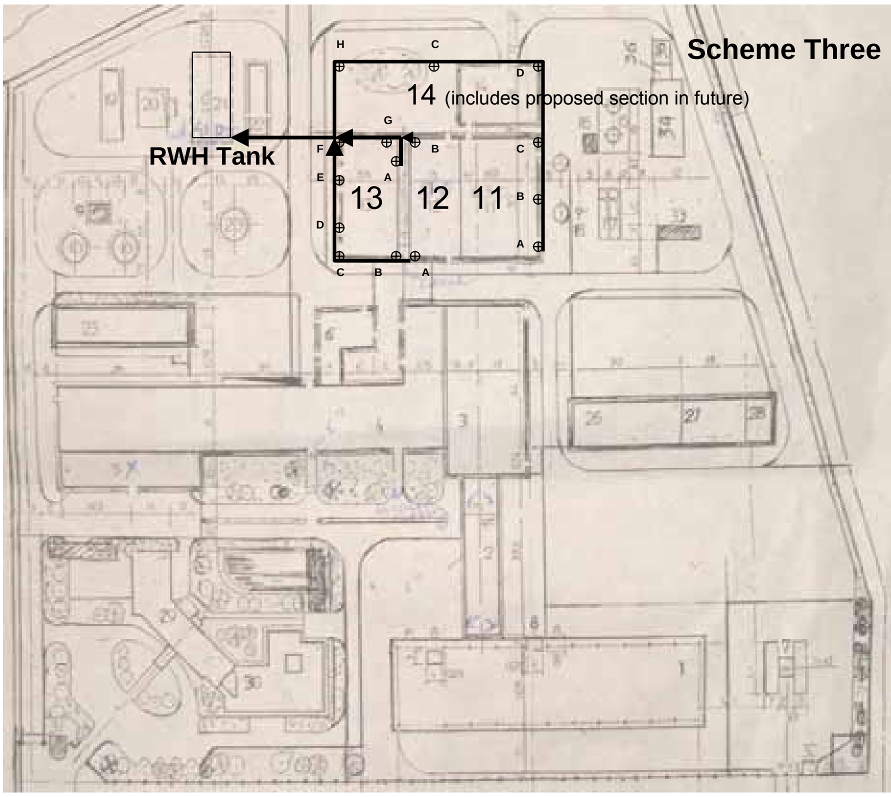
Pipe (Diameter in mm)	Cost per meter (VND)	Length in meters	Total Cost (VND)
63	12,400	77	948,600
75	18,000	26	462,000
90	24,400	38	927,200
110	36,000	186	6,696,000
140	50,000	302	15,100,000
160	75,300	21	1,581,300
180	117,300	141	16,514,667
200	117,300	127	14,861,910
225	147,500	24	3,479,525
250	181,200	0	0
280	227,500	5	1,023,750
315	286,700	0	0
Total (USD 3850)			***61,594,952***
	Cost per Unit	Number of Units	Total Cost (VND)
Inline Filters			21,600,000
Cost of Joints / Enlargers			36,482,158
Cost of Support System (every 2m)	100,000 (Estimated*)	944 (Number of Supports =944.2=472	94,00,000
Cost of Support Pillars	1,000,00 (Estimated*)	10**	10,000,000
Total (VND)			***224,077,110***
Total (USD)			***14,005***

*To be confirmed from local market

**To be confirmed again by measurements at site for each pillar at 4 meter length


Scheme One
RWH Tank
5AFtoTank
5A
34
4
3
5
2


Scheme Two
RWH Tank
Add into Route One
34
6
4
3
26
27
28
2



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1.5 Overall RWH Potential

The roof area covered, RWH potential is given in the Table 3 below.

Table 3: RWH Potential of RWH System

Average Annual rainfall in Binh Dinh	2000
Peak Rain Calculations	
Daily Maximum mm	100
Percent incident in 30 min	20%

RWH conveyance pipe route	Roof area covered in m^2	Rain fall harvesting potential (m^3/year) [1]
Route 1	5,070	9,126
Route 2		
Route 3	1,760	3,168
Total	***6,830***	***12,294***

[1] Based on average annual rainfall of 2000 mm.

1.6 Implementation aspects

During implementation of RWH system the following aspects need to be taken care of:

- Contour survey of proposed RWH routes. Based on these contours, the starting and ending EL can be measure with respect to drop in slope & length.
- Fitting of structural elements, (MS clamps, tie rods, MS cantilever angles) to secure pipes in place on structures as per pipe diameters and slope specified in the attached design sheet.
- Wherever the existing storm water drainage components (roof sheets, valley gutters, down take pipes etc.) are inadequate or damaged, suitable replacement will be require to be made. These costs are not included in the budgetary estimate provided in this report.
- Erection of PVC pipes in place as per the alignment, pipe diameters and slopes specified in the design sheet and fabrication of all joints using hot welding / FRP technique.
- Inline Filters: It is a better option than multi grade or dual media or pressure sand filtration, where we need filter feed pump, additional collection tank and valves and pipes. Inline filter operates with existing height of rain water harvesting pipes and has low head loss in filtration. It is provided with by pass line for periodical back washing of filters.
- The inline filters will be put above existing fresh water collection tank and filtered rainwater will be discharged into the tank.
- Hydraulic testing of all PVC pipes and inline filters to check leakages, structural failures and system adequacy etc.
- In the long run, it is recommended to collect actual rainfall data near Binh Dinh Sugar Company.

2.1 Determination of Wastewater Streams

The wastewater streams and their quality is shown in Table 4

Table 4: Wastewater Streams

	Wastewater Stream							
	Source of Generation	Quantity m^3/hr	Quality (as given by Sugar Company)					Discharge into
			COD	BOD_5	SS	Temp	pH	
1	Vacuum Water	63912	5 to 12	2 to 10	20 to 27	33	NA	River
2	C.W for equipment	531	150	0	≤50	40	NA	WWTP
3	Sanitary	280	4000	2400	>100	50	10 - 11	WWTP
4	Cloth Cleaning	200	1500	NA	1800	80	NA	WWTP
5	Ash filter	300	29	0	≤20	35	NA	Sedimentation tank
6	Dust filter	400	0	9	>100	25-27	NA	Sedimentation tank
7	Treated wastewater	1000	≤50	0	≤30	≤35	6.7	River

NA: Not Available

2.2 Treated Freshwater Consumption Points

To identify the appropriate wastewater reuse, the water consumption points with required levels of quantity and quality are shown in Table 5

Table 5: Water Consumption Points

	Use of Fresh treated water						
	Purpose	Quantity m^3/hr	Quality Requirements (as given by Sugar Company)				Source
			COD	BOD_5	SS	Temp	
1	Vacuum Water (Fresh untreated)	63912	≤50	NSR	100	<30	River
2	Imbibation water (Recycled)	540	NSR	NSR	≤50	>55	Distilled water recycled from 2,3,4 effect of evaporator
3	C.W for equipment (Fresh treated)	531	NSR	NSR	≤50	≤30	Clean water storage tank
4	Sanitary water (Fresh treated)	280	NSR	NSR	≤50	≤30	Clean water storage tank
5	Cloth Cleaning (recycled)	200	NSR	NSR	≤50	≤80	Same as 2
6	Ash filter (Fresh treated)	300	NSR	NSR	≤100	≤30	Clean water storage tank
7	Dust filter (Fresh treated)	400	NSR	NSR	≤100	≤30	Clean water storage tank
8	Boiler feed water (Fresh treated)	735	NSR	NSR	≤50	≤30	Clean water storage tank
9	Water for irrigation (Fresh treated)	60	NSR	NSR	≤100	≤30	Clean water storage tank
	Total of fresh treated water (3+4+6+7+8+9)	**2306**	NSR	NSR			

NSR: No Specific Requirement

2.3 Overall Design of Wastewater Reuse (WWR) System

Based on analysis of the different areas of water consumption and discussions with management of Sugar Company it was first decided that although vacuum water is the largest consumption area, it need not be considered for wastewater reuse as only untreated water is used here and thus the cost-benefit will not be attractive. Attention was therefore, focussed on areas where treated freshwater is used.

An analysis of treated freshwater consumption areas (3,4,6,7,8 & 9) shows that Ash Filter and Dust Filter have highest tolerance values for suspended solids and are also high consumption areas. Accordingly, it was decided to target these two application points for using wastewater.

The process of identification of appropriate wastewater stream for using at above identified application areas, the premise was to first use wastewater streams which require little or no treatment and can be reused directly. This will avoid any additional operation cost for reusing wastewater (except may be pumping cost) and thus the entire freshwater treatment cost will be saved. An analysis of different wastewater streams (Table 4) and discussions with management led to conclude that the following wastewater streams could be directly used for the earlier identified application areas (Ash Filter and Dust Filter):

1. Equipment cooling water (compressor cooling)
2. Equipment cooling water (sulphur burning)
3. Mill cooling water
4. Cooling water from boiler house

If need be then, treated water from effluent treatment plant (ETP) could also be used.

Field observation and further discussions with the management revealed that the actual quantity of cooling water is different from the values shown in Table 4. The actual quantity of cooling water available and the intended reuse is given in Table 6.

Table 6: Wastewater Reuse

Wastewater Streams	Quantity available m3/day	Intended Reuse	Quantity required m3/day
Equipment Cooling water (Compressor cooling)	300	Dust Filter	400
Equipment Cooling water (Sulphur burning)	210		
Mill cooling water	100	Ash Filter	300
Cooling water from Boiler House	80		
Treated Water from ETP	120		

Scheme 1:

The cooling water from compressor cooling and sulphur burning will be conveyed to dust filter of plywood shop through gravity flow using the natural slope of the ground. The existing water requirement of dust filter is 400 m^3/day and the total supply of cooling wastewater from compressor and sulphur burning is 510 m^3/day. Taking the entire quantity of wastewater (510 m3/day) to the dust filter enables avoidance of any control mechanisms. Since the storage tank has an overflow connection, the excess water (110 m^3/day) will overflow and will be discharged through the existing channel system.

The existing set up of storage tank/pump/piping will continue to be used thus no additional investment is required towards this. The dust filter outlet water will be discharged through the existing system.

Scheme 2:

The cooling water from the mill cooling, cooling water from boilers and treated water from Effluent Treatment Plant (ETP) will be conveyed to ash filter near boiler house. The existing water requirement of ash filter is 300 m^3/day. The sequence of usage of wastewater will be; first use up all the cooling wastewater from boilers, followed by mill cooling wastewater. The cooling wastewater from mill cooling is 100 m^3/day, from boiler house is 80 m^3/day and balance 120 m^3/day will be taken from ETP. In case of any problem from mill cooling or boiler house, the ETP will be capable of supplying 300 m^3/day of water to ash filter.

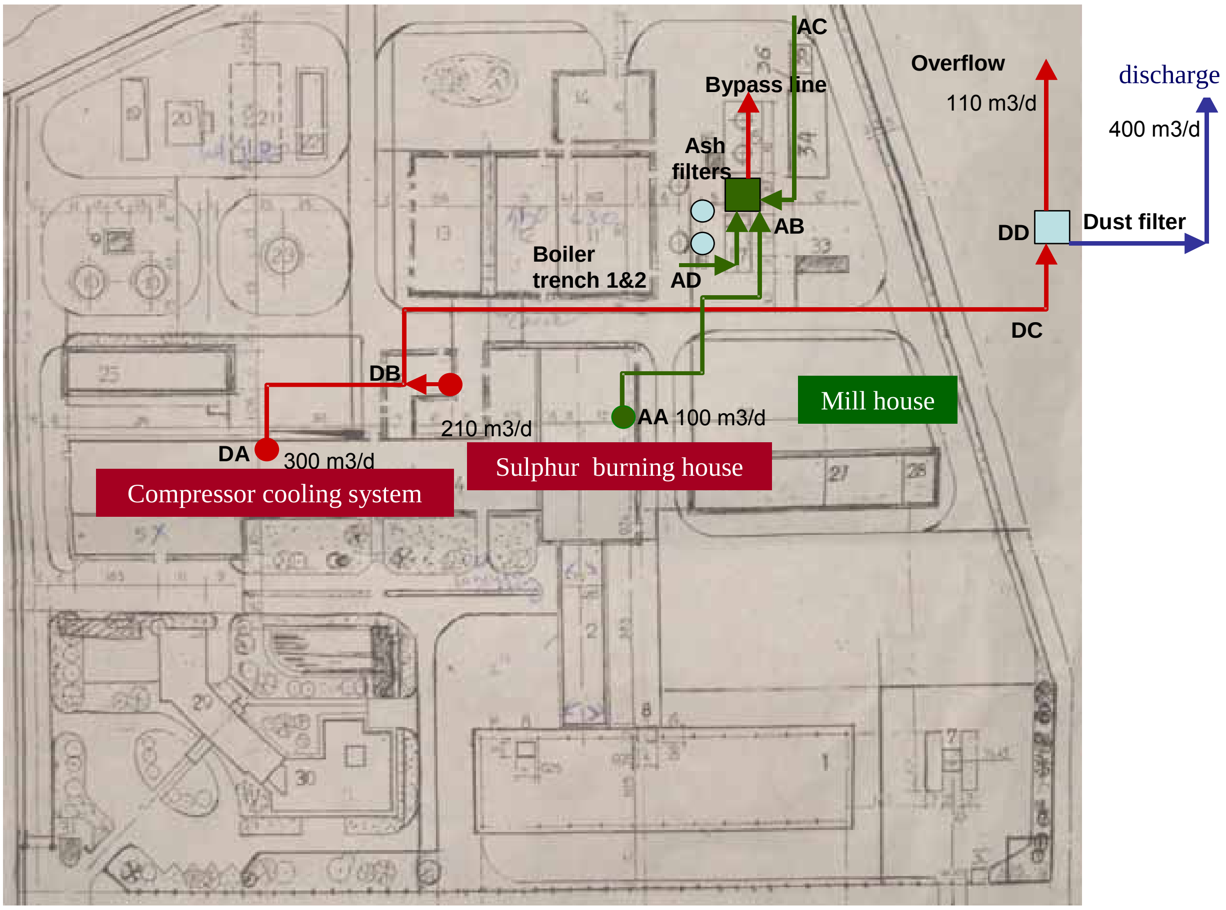
The cooling water and ETP treated water will be collected into new collection tank of 10 m^3 capacity. The sizing of tank is 2.5m x 1.75m X 2.5m. New ash feed pump of capacity 15m^3/hr will be installed on the new cooling water collection tank.

The ash filter outlet will be conveyed through existing channels to the ash ponds.

In both the cases, the existing supply system from fresh water tank through the central pump will be retained as stand by setup.

Detailed Design of WWR System

The detailed designs are provided in Table 8. The schematic layout and route plan for the pipe is shown in WWR Route, below:



2.4 Overall WWR Potential and Cost of WWR System

With this wastewater reuse system, the sugar company will be able to reduce their treated water consumption by 35% (from 2000 down to 1300 cubic meter per day). The costs, with design details of wastewater reuse system are shown in Table 7 and Table 8

Table 7: Summary of Costs for Wastewater Reuse System

Items	**Dongs**	**USD**
Pipes	**35,782,953**	2,251
Tees	**64,199**	4
Elbows	**410,399**	26
Total Cost	**35,847,152**	**2,255**

Table 8: Costs and Design Details for Wastewater Reuse System

Pipe section	Starting EL (mm)	Ending EL (mm)	MoC	Pipe length	Discharge	n	Slope (drop in m, length in m)		Slope 1 in	Dia in mm	Dia in inches	Actual Flow	Velocity m/s	Area of c/s m2	T junctions	L junctions	Pipe Costs in VN Dongs	Tee cost in VN DONGS	Elbow cost in VN DONGS
DA-DB (Compressor to Sulphur burning)	39.950	39.853	GI	39.0	0.003	0.0105	0.098	39.0	400	110	4.3	0.0051	0.54	0.01	3	7	3,744,000	28,800	67,200
DB-DC (Sulphur burning to factory premises)	39.853	39.486	GI	146.5	0.006	0.0105	0.366	146.5	400	140	5.5	0.0097	0.63	15.39	1	4	14,064,000	9,600	38,400
DC-DD (Factory premises to dust filter tank)	39.486	39.399	GI	35.0	0.006	0.0105	0.088	35.0	400	140	5.5	0.0097	0.63	15.39	0	4	3,360,000	0	38,400
AA-AB (Milling machines to New ash filter tank)	38.4	38.263	GI	68.74	2.315E-03	0.0105	0.137	68.7	500	90	3.5	0.0027	0.42	6.36	1	13	7,188,623	10,458	135,950
AD-AB (Boiler trench 1&2 to New ash filter tank)	39.8	39.756	GI	22	9.259E-04	0.0105	0.044	22.0	500	75	3.0	0.0016	0.37	4.42	1	6	1,263,130	5,742	34,449
AC-AB (ETP outlet to New ash filter tank)	39.8	39.672	GI	64.2	3.472E-03	0.0105	0.128	64.2	500	110	4.3	0.0046	0.48	9.50	1	10	6,163,200	9,600	96,000

Note:
75 & 90 mm diameter pipe are expensive as the wall thickness is higher. In the absence of data on per meter cost of 140 mm diameter pipe, it has been taken as same as that of 110 mm diameter pipe.

2.5 Implementation Aspects

Implementation of WWR system will involve following components.

- Contour survey of proposed WWR routes
- Laying of cooling water conveyance GI pipes through trenches along the proposed alignment complete with excavation, laying, jointing, testing etc.
- Fabrication / construction of storage tank for ash filter including excavation, foundation and all civil work, provision for inlets and out let as specified.
- Installation of ash filter feed pump on new tank including civil, mechanical and electrical work.
- Laying of feed pipe from ash filter feed pump to existing nozzles of ash filter etc. including all civil work
- Hydraulic testing of all GI pipes to check leakages, structural failures and system adequacy etc.