Economy and Environment Program
for Southeast Asia
Tanglin PO Box 101
Singapore 912404
Phone: (65) 6831-6854
Fax: (65) 6235-1849
E-mail: eepsea@idrc.org.sg
Web site: www.eepsea.org

RESEARCH REPORT

NO. 2003-RR11

Economic and Environmental Impacts of Using Treated Distillery Slops for Irrigation of Sugarcane Fields

Nerlita M. Manalili, Rodrigo B. Badayos and Moises A. Dorado

Agro-Industrial Development Program, SEAMEO Regional Center for Graduate Study and Research in Agriculture (SEARCA), College, Los Banos, Laguna 4031 Philippines

(nmm@agri.searca.org)

This report provides information on the use of wastes from sugarcane distillation as a resource for improving agricultural productivity. It analyzes various treatment options to find out which brings the most economic, environmental and social benefits to the industry, agriculture and the environment. It finds that when the waste slops are treated optimally, they can be an effective fertilizer and irrigation resource with minimal pollution impact. This not only benefits farmers by increasing yields, but removes a heavy financial burden from the sugarcane processing companies in the form of pollution cleanup costs or fines. The report recommends that the government support this innovative way of reducing pollution.

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August, 2003

Comments should be sent to: Nerlita M. Manalili, Head, Agro-Industrial Development Program, SEAMEO Regional Center for Graduate Study and Research in Agriculture (SEARCA), College, Los Banos, Laguna 4031 Philippines

Email: nmm@agri.searca.org

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EEPSEA is supported by the International Development Research Centre (IDRC); the Swedish International Development Cooperation Agency (Sida); and the Canadian International Development Agency (CIDA).

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ACKNOWLEDGEMENTS

The project team would like to extend their gratitude to the following:

The Economy and Environment Program for Southeast Asia (EEPSEA) through Dr. David Glover and Dr. Herminia Francisco, for making this research study a reality;

The reviewers of EEPSEA for their valuable inputs and comments on this project;

The management of the private distillery which has the most advanced treatment plant in the area, who also commissioned the study;

Mang Boy Vergara, and the sugarcane farmer-respondents of Barangays San Diego and Bungahan, Lian, Batangas for providing us a venue for a scientific exercise;

The Post Harvest Technology Center (PHTC) for selecting the Vietnam counterpart and facilitating the field experiments in Vietnam to the extent of using their own resources to ensure the success of the research project; and

The management and staff of SEAMEO SEARCA for their continued support in researches which promotes sustainable agriculture.

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EXECUTIVE SUMMARY

This study (undertaken in the Philippines and Vietnam) identified and evaluated five waste management alternatives (WMAs) whereby alcohol distilleries can reuse the resulting wastewater (commonly referred to as slops) for irrigation. The five alternatives ranged from no treatment of slops (raw form) to subjecting it to a series of processes before its use as irrigation for sugarcane. The options were analyzed based on the costs and benefits they provided to the distilleries, the farmers, and the environment. Benefits from slops irrigation included the increase in sugarcane production, water availability for the crops, and residual soil fertility after harvest, while the costs were the river pollution due to run off and groundwater pollution due to leaching. Results of the private benefit-cost for the distillery analysis (i.e. from the firm's point of view) showed that alternative WMA 4, which uses a combined anaerobic and aerobic treatment with recycling and process improvement before the slops are applied to sugarcane fields, will give the largest net benefit. This result was derived based on the assumption that firms will be made to pay penalty cost for exceeding water quality standards set for wastewater released into the environment. Due to the huge penalty imposed for such violation, it becomes profitable for firms to engage in WMA 4 to avoid penalty payments. This option has the highest net present value and benefit-cost ratio. From society's perspective however, the best option is WMA 2 (anaerobic treatment). The assumption here is that the government has mandated wastewater treatment to firms. As it turned out, there are WMAs that are cheaper to implement compared to the cost of paying the penalty. WMA 2 has the highest net present value: PHP 9.146 million. It also corresponds to the option that has the least cost of reducing BOD load (PHP 1,117/mg/l) and color reduction (PHP 5,029/Pco).

The resulting increase in sugarcane production due to the application of slops was estimated at 28 tonnes per hectare, valued at PHP 23,240 (USD 452). The value of residual soil fertility was PHP 53,736 (USD 1,045) per hectare with potassium contributing the highest amount at PHP 46,581 (USD 906) per hectare. In terms of volume of residual nutrients, phosphorous has the largest amount, estimated at the equivalent of 5,860 kg of phosphorous oxide (P_20_5) per hectare. Benefits to the distillery include alcohol sales and biogas production while costs include investments for additional facilities.

The costs of river clean-up (color and BOD due to run off) ranged from PHP 42,739 (USD 831) to PHP 88,434 (USD 1,720) per hectare of slop-irrigated field, respectively. The estimated value of groundwater contamination due to leaching ranged from PHP 8,811 (USD 171) to PHP 18,098 (USD 352) per hectare.

Changes in farming practices needed to use slops for irrigation include additional labor for monitoring slop application and increased weeding. There is also a decrease in fertilizer cost, since slops contain nutrients that augment the needs of the crops. The major concerns of farmers in accepting the technology are the possibility of water pollution and malodors especially from untreated slops. Slop irrigation has also brought about the enterprising activity of slop delivery. This requires coordination among distilleries, slop haulers, farmers, and local authorities.

In Vietnam, field experiments showed the adverse effects of raw slops on standing crops in the first few weeks after application due to high organic matter content, which decomposes in the soil. The canes, however, recovered until harvest time to reach desired growth targets. These results are novel, as previous experiments made use of newly planted crops, not standing crops.

While it has been shown that slops have economic value for agricultural use and that its environmental effect can be mitigated, there is still a need for policy adjustments, especially those governing the status of slops as a resource or a waste. In particular, clear standards are needed for slop utilization. The applicability of slops to other crops and other soil types needs to be investigated to arrive at a comprehensive policy for agricultural use of slops.

1.0 INTRODUCTION

Development brings with it transformation not only in economics but in ecological landscape as well. The journey from agricultural to agro-industrial development, which is the basic path traversed by agriculture-based developing economies, has put an enormous strain on the quality of their environment.

The expansion of industrial activities associated with development contributes to the already severe level of air and water pollution. If left to continue in its own course, the pollution problem is expected to be at a level that developing economies will be unable to curb. The fact that traditional pollution regulation is proving to be inappropriate is compounding the problem. For instance, regulatory institutions are often unable to enforce conventional discharge standards at the factory level and are cognizant that such standards are not cost effective because they require all polluting factories to tow the same line regardless of abatement costs and local environmental conditions.

These challenges drive environmental regulators in the economies to try fresh approaches and find new allies in the battle to curb pollution. In the Philippines, the state of environmental regulation is no different. Affected industries are therefore looking for alternatives to be able to clean their own mess while in the process contributing to economic development.

A particular case in point is a Philippine sugarcane-based distillery facing factory closure for failure to find an alternative option to dispose treated slops other than channel them into bodies of water. Factory closure is difficult to accept for an enterprise that had recently invested millions of Pesos on operational and infrastructural waste treatment system. This leaves not only the specific distillery in a bind but more so the surrounding sugarcane farming communities that are totally dependent on the said distillery's operation as market for their produce.

In search of better alternatives, the private distillery in partnership with SEARCA embarked in 1998 on a one-year research assessing the agricultural potentials of treated distillery slops as irrigation water and soil enhancer for sugarcane and paddy rice. Results show that slops application improved productivity in terms of increased tonnage, healthy growth stand and high percentage of juice sweetness in the case of sugarcane and increase yield for paddy. The added significance of the findings of the initial study is that it provided an opportunity for the problem of one to be the solution for the other. The farmer's problem of replenishing soil organic matter to attain crop production sustainability as well as irrigation water requirement are addressed by the distillery which, in turn, has the problem of too much slops with organic matter to dispose off. Moreover, reusing treated slops for irrigation highlights the waste management potentials in an agro-industrial supply chain for the greater benefit of the farming community and the value-adding distillery.

While the results and potentials were promising, there is an immediate need to look into the sustainability angle of the said option, both in economic and social perspective. In the system of using slops as irrigation for sugarcane, the possibility of contaminating water resources is present, even though it is not directly discharged into bodies of water and even if it has already passed a highly advanced wastewater treatment system. Concerns that are commonly raised in the use of slops for irrigation include surface and groundwater pollution when not properly managed; effect of the quality of irrigation water, particularly salts, on soils and crops; public health concerns related to pathogens; public acceptance; and marketability of the crops.

At present, the application of commercial fertilizer and irrigation is very limited due to its prohibitive cost to the farmers. Therefore, threats on soil, surface water and groundwater are lesser. However, once the use of slops for crops gains momentum and if the reuse is unregulated, the environmental impact of slops is expected to be greater.

Pathogens are not a risk with freshly generated distillery slops because of its high temperature, but if left unattended, as in the usual practice of distilleries, it can be a host for pathogens due to its high organic matter content. On the other hand, direct application to the farm in regulated amount will not be favorable for the growth of pathogens.

Since the slop reuse technology is new in the country, there are still no proper guidelines of using such new farming method that can lead to the indiscriminate use of slops. There is, for instance, that problem when farmers do not differentiate between treated and untreated slops whose impacts on crop yield and the environment are different.

An evaluation of the economic and environmental impact of this identified solution will enhance the adoption process and the regulation of the technology utilization, and hopefully solve both the problem of the distilleries and the sugarcane farmers. In the immediate vicinity of the distillery site under study is about 598 farming households that stand to gain or be negatively affected, depending upon how well the slop reuse is handled. However, with the technology being quickly adopted by farming households in the neighboring municipalities, if not appropriately regulated, the potential of slop reuse will not be maximized. This study addresses these concerns.

1.1 Research Objectives

This study looked into the economic and environmental impact of using treated distillery slops as irrigation to agricultural crops. The sugarcane farmers, who provide the raw materials, and the distilleries, are part of a supply chain or a network which contributes to the production and distribution of distilled alcohol and its by-products. The use of treated waste was anticipated to have implications on the operations of both.

The research included an assessment of the implications of such waste management method to the distillery supply chain. The applicability of the technology for industry-wide usage in the Philippines and for farm-level use in Vietnam was looked into.

In general, the study evaluated different levels of wastewater treatments using distillery slops in sugarcane fields in terms of economic and environmental impacts.

Specifically, the study:

1 Established the baseline conditions (in terms of costs of investment, effectiveness of waste treatment, and resultant environmental costs) for two scenarios: a) uncontrolled/unregulated/minimum compliance for disposal of wastewater, and b) full compliance to Department of Environment and Natural Resources (DENR) standard for wastewater treatment;

2 Measured the environmental costs associated with the baseline scenarios and the alternative levels of wastewater treatment;

3 Estimated the net present value (NPV) of implementing different levels of wastewater treatment for the distillery;

4 Measured the net benefits to the farmers of using distillery slops treated at varying levels for irrigation in sugarcane farming;

5 Computed the net present value (NPV) of using distillery slops as irrigation water from society's perspective;

6 Proposed some variations to the DENR regulatory policy affecting operations of distillery companies in the country; and

7 Pilot-tested the application of distillery slops as irrigation water in Vietnam and assessed its production impact.

1.2 Significance of the Study

1.2.1 The Sugar Industry and Environmental Pollution: Cases of the Philippines and Vietnam

The Philippines and Vietnam, at varying levels, are affected by growing urban industries and the consequent rapidly degrading environment. Groundwater contamination limits potable water supply. Efforts to address industrial pollution are greatly dependent on basic understanding of the industries' development and national environmental policies.

Transitional economies like Vietnam, for instance, are in the same if not worse situations compared to developing countries like the Philippines, as environmental monitoring bodies are even in a disorganized state. More so, distillery firms are of the small-medium enterprise (SME) types, which are often operating on a cash flow basis and lacking the capacity to adopt environmental initiatives. A simple distillery alone with a 50,000-liter capacity of ethanol per day generates 350,000 liters of wastewater on the average, 22% of which are solid substances. It is expected that the situation will worsen as Vietnam is targeting a one million-tonne sugarcane production this year leading to higher production of molasses and alcohol.

The Philippine Sugar Industry

The sugar industry is a major sector of the Philippine economy contributing PHP 33.892 billion (USD 659 million) to the gross national product and earning PHP 14.472 billion (USD 281 million) in exports. It provides direct agricultural employment to 556,000 people and industrial employment to 25,000 more Filipinos, giving a source of living to 5 million direct dependents (Sugar Regulatory Administration 2001).

Besides sugar, molasses is also produced after milling the sugarcane. In 1998, sugar mills in the Philippines that provide raw materials for some industries, specifically alcohol distilleries, produced 901,003 tonnes of molasses. Molasses is the main input needed in the production of ethyl alcohol, an ingredient used in the manufacture of alcoholic drinks like gin and rum.

In the Philippines, aggregate supply of alcohol is approximately 600,000 gauge liters per day or 360 million gauge liters annually. Alcohol is produced by 11 big distilleries that are controlled by two main companies. While originally, distilleries in the Philippines are concentrated in the Visayas region near the source of the raw materials, the region being the center of the country's sugarcane production, a number of distilleries have set up plants in Luzon to be near their markets. Transport from Visayas of carbon dioxide (CO_2), a by-product of distilleries catering to the Manila-based carbonated beverage companies is proving to be costly. Only three of the distilleries are independent in their operation.

For a sector that contributes PHP 3.6 billion (USD 70 million) of taxes annually from the production of 360 million-gauge liter of alcohol as well as secondary products such as ethyl alcohol and CO_2 for beverage production, the picture is bleak unless alternative solutions are arrived at soon (Manalili, et. al. 1999). It is a situation where to fully meet regulation requirement and to stay in operation, a distillery has to invest in costly wastewater treatment facilities or take the risk of paying penalties with minimum compliance. Either way, society at large is the loser as it has to shoulder the unnecessary high cost of production that will surely be passed on to consumers in the case of the former or suffer the effects of environmental degradation in the case of the latter.

In spite of a significant tax contribution to the national coffers, the Local Government Units (LGUs) or municipalities where distilleries generally operate take minimal benefits from these tax revenues. There is no direct benefit to the municipality where the distilleries are situated. In fact, only pollution effects of the distilleries are focused on. It is therefore not surprising that distilleries are negatively perceived by the local community and the fact that the latter have somewhat ridden the bandwagon clamoring for a "cleaner environment" is not helping to address the problem at source. Thus, apart from environmental regulation, there is likewise a need to assess economic taxation policies in support of a more sustainable and effective regulation. The need for an integrated approach of redirecting industrial taxes for the benefit of the directly affected LGUs and the corresponding communities is an example.

Environmental Regulation in the Philippines

In the Philippines, environmental management is a command-and-control measure anchored on two regulatory frameworks of environmental impact assessment (EIA) and environmental standards (and their monitoring). These frameworks, however, are not without their share of implementation problems. The EIA system does not have an effective conflict-resolution structure while the implementation of standards is lacking in consistency, effectiveness, and enforcement. Despite the stringent environmental regulation, the level of pollution of many public waters is increasing. River surveys conducted from 1989 to 1992 showed that 4% of the 125 rivers are already biologically dead (Batcagan 2000).

Two DENR Administrative Orders (DAO) govern effluent and water quality standards. These are DAO 34 (Series 1990) for water usage and classification/water quality criteria and DAO 35 (Series 1990) for effluent regulation with particular emphasis on surface water pollution specifically on industrial BOD. However, the regressive structure of the fines system defined under Presidential Decree No. 984 (PD 984) of the National Pollution Control Act for non-compliance to environmental standards encourages non-compliance more than reducing loads in the same manner that the lack of consistent monitoring and enforcement due to inadequate facilities and insufficient manpower provides an even bigger incentive for non-compliance.

Cognizant of the aforementioned policy flaws, alternative ways to effectively manage the worsening water pollution problem are being considered (Table 1). There is growing openness in trying out economic instruments, although several instruments currently being implemented are not thought of as policy tools according to Batcagan. He added that adoption of economic instruments, however, has been low due to some institutional, political and perception problems and that common objection arises from the perception that economic instruments, e.g., a pollution charge, give industries the "right to pollute". In the area of legislation, Batcagan added, the regulatory body is also not allowed to levy pollution taxes unless through congressional action; there are also restrictions in retaining and earmarking revenues collected from fines, penalties, and from the issuance of permit and licenses and that having been used to command-and-control, regulatory bodies are sometimes apprehensive of government losing control in cases where effluent charges are contemplated, or industry being made worse off or uncompetitive.

Table 1 Wastewater Management Policies.

Policy/Management System	*Status*	*Legal Basis*	*Description*
Environmental User Fee Program	Currently being implemented	PD 984 DAO No. 2002-16	• Focus on organic waste (BOD) • Enforced in the Laguna Lake • May encourage disposal of untreated waste due to high cost of treatment • Does not effectively encourage waste recycling • Does not cover disposal on both productive and idle lands
Wastewater Permitting System	Proposed	PD 984	• Can accommodate multiple pollutants • Internalized cost of pollution • Viewed as a "license" rather than a tax

The Vietnam Sugar Industry

Vietnam has undertaken massive investments in its sugar industry since 1995 with over USD 1 billion spent on milling capacity and infrastructure in sugar-growing regions. However, the Vietnam government is still concerned about the efficiency of its program and according to a study on its sugar program (Center for International Economics 2001), the industry is not making a net contribution to the economy but rather, it is causing net cost to the economy of around USD 80 to 120 million per year.

The huge loss the sugar industry is imposing on the economy is largely due to the number of small mills in the country. There are 28 small mills in Vietnam and because the factor of economies of scale is strong in the industry, increasing the size of mills as well as production is very important. The increase in size and production will increase the efficiency resulting in lesser cost per unit of sugar produced. Although they have large mills, the remaining mills are small according to world standards, costs are high, utilization of capacity is low and extraction rates are low.

Vietnamese cane and sugar yields are also low compared to world standards. Cane yield is estimated to be only 60% of leading cane producers whereas sugar production appears to be half. Vietnam uses nearly twice as much cane to produce one tonne of sugar as Australia. Further placing Vietnam at an international disadvantage , according to the same Center for International Economics (CIE) are inferior varieties, poor irrigation strategies, small-scale production, incorrect application of fertilizers and pesticides and poor harvesting coordination.

Environmental Regulation in Vietnam

At the national level, the Ministry of Science, Technology and Environment (MOSTE) has the overall responsibility for the environmental sector and serves as the focal point of all environment-related activities. The Environmental Committee (ENCO) and the Provincial Departments of Science, Technology, and Environment (DOSTE) support it at the local level.

Despite the formation of different government bodies to address the problem of pollution in Vietnam and the existence of environmental laws and regulations, the monitoring and the enforcement of the said laws is still weak. Among the major reasons for this weakness are the lack of budget, lack of resource person and experience to implement the law, and lack of proper equipment needed in the implementation.

The obsolescence of the equipment used by the firms add to the problem of weak enforcement and monitoring on the part of the government. Most factories began operating many years ago. Because of lack of funds, they have no wastewater treatment systems and the wastes are disposed directly to bodies of water causing heavy pollution. They also have no environmental experts and plans for improvement, making it difficult for them to comply with the standards. It is also very hard to change the mentality of the polluters in the area.

The water pollution in Vietnam can be classified into low, medium, high, and very high. The degree of pollution in the city is classified as very high. Because of this, the need to invest in cleaning technology and cleaner production system is of paramount importance to prevent further deterioration of the water quality in the city. Construction of wastewater treatment facilities is also needed as well as technology enhancing researches on food, drink, and the manufacturing industry.

Most of the distilleries in Ho Chi Minh City (HCMC) operate in small scale and cannot afford to acquire modern wastewater treatment facilities. This adds to the problem of pollution as the raw slops are being discharged into the environment.

1.2.2 Wastewater Reuse: Solution for the Farm and the Distilleries

The slop application technology in the Philippines, although quite new, can be adopted in HCMC and the study on the effect of their slops on sugarcane is the first step towards better management of their wastewater through use in agriculture. This environmental issue faced by the industry clearly shows a multi-dimensional agro-industrial problem which requires first, a technical solution to the immediate problem of pollution; second, an economic dimension which should provide a sustainable solution; third, a serious socio-cultural dimension which should establish a harmonious relationship with the immediate community that threatens its very existence; and finally, a policy dimension which should enable the government to take a more supportive action rather than always a regulatory stance.

2.0 REVIEW OF LITERATURE

2.1 Environmental Initiatives and Sustainable Development

Industrial pollution has always been a problem associated with economic growth and development. The usual thinking is that it is an inevitable outcome of development. While the battle against industrial pollution is on the uptrend, these are not without the concomitant high costs of regulation. For countries already confronted with poverty and economic growth problems, addressing environmental problems, according to the World Bank, are added constraints and resources used to curb emissions could also be used to build schools or train doctors. In some cases, misconceptions add to the difficulty of pollution abatement. Not many would know that an economy that depends largely on food and paper production (where most ASEAN countries can be categorized) poses a much greater threat of organic water pollution than one based on metals and non-metallic minerals.

Sustaining the trend is likewise an added concern, specifically in situations where there are barriers for industries to adopt environmental initiatives in a country. These barriers come in the form of minimal effort to develop incentives that will balance off disincentives, inadequate resource pricing (i.e., water) and lack of comprehensive environmental policies or if ever policies are in place, the lax enforcement and poor monitoring by government environmental institutions. To address these barriers and to make efforts sustainable, there is a need for a system of integrated management involving resources, people and consumer interest.

One way of ensuring that growth is environmentally sustainable, particularly in agriculture, is by paying more attention to: a) the sustainability features of recommended technologies; b) the broader aspects of natural resource management at the watersheds and landscape levels and c) the problem of resource poor areas (APCPA 1999).

Economic growth is the best assurance of sustainable development (Girt 1994). Improved productivity and improved earnings are the best supports that sustainable development can have, thus Girt added that there is a need to merge environment and economics into decision-making.

Following this line of thought, convincing supply chain stakeholders of the appropriateness of a generated waste management technology and consequently adopting the same requires translation of decision options into economic terms and efficiency measures. Questions as follows require answers:

How much waste management initiative can an industrial enterprise afford? How much savings, in terms of reduced farm inputs, are derived from the technology? How much will it cost the government to assess social benefits of pollution control to save life or the extent to which a community can bear with (tolerate) pollution?

Benefit cost studies (Pollution Prevention and Abatement Handbook 1998, Toward Cleaner Production) in Asia and Latin America show that pollution damage remains unjustifiably heavy given the low cost of abatement. The same studies show that more action is needed on three fronts, namely: regulatory reform, economic policy reform and better management within factories.

2.2 Waste Management as a Sustainable Agriculture Option

Looking into the potentials of wastes for other purposes like in agriculture is another option fast gaining grounds, specifically when the call of times is going back to basics. The use of distillery slops has been inching slowly to the area of agriculture here in the Philippines, especially in sugarcane farms. Farmers observed improvements on the growth of cane plant both on germination and on sprouting of ratoon, a new cane that grows from the stubble left behind after harvesting. Moreover, farmers commonly observe an apparent increase in the total tonnage harvested and in a study by Manalili et al. 1999, the increase in yield of sugarcane due to slops was estimated to be at 30 tonnes per hectare.

True to the observation of many sugarcane farmers in the eastern province of Batangas, Philippines, growth of sugarcane irrigated with slops really improved. The observed improvements in plant growth are brought about by the high nutrient content of slops, especially potassium as well as the water that slops contain. Sugarcane is a vegetative material. The growth of sugarcane is greatly dependent on water transpired thus availability of water during growth stages will give maximum yield. (Landon 1984)

While many farmers are aware of the possible pollution of groundwater and other bodies of water, nobody is as yet concerned about the danger of heavy application of slops. Heavy application of slops is anticipated to cause soil fertility problems. According to Johnson (1979), should the levels of nitrogen and potassium in the soil become excessive or out of balance with other plant nutrients, the following may occur:

1 Excessive vegetative growth,

2 Lodging,

3 Excessive non-protein nitrogen levels in crops, which causes digestive problems when fed to animals,

4 Delayed maturity, and

5 Lowered availability of magnesium due to excessive levels of potassium.

The long-term growing of sugarcane in many areas in the Philippines has significantly diminished the levels of nutrients in soil. Soil analysis in many sugarcane farms show low to very low level of organic matter. The diminishing soil nutrient level is aggravated by soil erosion. Farmers have no apparent solution to soil erosion.

Sugarcane growing in the Philippines is predominantly a monocropping system. It is common to see farms subjected to a three to four year cycles of one plant cane with two to three years of ratoons. The cycle is repeated without any fallow period. Thus, many of the sugarcane farms suffer from both infertility as well as nutrient imbalance. The nutrient imbalance is on account of heavy dosage of nitrogen application without corresponding application of other nutrients. Many researchers, extensionists and farmers are not adequately aware of the dangers of long-term negative phosphorous (P), potassium (K) and micronutrient balances (Dixon et al. 2001).

2.3 Waste Management Approaches

Slop utilization is a sustainable agriculture option where the waste is turned into a resource and where both environmental and land use concerns are addressed. Aiming at sustainable agriculture, however, calls for the integration of the environmental and agricultural policies (Miller 1998). These major approaches for integration, added Miller, are: a) advisory and voluntary approaches where adoption of environmentally appropriate practices rely on encouragement and persuasion, b) economic approaches where the fact that farmers tend to be responsive to the changes in the relative profitability of different products and the cost of production techniques is relied on, and c) regulatory approaches which are based on the setting of standards.

A wide variety of wastewater management approaches are practiced throughout the world but they can be classified into three broad categories namely decentralized local action, coordinate regional action and uniform national standard system (Table 2).

Table 2 Waste Management Approaches.

Decentralized	• A project-by-project approach driven by individual initiatives • May solve local problems but is often inefficient or not capable of addressing widespread problems or large systems • Usually the first stage in wastewater control is seldom adopted as a long-term approach
Coordinated Regional Action (or river basin)	• Most attractive in principle as it could lead to a comprehensive and cost effective program • Affords flexibility to set appropriate local standards within a national framework but requires a level of institutional sophistication
Uniform National Standards	• Hard to implement due to difficulty of apportioning allowable loads among discharges and of determining water quality violators though simple and affords uniformity in application • System where state sets water quality standards for different bodies of water and then set limits on discharges at loads consistent with quality

While many developing countries have adopted the uniform national discharge standards, these are often ignored as reported in the World Bank's Greening Industry – New Roles for Communities, Markets and Government. The lack of financial and adequate institutional resources will impose a cost-minimizing priority-setting approach in the short-term to medium-term. This needs to be carried out on a water body basis.

There are a number of ways by which wastewater pollution can be addressed according to Fukui et al., such as through local governments' pollution control agreement and private sector initiatives. The varying forms and structure of these agreements and initiatives by country are usually the first indication that the environmental problem has been recognised. As such, the capacities of these agreement/enforcement initiating agencies need be enhanced. Having pollution control agreements between businesses, local governments and even citizens is another option though this one is highly anchored on political will and social climate. The first two are less regulatory in nature than the pollution pays principle (PPP) approach, which is said to have contributed to the internalization of a market-based envivonmental response.

2.4 Various International Policies on Wastes

The significance of waste policies to the agricultural and commercial enterprises was overcast by reports of large increases in license fees and strict guidelines. These policies have specific requirements that impinge upon the development application stage and the ability of the developer to receive local government consent for the development to proceed.

According to Patterson and Lott (1999), licensing fees have two components: an administrative fee based upon type and size of activity with an incremental fee structure over two years. In many cases, the administration fee will be higher than the current fee. The second part of the license fee will be based upon assessable pollutant loads above a fee threshold. For the agricultural sector, these are currently set to zero.

Monitoring to determine assessable pollutant loads will become an essential ingredient in each operation and should primarily be associated with better management and decision-making rather than conformance requirements. In this way, real solutions and pollution reductions will be realized well before conformance monitoring is likely to indicate the need for remedial actions.

The issue of simply shifting the pollutants from bodies of water to the land is one of the concerns. This is due to poor appreciation of the factors relevant in determining the assessable pollution threshold values.

In recent years throughout the Organisation for Economic Cooperation and Development (OECD) taxes and charges designed to solve environmental problems have proliferated (Hamilton et al. 2002). For the most part, the development and implementation of these measures have not been based on systematic collection of quantitative information on environmental damage but on a broad consensus as to the critical areas that need to be addressed.

3.0 PROJECT SITE

For the purposes of continuity of study results and implications, the Philippine component was undertaken in Lian, Batangas, the same site where the previous SEARCA research was undertaken. Vietnam was selected as the other country site as it faces similar environmental concerns from its sugar refineries and distilleries. The Binh Loi Village, Binh Chanh District in Ho Chi Minh City was selected on the basis of slop availability and the presence of sugarcane areas where slop utilization has potentials.

3.1 Lian, Batangas, Philippines

The municipality of Lian is located in the western section or District 1 of the province of Batangas. The said district, which comprises of 8 other municipalities, is known as sugar, aqua culture, and tourism area. Lian has low flat land suited for lowland rice culture.

Of the 37,022 inhabitants, 82% live in the rural area. The town's agriculture includes livestock, poultry, fishery, and crops. It has 6,745 ha of agricultural land (74% of the total), of which only 276 ha are with irrigation. Sugarcane is the major crop, with a total area planted of 5,557 ha or 82% of the total agricultural land. The total sugarcane production is 107,987 metric tonnes of which 12,509 metric tonnes are surplus produce (Crop Year 1997).

The town has one sugar mill that processes the harvested canes. The molasses produced by the mill is then used by the three distilleries located in the town to produce alcohol for beverages.

3.1.2 Alcohol Distilleries and Slop Irrigation in Batangas, Philippines

Distilleries produce huge amounts of slops as they produce alcohol. The raw slops produced by the distilleries are high in BOD and usually very dark in color making it necessary to undergo treatment to lower polluting potential before being disposed of the environment. While undergoing treatment, slops are usually stored in lagoons built by the distilleries themselves. These lagoons serve as storage for slops before being disposed to the rivers usually located near the distillery.

There are currently three alcohol distilleries in the project site but only two are operating and are producing slops. However, it is very important to note that only one of the three distilleries in the area are confirmed to have treatment facilities necessary for the slops to be treated to required government standards before being disposed into the river.

Adverse effect on the river resources has resulted in public protests against the practice of disposing slops into river. This has prompted the distilleries to look for less damaging and more productive ways to dispose slops. Coupled with the lack of irrigation facilities for sugarcane plantation in the area, the idea of using slops for sugarcane growing cropped up. The practice started more than three years ago with farmers near the distilleries as the first users of slops as irrigation. Even without the scientific background on the new system, the farmers have confirmed good results on yield based on their experiences.

From the time slops was first used as irrigation, it has now been the preferred practice by farmers in the area due to its positive effect in yield and the reported decrease in the use of commercial fertilizers. The increased popularity of the slops has resulted in more demand for slops compared to the volume that the distilleries were originally producing. Due to current supply deficit, some farmers were unable to receive slops even if they are willing to irrigate it to their farms.

Slops can be delivered to the farms in two ways: by series of pipes or by system of tankers where slops can be stored and transported. The piping system can be adopted only for farms located within the immediate vicinity of the distilleries. Farmers request directly to the management for slops to be delivered to their farms. The slops are then pumped to the nearby requesting sugarcane field by using a series of pipes connected to the lagoons where slops are stored. The piping system is currently not being used as the distillery possibly adopting the system of delivery is out of commission.

The delivery system presently being used is through the use of tankers, which can deliver slops even to plantations distant to the distillery where the slops are produced. In this delivery set up, there is a middle group between the distillery and farmers. This group is separate from the distillery itself but is commissioned to manage and oversee the delivery of slops to the farms. Sugarcane farmers direct their request to the haulers instead of the distillery. The requesting farms are then evaluated based on certain criteria most notable of which is the distance from populated areas like group of houses, commercial establishments, schools, and buildings. This criterion was arrived at from consultation with local community leaders and is specifically important since the system is currently being used for delivery of untreated slops.

At the current set-up of slop distribution, the farmers do not pay for any of the slops delivered or any delivery cost the haulers may incur. The distillery is just too happy that their slops are being used as irrigation instead of being disposed into river, which may cause serious environmental concern and subsequently closure of the firm by the regulatory body.

It is also important to note that distilleries do not alter slops composition as to make it more of a fertilizer than irrigation. Further development of the technology, however, may lead to farmers buying the slops as liquid fertilizer instead of receiving it for free.

Reports of bribing drivers of the tankers may be the cost of the slop delivery but this is based only on few interviews and observations. Due to the increasing demand for slops, some farmers resort to bribing to get top priority on the delivery. Bribing the drivers entails lesser cost than providing irrigation and buying commercial fertilizers which are the consequences of non-delivery of slops.

3.2 Binh Loi Village, Binh Chanh District, Ho Chi Minh City, Vietnam

The Bin Chanh District is composed of 19 villages and one small town occupying 30,472 ha. It is in the rural area of Ho Chi Minh City whose main source of livelihood and income is agriculture. The standard of living is low compared with the other districts of Ho Chi Minh City, formerly Saigon, the capital of South Vietnam.

In Binh Loi village, one of the villages of Bin Chanh, the main crop is sugarcane with production reaching 55-60 tonnes per hectare on the average. Fourteen small private sugar refineries and distilleries for alcohol process them. Binh Loi was chosen as a farm site to demonstrate the use of distillery slops as irrigation in sugarcane fields because of the availability of slops, a waste product of distilling alcohol, produced by the distilleries in the area. It is also easily accessed for conducting monitoring activities on the status of the demonstration farm.

The Post Harvest Technology Center, the collaborating institution, located in Ho Chi Minh City, oversees and manages the establishment of the demonstration farm in Binh Loi.

4.0 METHODOLOGY

The study took off from the results of the previous SEARCA research where the technical feasibility of the use of treated slops for agricultural purposes as a distillery waste management option had been established. The SEARCA study confirmed the technology that slops could significantly increase yield of paddy rice and sugarcane when used as irrigation. In the case of the sugarcane, the increase in the height, number and weight of millable stalks, and diameter of the canes have resulted in the increase in tonnage per hectare. More importantly, an increase in the sweetness of the juice (BRIX) has also resulted from the use of slops as irrigation.

This follow-up study looked into varying ways of treating slops or the waste treatment option possible for a given distillery. The methodology is schematically shown in Figure 1. As an envisioned industry-led and community assisted model of waste management, the objective was to determine the treatment option that will render the least cost for the distillery in terms of investment and will give the most benefit in the form of production but which will minimize the effect on the environment, particularly on the water resources since the slops will be used as irrigation. The effect of the different options on the farm and community level was also taken into account for analysis.

The Philippine site where all the research initiative started is where the expanded activity to cover economic and environmental impact of the study was undertaken. Thus, this Philippine component dealt with the evaluation of the various treatment options of a distillery. The Vietnam component, on the other hand, served as the venue for exploring further the technical boundaries of slop utilization given varying stages of crop growth and field situation. It likewise focused on the establishment of the technical viability of using untreated slops as irrigation water under the existing farm practices of the country. Both sites, however, provided cross-cultural policy insights in addressing an environmental concern in an agro-industrial setting where environmental policies are still in the development process. These insights served as the basis for the study's policy recommendations.

4.1 Estimation and Analysis of Benefits and Costs

In as much as the wastewater treatment options were evaluated primarily from the perspective of the adopting distillery, financial analysis was used to establish the appropriate firm option. Benefits and costs of the different alternatives to the distillery were valued and used in financial analysis to determine the appropriate option on the firm’s point of view. Two assumptions were made in the analysis: one is where firms are strictly required to pay the penalty for any exceedance to waste water quality standards, and the other, when penalty for violations are not strictly enforced.

Considering that the waste treatment option is linked with the slop utilization at the receiving farm, financial analysis was likewise used in the evaluation at the farm level. Financial benefits and costs to the farm with and without slop irrigation was estimated and used subsequently in the social benefit-cost analysis to show the overall beneficial effect of using slops for irrigation.

There are various methods in estimating the economic impacts of the slop irrigation in sugarcane fields, namely, market-based techniques, cost-based techniques; travel cost techniques, and contingent valuation technique. In this study, the market-based method was used specifically to measure the value of the change in production, increase water availability, and the residual soil fertility due to slops application. Similarly, actual market prices were used in measuring the value of impact on the environment.

The impacts of slops irrigation on the environment was valued using cost technique that is the costs that will be incurred by the distillery to undo the damage (i.e., river clean-up after receiving run off from application of slops on agricultural land to meet requirement standards of color and BOD). Resultant Net Present Value (NPV), Benefit Cost Ratio (BCR), and Internal Rate of Return (IRR) of the treatment option were calculated. Note that values for these measures were arrived at as incremental to base values.

For purposes of assessing the overall impact of the waste treatment options to health and environment and considering that the distillery are presumed to take responsibility to whatever damage created, a social benefit-cost analysis was undertaken in the study. In this analysis, both the effects on the distillery and the farm were considered; the environmental costs and benefits involved in each WMA were also used. Unlike the previous assumptions where firms only resort to payment of penalty for any violation of wastewater standards, it is assumed here that firms are mandated to undertake wastewater treatments. The analysis was done using the incremental changes of the benefits and costs in relation with the identified baseline condition.

4.2 Evaluation of the Impact on the Hydro Ecological Resources

Technical evaluation on the effect of slops on the hydro-ecological aspect of the environment was conducted. This included analysis on surface and groundwater resources, and soil resources involving actual site measurements and simulation studies.

a. Data Collection

Two major activities were performed in establishing the possible effects on the surface water resource. The first activity involved a measurement of the quality of the river adjacent to the farms by taking samples from different points and analyzing it for color and BOD level. The second activity involved the measurement of the quality of runoff water (color and BOD) where several plots were randomly selected from the existing sugarcane fields for both untreated and treated with slops. Water was applied on the selected plots to simulated runoff conditions. Water samples were then collected for analysis.

A simple simulation was also performed to predict possible BOD loading at the downstream condition. Streeter-Phelps for multiple-point sources were used in the simulation.

The data collected to establish possible impact on the groundwater resources include: 1) water analysis on selected wells within the project site, and 2) soil analysis of farms untreated and treated with slops. The water analysis included color and BOD. These parameters gave an indication on the level of contamination from the slops. Water samples were taken from at least five existing wells. For the soil analysis, core samples were taken, three from each randomly selected farms, which are untreated and treated with slops. Analysis included only color and organic matter (OM) level to determine the extent of contamination.

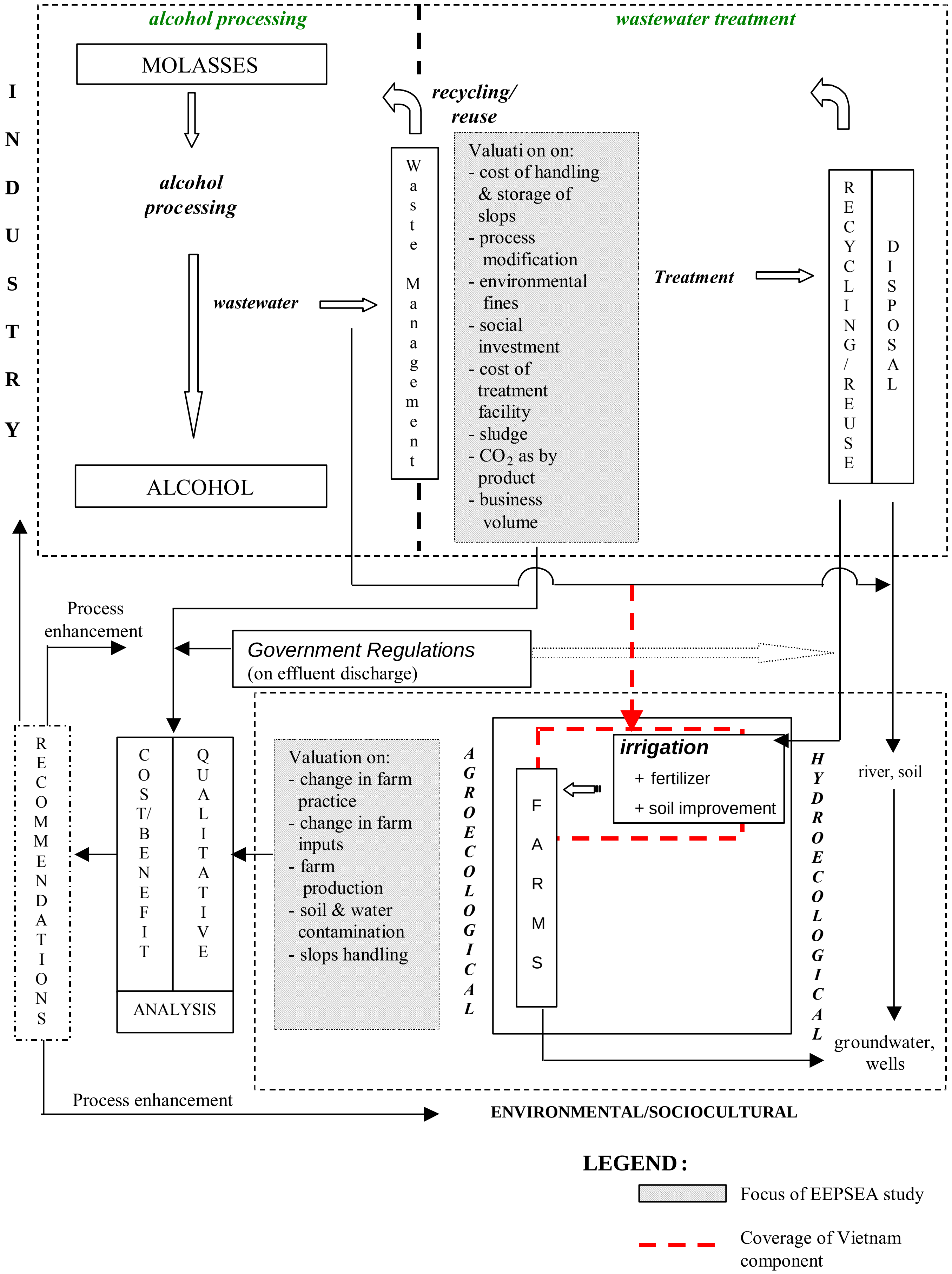

Figure 1 Schematic Diagram of the Methodological Framework.

b. Data Analysis

Results of the primary data collection were evaluated in relation to the results of the previous lysimeter study and water analysis. The level and extent of contamination on the hydro ecological resources of the project site were projected for the continuous application of slops in the farms. The effects were quantified mainly based on the color and BOD concentration using established associated impacts that are commonly caused by these parameters. Color normally reduces the utility of the water resource while BOD indirectly indicates the organic concentration of water that is normally an undesirable trait if water is to be used for drinking and some other contact use. Also, authorities have used BOD as a primary parameter for evaluating the level of pollution of water.

The simulation study on runoff was used to project the possible level of pollution of the surface water or river. Existing local values were established on the surface runoff and soil erosion to further establish the possible impact of the application of slops.

The result of the data collection and data analysis on the ground water quality was used to formulate ways preventing possible contamination. These included the amount and cycle of slop application so as to maintain the filtering effect of the soil; the change in the cultivation practices so as to reduce runoff and erosion problems; and proper well construction.

4.3 Farm Survey

A farm survey was undertaken to determine technical and socio-economic impact of the use of slops for agricultural purposes with users of treated and untreated slops as respondents. Those who were slop recipients of the previous study formed the respondents for users of treated slops while untreated slops respondents were farmers in the vicinity who were serviced by other distilleries. Twenty-two farmer-users of treated slops and only four untreated slop users were included in the survey. The former is almost a complete enumeration of treated slop users while the small sample of the latter is due to problems and constraints outside the control of the project team (refer to problems encountered in the survey). For comparative purposes, questions on farming practices before and after the use of slop irrigation system were included in survey.

4.3.1 Agro-ecological

Two types of survey were conducted for the agro-ecological part, namely: 1) land resource survey, and 2) key informant survey from a pool of sugarcane farmers. The land resource survey was intended to evaluate sugarcane farm conditions relative to the growing of sugarcane. This was accomplished by first gathering secondary data, which included, among others, soils map, land use map, climatic map, and irrigation infrastructure. Upon the analysis of the above information, selected sugarcane farms were identified and subsequently visited for the evaluation of the following land qualities: workability, water availability, terrain, rooting condition, nutrient retention, nutrient availability, flood hazard, soil borne pest and diseases, and accessibility.

The key informant interview was done to assess the adjustments done by the farmers in growing sugarcane with the use of slops as irrigation. This part of the study uses two groups of farmers: 1) those that receive slops through established piping system and 2) those receiving slops from tankers delivered by private organization. For purposes of comparison, non-slops users were also included in the survey. The farms of those interviewed were included in the land resource survey.

Slops applied on sugarcane were evaluated also according to irrigation quality as well as fertilizing value. Assessment of slop quality as irrigation water depended principally on the plant response. Slop was analyzed for its nutrient content, to ensure it does not contain harmful substances that will affect plant growth. In addition, results of slop analysis were evaluated relative to the results of soil analysis to establish adequacy of nutrients available for plant use. Soil samples were collected for analysis before and after harvesting the canes in selected areas. This was done to determine available nutrients for the crop as well as residual nutrients in soil that may benefit succeeding crops. The study likewise assessed adjustment in terms of cultural practices in response to slops use for irrigation.

4.3.2 Socio-cultural Aspect

For the socio-cultural component, the following activities were done: 1) field reconnaissance and initial interaction with farmers, 2) collection and analysis of secondary data, 3) informal discussion with local officials, i.e., municipal planning development officer, municipal agriculture officer, 4) development of guide questions for the semi-restructured interview, 5) semi-structured interview with key informant farmers, and 6) formulation of recommendations to enhance utilization of the technology of applying treated distillery slops as irrigation water. Key informants include relatively long-time users of treated and untreated slops for sugarcane, leaders of affected community, and some households. The information gathered from the mentioned activities was used in the analysis of the socio-economic aspect of the project that include determination of the technology acceptance among farmers and the community and institutional effect of the said technology.

4.3.3 Problems Encountered in the Survey

The current situation of the slop irrigation system in the province of Batangas, Philippines is on a distillery-farmer basis. Certain farmers are tied to one distillery where they get their supply of slops. Studies on the use of slops in the area involves team-ups between the distilleries and research groups. The supply of slops tie the farmers to the distillery-researcher team-up and thus have limited the sharing of information about the research topic. Because of this set-up, the research team had a difficult time surveying slop-irrigated areas where other researchers and distilleries operate. This is especially true with respondents who use untreated slops unlike users of treated slops who were already part of the previous study. This situation has resulted in minimum information gathered from other areas and other users of slops.

5.0 VIETNAM COMPONENT (FIELD EXPERIMENTS)

In the Vietnam component, field test of the technology was undertaken for the purpose of determining other factors that may come into play in the slop utilization amidst a different farming system and environmental regulatory set-up. The use of untreated slops likewise provided the basis for comparison against the treated slops utilization in the Philippine component.

Field experiment on the use of slops as irrigation for sugarcane was done to determine its effects on the growth of standing sugarcane crop. This is very different since the empirical data from Philippines were based on slops irrigated on newly planted or recently ratooned cane. In the Vietnam study, slop was applied to two-month-old canes using the following treatments:

Treatments:

1. Control experiment: Water irrigation –control water from the drain.

2. Volume of slops irrigation: 200 tonnes per hectare.

3. Volume of slops irrigation: 400 tonnes per hectare.

4. Volume of slops irrigation: 600 tonnes per hectare.

The volume of slops per treatment was divided into two equal amounts and irrigated to the crops at different stages of growth. This was done as there were signs that the young plants are unable to withstand the large amount of slops initially applied. After slop irrigation, the sugarcane field was watered for 7 days, irrigating once a day with 40 m^3 per hectare.

The experiment was done in small and large scales. In the small-scale trial, the slop treatments were applied on a completely randomized block and replicated three times. Simple randomization was the one used in the large-scale trial.

Slop samples were collected and analyzed to determine their nutrient content. Likewise, soil samples from the field experiments were also taken for analysis. The following properties were determined: pH, organic matter, cation exchange capacity (CEC), phosphorous content, exchangeable potassium, exchangeable calcium, exchangeable magnesium, and exchangeable sodium.

The crops were observed and the following growth parameters were measured: plant height, leaf and stalk colors, stalk diameter, and stalk yield. These parameters were measured at a specific time interval from the time of the slops application to standing crops up to the time of harvest.

6.0 RESULTS AND DISCUSSION

In the succeeding discussion of the results, there are several references made to a Plant (firm or distillery), which is the basis for coming up with the alternatives discussed below. The Plant is hereby described to establish the basic features of the distillery, which has the option to adopt different waste management alternatives.

The distillery plant is a typical plant having a distillery and an ancillary section. The distillery section converts sucrose of molasses into ethyl alcohol and produces carbon dioxide as by-product. The ancillary section treats the waste product, producing yeast and biogas.

The distillery section has two processing sections, the fermentation and distillation sections. In the fermentation section, the sugar in the molasses is converted through the enzymatic action of yeast, a biochemical process. The resulting alcohol liquor from this section, termed as 'beer', is then pumped to the distillation section for recovery, purification and concentration of alcohol.

Three columns in the distillery section perform distinct and separate functions. The stripper or 'beer still' exhausts the beer of all traces of alcohol. The purifying or aldehyde column separates the lower boiling constituents such as aldehydes from the higher boiling fraction and further concentrates the ethyl alcohol. An additional column can be added, to concentrate the low boiling impurities earlier extracted to 94.5% alcohol.

6.1 Waste Management Alternatives

Five identified WMAs that can be adopted by the Plant were evaluated and they are as follows:

WMA 1 is the direct application of slops to sugarcane fields without treatment except for cooling of the wastewater. Cooling is required due to high temperature of wastewater reaching more than 70°C.

WMA 2 uses anaerobic treatment before the slops are applied to sugarcane fields. This alternative also has a biogas recovery component.

WMA 3 uses a combined anaerobic and aerobic treatment in series before the slops are applied to sugarcane fields.

WMA 4 uses the same series of treatment as WMA 3, but with recycling of wastewater. Recycling is not applied for WMAs 1 and 2 since the wastewater from these alternatives will not pass the quality requirement in the processing of alcohol. The series of anaerobic and aerobic treatment will be sufficient for satisfying the quality requirement of the recycled wastewater.

WMA 5 uses the same series of treatment as WMA 4 and is also with recycling. Additional lagoons, however, will be provided as an added treatment for the wastewater before these are applied to the sugarcane fields.

The choice of the different alternatives with their features and implications are presented in Table 3. These were based on the existing set-up of the Plant. The Plant is currently equipped with a state-of-the-art wastewater treatment plant employing a series of anaerobic and aerobic treatment with biogas recovery.

Alternative 1 (WMA 1) has been considered as an option since the sugarcane farms may benefit from the high organic content of the slops. Also, most distillery plants in the country are not fitted with the same kind of wastewater treatment plant (WTP) as the Plant studied, and therefore the economic and environmental evaluation on this alternative can serve as baseline information for other plants.

Alternatives 2 to 5 (WMAs 2 to 5) provide options wherein the major components of the WTP of the Plant are utilized piece-by-piece up to the complete WTP level that the Plant is currently utilizing. This will provide information on the level of treatment to be applied, if ever needed, to make the utilization of slops for agriculture economically and environmentally acceptable.

Table 3 Description and Implications of the Waste Management Alternatives

Waste Treatment Option	*Feature / Description*	*Implications to distillery*	*Implication to farmers**	*Environmental effect*
WMA 1	W/o treatment	• no additional operating and maintenance cost • additional investment on cooling ponds	• high nutrient content	• high BOD load and dark color of slops
WMA 2	Anaerobic treatment	• additional investment on methane reactor • additional operating cost • additional income from biogas production	• reduced nutrient content	• reduction in BOD load and color
WMA 3	Anaerobic treatment and aerobic treatment (without recycling)	• additional investment on methane reactor and aeration tank • higher operating cost • additional income from biogas production	• further reduction in nutrient content	• further reduction in BOD load and color
WMA 4	Anaerobic treatment and aerobic treatment (with recycling & process improvement)	• additional investment on methane reactor, aeration tank, and system modification • additional operating cost • additional income from biogas production and increase alcohol production	• further reduction in nutrient content	• further reduction in BOD load and color • less production of wastewater due to recycling
WMA 5	Anaerobic treatment, aerobic treatment and lagoon (with recycling & process improvement)	• additional investment on methane reactor, aeration tank, and system modification • additional operating cost • additional income from biogas production and increase alcohol production	• low nutrient content	• further reduction in BOD load and color • less production of wastewater due to recycling • further waste processing with lagoon

*The more complete the treatment, the lower nutrient content of the slops.

The characteristic of the wastewater from the distilleries exceeds the allowable limits set for effluents. However such effluent standard applies only for direct disposal of wastewater to bodies of water and is silent on the standards on the disposal to agricultural lands. Thus, the agricultural alternative will make WMA 1 as well as the other WMAs not employing complete treatment as probable disposal option. Nonetheless, the environmental evaluation that was conducted on the different alternatives included measurements and approximation on the concentration of slops and its possible threat to the environment after it has been applied to sugarcane fields.

6.1.1 Variations in the Quality of Slop from the Various WMAs

Due to the different levels of treatments that were applied to the various WMAs, it was expected that there would also be variations in the quality of slops. Table 4 shows an analysis conducted on the slops at various levels of treatment from the existing wastewater treatment plant of the distillery.

Table 4 Analysis of Slops at Various Levels of Treatment Obtained from Existing Wastewater Treatment Plant.

Type of Treatment	*Parameters*					
	BOD_5 (mg/l)	%OM	%N	Avail P (ppm)	Exch. K (meq/100g)	Color (Pco)
Raw Slops	57,500.00	4.31	0.376	10.12	12.26	47,500
Anaerobic Treatment	7,030.00	2.43	0.295	9.32	11.32	36,290
Anaerobic + Aerobic Treatments	825	0.46	0.191	5.27	7.13	32,185
Anaerobic + Aerobic + Lagoons	265	0.262	0.187	5.2	5.19	27,302

These variations in the quality of slops will have impact, both on the environment as a pollutant and on the sugarcane field as a production input. It can be seen in the same Table that a more complete treatment will be more desirable for the environment, but may be less desirable for agricultural production. Therefore, further tests were applied to determine the most desirable alternative, environmentally and economically.

6.2 Benefits and Costs to the Distillery of the WMAs

The five waste treatment options were evaluated in terms of the potential cost and benefits to the distilleries. To determine the option most financially advantageous to the distilleries, a financial analysis was done.

6.2.1 Benefits to the Plant

Earlier discussion mentioned that besides alcohol, the distillery also produced biogas. Net sales from alcohol production for WMAs 1 to 3 were estimated at PHP 105 million (USD 2.04 million) at a daily production of 50,000 liters. For WMAs 4 and 5, net sales will be higher by PHP 3.7 million (USD 72,097) due to wastewater recycling (Table 5). Additional benefits of around PHP 4.05 million (USD 78,778) can be realized from WMAs 2 to 5 due to the production of biogas from the anaerobic treatment of the slops. Benefits due to reduction in the concentration of the various slop parameters, like BOD_5, were presented in the latter part of the study results.

Table 5 Summary of Benefits from the WMAs.

WMA	*Added Benefits (PHP)*		*TOTAL ADDED BENEFIT OF WMA*
	Alcohol Production	*Biogas Production*	
1	0	0	0
2	0	4,050,000	4,050,000
3	0	4,050,000	4,050,000
4	3,706,500	4,050,000	7,756,500
5	3,706,500	4,050,000	7,756,500

Note: 1 USD = PHP 51.41

6.2.2 Cost to the Plant of the Wastewater Management Alternatives

Since the waste management alternatives described earlier entailed costs, it is necessary to present these costs in assessing the WMAs particularly the option with slop distribution for agricultural use. The investment costs provided an initial picture of the financial viability and cost effectiveness of each WMA. Then a benefit-cost analysis was done to determine the best alternative for the distillery to adopt in the long run. In this analysis, the cost of cleaning and the corresponding fines and penalties that will result from the use of their slop were included. This was done to include the negative externalities brought about by the slop irrigation system.

Investment Cost

Table 6 shows a summary of the costs of the various WMAs.

Table 6 Investment Cost of Wastewater Management Alternatives (WMAs) Distribution.

COSTS	*WMA (PHP)*				
	1	*2*	*3*	*4*	*5*
Investment					
Methane reactor	0	54,000,000	54,000,000	54,000,000	54,000,000
Aeration tank	0	0	36,000,000	36,000,000	36,000,000
Cost of lagoons	0	0	0	0	10,000,000
Cost of treatment					
(includes MOE)	0	3,150,000	5,100,000	5,100,000	6,000,000
Cooling ponds	773,806	0	0	0	0
System modification	0	0	0	4,500,000	4,500,000
Cost of Distribution	112,000	112,000	112,000	110,697	110,697
TOTAL COST	**885,806**	**57,262,000**	**95,212,000**	**99,710,697**	**110,610,697**

Note: 1 USD = 51.41 PHP

The major costs for WMA 1 include the construction of cooling ponds [PHP 773,806 (USD 15,052)] and the establishment of irrigation system [PHP 112,000 (USD 2,179)] for slops application. The total capacity of the cooling ponds is 6,729 m^3, which can store an equivalent of seven days of slops generated by the Plant. The seven-day period for storage is based on a minimum of seven days irrigation interval.

For Alternative 2 (WMA 2), the major costs include PHP 54 million (USD 1.05 million) for a 4,500 m^3 methane reactor, PHP 3.15 million (USD 61,272) cost of operation, and PHP 112,000 (USD 2,179) cost of sprinkler irrigation system.

Aside from the PHP 54 million (USD 1.05 million) cost of methane reactor, WMA 3 will require an additional PHP 36 million (USD 700,253) for the 6,600 m^3 aeration tank, PHP 5.1 million (USD 99,202) operational cost, and PHP 112,000 (USD 2,179) cost of sprinkler irrigation system.

WMA 4 will entail the same PHP 90 million (USD 1.75 million) cost of WTP as in WMA 3, and the same operational cost. It will also require an additional PHP 4.5 million (USD 87,532) outlay due to the required modification in the processing as a result of wastewater recycling. The cost of installation of sprinkler irrigation system is lower at PHP 110,697 (USD 2,153) due to the decrease in area of sugarcane farm that can be served, also as a result of wastewater recycling.

The required investment of PHP 100 million (USD 1.95 million) of WMA 5 is higher compared to WMA 4 due to the additional cost of lagoons. Also, the operational cost is higher at PHP 6 million (USD 116,709) while the costs of modifying the processing and setting up of sprinkler irrigation is the same with that of WMA 4.

The installation of an irrigation system was included as a cost to the distillery in all of the alternatives as a form of goodwill for being allowed to dispose of or irrigate the slops to the adjoining sugarcane fields.

It is evident from the Table presented above, with only the cost to the distillery as a basis that it will be costlier if a more complete wastewater treatment (Alternative 5) is adopted.

6.3 Economic Impact of Slop Irrigation in Sugarcane

6.3.1 Economic Benefits of Using Slops as Irrigation

Increased Sugarcane Production

In valuing the effect of slop in the yield of sugarcane, two factors are usually considered: the number of tonne cane per hectare which is the most common basis of measuring the yield of any crop and the piculs sugar per tonne cane (ps/tc) which is a measure of the actual amount of sugar that can be extracted from certain amount of cane. Tonnage enhancement is somehow within the control of the farmers. Even with good farm practice, the ps/tc enhancement is not that easy to attain. This is because it depends on the quality of the juice from the harvested canes and is usually determined in the laboratory of the distilleries. In the Philippines, sugar mills often dictate ps/tc leaving the sugarcane farmers without means to validate whatever is dictated. While this factor is very important in valuing the increase in yield (since the price paid is based on the number of piculs), the said measure, however, cannot be used in the absence of readily available data.

A previous study result where sugarcane yield increased (from 100 tonnes to 130 tonnes per hectare or a net increase of 30 tonnes of sugarcane per hectare) when slops was used as irrigation was further validated by the survey conducted between users and non-users of slops. Yield of non-users of slops averaged only 95 tonnes of cane per hectare compared to 123 tonnes per hectare harvested by the users of slops or a net increase in yield of 28 tonnes per hectare.

For purposes of estimating the total value of the increase in yield of sugarcane due to slop irrigation, the result of the survey, which is 28 tonnes per hectare, was used together with the survey-generated average ps/tc of 1.0 (not to mention that ps/tc normally increases by 25% or more as harvesting covers more mature cane towards the latter part of milling season) with the given average price per picul of PHP 830 (USD 16.14). Thus, on a per hectare basis, the value of the increase in sugarcane production due to slops irrigation is PHP 23,240 (USD 452) for one cropping or one year. Having estimated the area that a distillery can service in one year as 135.92 ha and given the volume of slops generated, the total benefit from the increase in sugarcane production resulting from the use of slops as irrigation material is PHP 3,158,780 (USD 61,443).

Increased Water Availability

The recommended amount of irrigation for sugarcane is 1,277mm per hectare and this can easily be provided by application of slops in case of water unavailability. While it is difficult to value this sudden availability of water from slops, one practical method of doing so is to equate it to the cost of irrigating sugarcane farms when there are no slop applications. On a per hectare basis, the increase in water availability owing to slops is valued at PHP 800 (USD 15.6) with the average irrigation expense incurred by farmer using ordinary water as basis. However, this value is applicable only if slops are given and delivered free of charge as what the set-up presently is. The moment the distilleries start charging fees for the delivery and usage of slops, the benefit from slop in the form of water availability will be eroded and will now be viewed as cost of irrigation.

The increase in the yield is likewise attributable partly to the increase in available moisture for the crops, given an optimum amount of moisture needed for maximum plant growth that can be obtained from slops.

Residual Soil Fertility

Previous study results revealed that slops have fertilizing value. To avoid double counting of benefits arising from enhanced soil fertility, which is already accounted for by the increase in yield, the residual soil fertility brought about by slop application was valued. These residual nutrients are the excess nutrients from the slops that remained in the soil even after the crops have been harvested and are expected to still have a positive effect on the next cropping of the canes. Estimates of the residual value were based on the soil analysis after harvesting.

The observed difference on soil fertility (noted as %OM, P, K) between areas with and without slops application measured after harvesting, was included as additional benefit in slops application to sugarcane. Quantification of soil analysis uses the critical values of major nutrients in soil (Table 7) and the SRA fertilizer recommendation. It was assumed that the succeeding crop (plant cane or ratoon crop) would be benefited by the high soil fertility analysis of areas applied with slops.

Table 7 Critical Values of Major Nutrients in Soil.

Nutrient	*Rating*		
	High	*Medium*	*Low*
PH	8.0 – 7.0	7.0 – 5.5	< 5.5
Organic Matter (%)	> 4.5	3.5 – 4.5	< 2.0
CEC (meq/100g)	40 – 25	25 – 15	< 15
Avail P (ppm)	> 21	20 - 12	< 12
Exch K (meq/100g)	0.8 – 0.4	0.4 – 0.2	0.2 – 0.03
Exch Ca (meq/100g)	> 10	10 – 4	< 4
Exch Mg (meq/100g)	> 0.5	0.5 – 0.2	< 0.2

Table 8 shows the increase in residual soil fertility due to slops application. Note that the analysis shows only empirical result for the treated slops in general. No analysis was done on a per WMA basis due to limitations in data itself (possible alternatives were identified but not necessarily existing in the project site).

Table 8 Residual Nutrients due to Slops Irrigation.

Soil Properties	*Untreated Soil Sample (Intial)*	*Slops treated soil after harvest*	*Residual*	*Equivalent Amount of Nutrients (per hectare)*			
				(in Kg/ha)	*(in 50-kg sacks fert)*	*price per sack**	*Value (in PHP)*
Organic Matter (%)	1.67	2.03	0.36	187.5	8.3	494.4	4,118.4
Avail P (ppm)	7.66	19.99	12.33	5,860.9	5.7	535.5	3,036.3
Exch. K (meq/100g)	1.14	3.87	2.74	2,560.0	85.3	545.9	46,581.6

Note:

*Subsidy on prices of fertilizers removed.

**For valuation of equivalent nutrients, the following commercial fertilizers were used

Nitrogen (N): Urea

Phosphorous (P2O5): Solophos

Potassium (K2O): Muriate of Potash

1 USD = 51.41 PHP

The residual nutrient effect of the slops was due to the high amount of the nutrients itself contained in slops that were not fully used up by the sugarcanes even without the use of commercial fertilizers. Based on the computations, potassium has the largest amount in terms of value with PHP 46,581.6 (USD 906) per hectare followed by nitrogen and phosphorous. In terms of volume of nutrients, phosphorous has the largest amount with the residual equivalent to 5,860.9 kg of P_2O_5 per hectare.

6.4 Environmental Effects of Slop Irrigation

6.4.2 Impacts on the Water Resources

The impact of the different WMAs on the water resources of the area was evaluated based on the possible contamination of water resources (river and groundwater) due to surface runoff and leaching. Contamination of the water resources due to direct discharge of slop was not considered, since the slops will be fully utilized to irrigate the adjoining sugarcane areas.

Results of the lysimeter test from the previous study (Table 9) show high reduction in the concentration of various parameters in the slops when applied to the soil.

Table 9 Results of Previous Lysimeter Study.

Parameters	*Untreated Slops*	*Leachate 1*	*Leachate 2*	*Ave. reduction (%)*
Color (Pco)	47,500	8,160	4,200	82.82
Turbidity (Ftu)	10,000	880	1,020	91.20
BOD_5 (mg/l)	57,500	10,983	7,303	84.10
%N	0.376	0.089	0.147	68.55
Available P (ppm)	10.120	2.409	2.530	75.60
Exch K (meq/100g)	9.260	3.598	3.088	63.90
TDS (mg/l)	580	163	167	71.90
Conductivity (mS/cm)	1,280	360	340	71.88
Percolation (mm/day)		3.3	2.7	

The high reduction in the concentration of the various wastewater parameters (color, BOD_5, etc.) due to its application to the soil will also result in a possible reduction in the contamination of both surface and groundwater resources during episodes of runoff and leaching.

The results of the modeling performed to determine the variation in the quality of runoff and leachate water as they come in contact with soils irrigated with slops from the different WMAs are presented in Table 10.

Considerable reduction in concentration BOD_5 is predicted for both runoff and leachate. Values for WMAs 3 to 5 can, in fact, satisfy effluent standards. The high color concentration remains the main problem. Even with complete treatment at WMA 5, the color concentration is well above the standard.

There is considerable reduction also in the case of the major nutrients N, P and K. On this aspect, it is both favorable from an environmental and economic point of view. Reduction in nutrient concentration in the runoff and leachate indicates retention of these nutrients in the soil leading to possible absorption of the crops, and it also indicates less contamination of the environment.

Table 10 Quality of Runoff and Leachate Water Obtained from Modeling.

Nutrients		*WASTE MANAGEMENT ALTERNATIVES*				
		1	*2*	*3*	*4*	*5*
Surface runoff	Color (PCo)	7,181	5,486	4,866	4,866	4,127
	BOD_5 (mg/l)	8,045	984	115	115	37
	%N	0.10	0.08	0.05	0.05	0.05
	Available P (ppm)	2.17	2.00	1.13	1.13	1.12
	Exch K (meq/100g)	3.90	3.60	3.60	3.60	3.60
Leaching	Color (PCo)	8,160	6,234	5,529	5,529	4,690
	BOD_5 (mg/l)	9,143	1,118	131	131	42
	%N	0.12	0.09	0.06	0.06	0.06
	Available P (ppm)	2.47	2.27	1.29	1.29	1.27
	Exch K (meq/100g)	4.43	4.09	4.09	4.09	4.09

6.4.1 Cost of the Impact on Water Resources

The impacts on the environment of slop irrigation were valued by estimating the cost that would be hypothetically incurred if the river and groundwater are treated to bring back to required BOD and color level after it has been contaminated by the slops. The process would be similar to taking the contaminated water resources to a treatment plant and bringing the quality to a standard level before discharging it downstream. This process of clean up is the responsibility of the distillery as the slops' ownership belongs to them even after discharges and/or irrigation to sugarcane fields.

River Pollution due to Runoff

Shown in Table 11 is the cost range of river clean up due to runoff or bringing back the color of the river to the desirable level per water management option. The results show that the cost of reducing the color ranged from PHP 42,739 (USD 825) to PHP 75,549 (USD 1,469) per hectare of sugarcane field irrigated with slops. The less treatment the slop undergoes, the higher the cost involved in cleaning up as shown in Alternatives 1 and 5 where Alternative 1 (no treatment before slop irrigation) registering the lowest clean-up cost compared to Alternative 5 (extensive treatment before slop utilization) with the highest.

In the process of reducing the color of the river due to runoff, the BOD level is also reduced although not to the acceptable level. In this case, additional cost will be incurred in bringing the BOD load of the river to the acceptable level. Similar to the case of color, the cost of cleaning up for BOD also decreases as the alternative uses more treatment to its slop before its use as irrigation.

The combined cost of cleaning the river of the color and BOD load due to slop irrigation is also shown in the previous Table**.** The estimated cost of pollution of the river from runoff ranged from PHP 88,434 (USD 1,720) for Alternative 1 to PHP 42,739 (USD 825) for Alternative 5 per hectare of slop-irrigated field per year.

Table 11 Cost of Cleaning River Pollution (Color and BOD) due to Runoff (Per Hectare of Slop-irrigated Field Per Year*).

WMA	*Cost of reducing Color to 150 Pco (PHP)*	*Cost of reducing BOD5 to 80 mg/l (PHP)*	*Total cost of cleaning due to runoff (PHP)*
1	75,549	12,885	88,434
2	57,339	1,462	58,801
3	50,671	57	50,728
4	50,671	57	50,728
5	42,739	0	42,739

Note: 150 PCo (desirable color level)

*Assuming 1,277mm of slops applied per hectare

1 USD = 51.41 PHP

Groundwater Contamination due to Seepage

Table 12 shows the cost of reducing the color of the groundwater. When the slop is not treated (Alternative 1), the cost of reducing the color to 100 PCo is at the greatest at PHP 15,466 (USD 300). However, subjecting the slops to various treatments as in Alternative 5 before use in the farm will only incur PHP 8,808 (USD 171) in cleaning-up cost per hectare of slop-irrigated sugarcane field.

Since the level of BOD is not yet up to the acceptable level even after having reduced the color, there is still a need for further reduction of the BOD in the contaminated groundwater. As shown in Table 12, the cost of reducing BOD5 for Alternative 5 is much lower than the rest of the alternatives.

Table 12 Cost of Cleaning River Pollution due to Leaching (Per Hectare of Slop-irrigated Field Per Year).

WMA	*Cost of reducing Color to 100 PCo (PHP)*	*Cost of reducing BOD5 to 80 mg/l (PHP)*	*Total cost of cleaning due to leaching (PHP)*
1	15,466	2,632	18,098
2	11,771	314	12,085
3	10,417	29	10,447
4	10,417	29	10,447
5	8,808	4	8,811

Note: 100 PCo (desirable color level)

*Assuming 1,277mm of slops applied per hectare

1 USD = 51.41 PHP

As shown in the previous table, the total cost of cleaning the groundwater is estimated to range from PHP 8,811 (USD 171) to PHP 18,098 (USD 352) per hectare of slop-irrigated field. The cost differed depending on the wastewater management alternative source of slops to be used in irrigating the farm.

Table 13 shows the total cost of cleaning the pollution from slops due to runoff and leaching.

Table 13 Total Cost of Cleaning the Pollution from Slops Per Hectare of Slop-irrigated Field Per Year.

WMA	*Total Cost of Cleaning due to runoff (PHP)*	*Total Cost of cleaning due to leaching (PHP)*	*Total cost of cleaning (PHP)*
1	88,434	18,098	106,532
2	58,801	12,085	70,886
3	50,728	10,447	61,175
4	50,728	10,447	61,175
5	42,739	8,811	51,550

Note: 1 USD = 51.41 PHP

Cost of BOD Loading

The different waste treatment options have a resultant slop of varying BOD loads due to runoff and seepages. Figure 2 shows the corresponding cost of attaining the BOD loads of the slops per alternative.

Shown in the figure is the inverse relationship between the investment in waste treatment and the BOD load of the slops from the different WMAs. From WMA 5 to WMA 1 (from least to most BOD load), the investment on treatment facilities and operating cost decreases. On the other hand, direct proportional relationship is observed between BOD load and cost of cleaning plus the penalties or fines paid by the distillery due to the load.

It is worth noting that the cost of investment is incurred on a one-time basis (first year) while cost of penalties and cost of cleaning are incurred annually based on continuous operation of the plant and use of slops for irrigation.

The investment curve shows a gradual decrease up to point A after which the drop in investment is steep. On the other hand, the combined value of cost of cleaning and penalties gradually increases up to point D after which the slope increases dramatically. Although both curves have a point at which the slope changes rapidly, the BOD load at which those curves changes slope dramatically is different. The cost of investment drops off at a lower value of BOD load compared to the BOD load at which cost of cleaning and penalties increases rapidly. This gives us an area where the combined cost of cleaning and penalties are relatively constant (point C to D) while the investment is decreasing at a much larger rate (point A to B). At X_1 level of BOD load, the combined cost of cleaning and penalties is minimized while investment in waste treatment is reduced dramatically.

Further movement to the right of point B of the investment curve, decreasing investment cost, will result in increased BOD load and drastic increase in cost of cleaning and penalties. Since investment is incurred on a one-time basis only (one year), the distillery will be incurring higher cost as the cost of cleaning and penalties will still continue as long as it operates and produces slops for irrigation.

In terms of the cost of reducing BOD load and color by the different WMAs, with the investment cost as the basis for computation, WMA 2 requires the least amount of cost among the alternatives. With WMA 1 as the baseline condition, the cost per mg/l of

BOD reduced and cost per Pco reduced for WMA 2 is PHP1,117 and PHP5,029 respectively. Both amount are the lowest among the alternatives (Table 14).

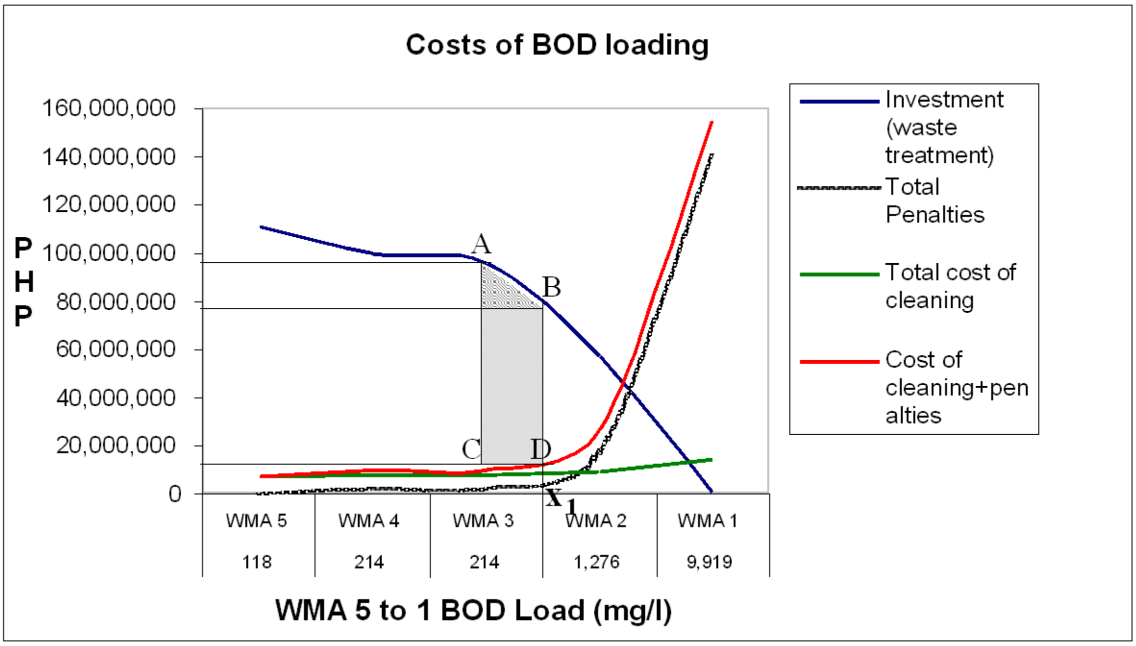

Figure 2 Cost of BOD Loading by Waste Management Alternative.

Note: 1 USD = 51.41 PHP

Table 14 Cost of Reducing BOD Load and Color by Waste Management Alternative.

	BOD reduction (mg/l)	*Color reduction (Pco)*	*Additional investment (PHP)*	*Cost of reducing BOD (PHP per mg/l)*	*Cost of reducing color (PHP/Pco)*
Baseline Condition: WMA 1 (no treatment)					
WMA 2	50,470.00	11,210	56,376,194	1,117	5,029
WMA 3	56,675.00	15,315	94,326,194	1,664	6,159
WMA 4	56,675.00	15,315	98,824,891	1,744	6,453
WMA 5	57,235.00	20,198	109,724,891	1,917	5,432

Table 15 presents the summary of the costs of the WMAs. The direct (investment) cost is lowest for Alternative 1 but it has the highest environmental cost, while the one with the most direct cost is Alternative 5 but it has the least environmental cost.

Table 15 Summary of Costs by WMA.

WMA	*Direct cost (PHP)*	*Environmental cost* (PHP)*	*Non-quantifiable costs (PHP)*
1	885,806	106,532	Mainly odor from less treated slops
2	57,262,000	70,886	
3	95,212,000	61,175	
4	99,710,697	61,175	
5	110,610,697	51,550	

Note: *Cost of cleaning river and groundwater pollution excluding fines (per hectare of slop-irrigated field)

1 USD = 51.41 PHP

6.5 Financial and Economic Analysis of Using Slops for Irrigation

Both financial and economic analysis were done for the use of slops as irrigation to sugarcane. Financial analysis were undertaken on the farm and the distillery level to show the financial gains in adopting the slop irrigation technology. Included in the financial analysis of the farm were the benefit (sugarcane yield) and the cost of production. The financial analysis of the distillery included the alcohol and biogas production as the main benefits and the investment and operating expenses as the costs. In addition, the penalty for violating standards set for wastewater discharged into the environment was calculated. The economic analysis (social benefit cost analysis) was undertaken to determine the overall effect to society of using slops for irrigation of sugarcane fields. Impacts on both the distillery and the farms were considered, as well the effect in the environment (river pollution and groundwater contamination) of the use of slop for irrigation. It was assumed here that firms are mandated to undertake wastewater treatment - to offset the environmental effects.

6.6 Financial Analysis of the Distillery and the Farm

6.6.1 Firm Level

There are two scenarios that were considered in the financial analysis from the distillery's perspective:

> NPV^a (first scenario) – the distillery does not pay the penalty for the exceedence of wastewater quality standards set by the regulatory agency. It is assumed here that while there are standards identified, the government does not strictly enforce collection of penalties for violation of said standards.
>
> NPV^b (second scenario) – the government is strictly implementing the law and the distilleries are made to pay the penalty for causing contamination of water resources by using slops as irrigation.

Table 16 shows the results of the financial analysis of the distillery for the different WMAs. As one would expect, when the distilleries will not be made to pay the penalty for the contamination of the environment, they will adopt the minimum treatment possible (WMA1). Firms will just continue their current practice of simply holding the raw slops in cooling ponds to allow its temperature to go down before being used as irrigation to sugarcane. With this option, the net present value (NPV[a]) of WMA 1 to the firm is PHP 850,122,785.

If the government regulatory agency, however, will strictly enforce making the firms accountable for the contamination of the environment by imposing strictly the penalties, then, the distilleries will have to consider the net benefits of the different wastewater treatment alternatives in relation to the current practice (WMA1). As shown in Table 15, the best option for the firms is WMA 4 (anaerobic and aerobic treatment with recycling & process improvement). It corresponds to the highest level of net benefit at relatively reasonable cost (PHP 1,062,363,108). At this level of treatment, the amount of penalty reduced (translated to improvement in slop quality) relative to the baseline condition WMA 1 (no treatment), is much more greater than additional cost of the new treatment facilities.

Table 16 Financial Benefit Cost Analysis (Firm Level).

Returns/Income (in PHP)					
	WMA 1	**WMA 2**	**WMA 3**	**WMA 4**	**WMA 5**
Alcohol production	105,000,000	105,000,000	105,000,000	108,706,500	108,706,500
Biogas production	0	4,050,000	4,050,000	4,050,000	4,050,000
Salvage value	221,452	14,315,500	23,803,000	24,927,673	27,652,674
(25% of investment)					
Costs / Expenses (in PHP)					
Investment					
Methane reactor	0	54,000,000	54,000,000	54,000,000	54,000,000
Aeration tank	0	0	36,000,000	36,000,000	36,000,000
Cost of lagoons	0	0	0	0	10,000,000
Cost of treatment (includes MOE)	0	3,150,000	5,100,000	5,100,000	6,000,000
Cooling ponds	773,806	0	0	0	0
System modification	0	0	0	4,500,000	4,500,000
Cost of Distribution	112,000	112,000	112,000	110,697	110,697
Penalty	140,477,932	17,174,938	2,015,535	2,015,535	109,205
Net Present Value					
NPV[a]	**850,122,785**	810,698,322	762,975,807	758,440,881	742,276,501
NPV[b]		960,907,186	1,034,999,840	**1,062,363,108**	997,095,645

NPV[a] – the distillery does not pay the penalty for contamination due to slops

NPV[b] – the government is strictly implementing the law and firms are forced to pay the penalties. WMA 1 served as the baseline condition.

6.6.2 Farm Level

Cost and Returns Analysis

A cost and returns comparison of the two scenarios with and without slop for irrigation was made (Table 17). The benefits basically are increases in yield and reduction in fertilizer, irrigation, and land preparation expenditures. Additional costs incurred on the farm due to slop irrigation were labor cost specifically in weeding, harvesting, and overseeing of slop applications. The application of rich slops has resulted in an increase in both sugarcane yield and incidence of weeds, which consequently resulted in an increase in the cost of harvesting and weeding. Harvesting cost is directly proportional to the amount of canes harvested.

Table 17 Comparative Cost and Returns of User and Non-user of Slops as Sugarcane Irrigation (Per Hectare).

	Without slops irrigation (PHP)	*Slop Irrigated Farms (PHP)*	
		Treated slops	*Untreated slops*
Returns			
Yield	42,157	64,000	54,234
TOTAL RETURNS	42,157	64,000	54,234
Costs			
Land Preparation	2,125	2,667	2,125
Planting & management	1,129	500	1,129
Irrigation	450	0	0
Fertilizers	3,513	1,733	591
Pesticides	25	467	25
Weeding	540	600	1,380
Harvesting	8,635	8,000	10,547
Transporting	120	547	120
TOTAL COSTS	16,537	14,513	15,917
NET RETURNS	25,620	49,487	38,317

Note: 1 USD = 51.41 PHP

Financial Analysis

The result of the financial analysis for a five-year period of slop application indicated a positive benefit for the farm with a total net discounted benefit of PHP 82,521 (USD 1,605) per hectare which is almost six times (BCR = 5.86) the total cost. Also, the rate of return for the farms is quite high at over 600%. These are mainly due to the increase in the yield attributed to slop application. The value of the increase in the yield far outweighs the additional cost entailed by slop irrigation. The foregoing analysis was mainly for treated slops. Similar analysis for each WMA was not possible due to lack of empirical data especially on the effect of the different slop quality (from each WMA) on yield and also the corresponding change in other benefits and costs. On the basis of previous field and pot experiments, however, each WMA is expected to yield more benefits than costs to the farm.

This, however, does not include the benefits of the carryover effect of slop application to second and third croppings. It is expected that slop application have residual benefits for the succeeding croppings, as evidenced by the comparative soil analysis before slop application and after harvest of sugarcanes.

6.7 Social Benefit-Cost Analysis

The financial analysis for both the farm and the distillery yielded positive net benefits. To determine the overall effect of the different alternatives of the use of slop as irrigation to the society, results of the financial analysis on the farm and the distillery were used in the social benefit cost analysis. In the social BCA, the effect on the environment, specifically including river pollution and groundwater contamination was included in the analysis. Further, it was assumed that firms are strictly mandated to undertake wastewater treatments instead of being offered the option of paying the penalty. As such, the analysis considered the costs and benefits of shifting from WMA 1 to the other alternatives. Table 18 summarizes the results of the social BCAs.

The results of the analysis show that only WMA 2 (anaerobic treatment with biogas recovery) will yield positive net benefits for the society with the rest of the alternatives bringing in more costs than benefits (in relation to the baseline condition) with negative NPV and IRR. The negative result for WMAs 3 to 5 was due to the high investment on waste treatment which the increase production of alcohol and biogas and the reduction in cost of cleaning the pollution cannot offset. From society's perspective, the level of treatment associated with WMA 2 will be socially efficient.

Table 18 Results of the Economic Analysis of Using Slops for Irrigation of Sugarcane Fields.

BENEFITS (in PHP)					
	WMA 1	**WMA 2**	**WMA 3**	**WMA 4**	**WMA 5**
Distillery					
alcohol production	105,000,000	105,000,000	105,000,000	108,706,500	108,706,500
biogas production	0	4,050,000	4,050,000	4,050,000	4,050,000
salvage value(25% investment)	221,452	14,315,500	23,803,000	24,927,673	27,652,674
Sub-total	105,221,452	123,365,500	132,853,000	137,684,173	140,409,174
Farm					
harvest/yield	7,371,485	8,698,880	8,698,880	8,698,880	8,698,880
residual fertility	7,303,797	7,303,797	7,303,797	7,303,797	7,303,797
Sub-total	14,675,282	16,002,677	16,002,677	16,002,677	16,002,677
Environment					
Sub-total					
TOTAL BENEFITS	**119,896,734**	**139,368,177**	**148,855,677**	**153,686,850**	**156,411,851**
COSTS (in PHP)					
Distillery					
Investment	885,806	57,262,000	95,212,000	99,710,695	110,610,695
Operating	0	3,150,000	5,100,000	5,100,000	6,000,000
Sub-total	885,806	60,412,000	100,312,000	104,810,695	116,610,695
Farm					
land preparation	288,830	362,499	362,499	362,499	362,499
planting and mgt	153,454	67,960	67,960	67,960	67,960
irrigation	0	0	0	0	0
fertilizer	80,329	235,459	235,459	235,459	235,459
pesticide	3,398	63,475	63,475	63,475	63,475
weeding	187,569	81,552	81,552	81,552	81,552
harvesting	1,433,548	1,087,360	1,087,360	1,087,360	1,087,360
transporting	16,310	74,348	74,348	74,348	74,348
Sub-total	2,163,439	1,972,653	1,972,653	1,972,653	1,972,653
Environment					
river pollution	12,019,915	7,992,220	6,894,977	6,894,977	5,809,048
groundwater pollution	2,459,872	1,642,564	1,419,909	1,419,909	1,197,635
Sub-total					
TOTAL COSTS	3,049,245	62,384,653	102,284,653	106,783,348	118,583,348
Net Present Value (WMA 1 as baseline condition)		**9,146,712**	(29,743,265)	(3,648,379)	(9,993,198)

7.0 VIETNAM COMPONENT - RESULTS AND DISCUSSION

Table 19 shows the analysis of slops from Vietnam. The slops contain dry matters and organic matters in significant rates, besides that of N, K and Na, and phosphorous in minor quantity.

Table 19 Analysis of Untreated Slops from Vietnam.

Item Analyzed	*Result*
Dry matter (%)	4.50
Organic Carbon	3.73
Total Na (%)	0.06
Total Nitrogen (%)	0.09
Total P_2O_5 (%)	0.01
Total K_2O (%)	0.32
PH	4.50
Electro-Conductivity EC (mS/cm)	44.00
EC of Molasses before distillation (mS/cm)	0.90
EC of channel water at sugarcane field (mS/cm)	0.60

The Electric Conductivity reflects the ion concentrations in solution. The slops-EC is equal to 44 mS/ cm indicating that the slops contain high ion concentration, which may cause the plant to experience lack of physiological water and may induce abnormal growth of sugarcane plants.

7.1 Results of Soil Analysis

The soil used in the experiment belongs to acid soils (pH < 5), with low N- and P-contents, average organic matter contents, acceptable C.E.C. and rather high exchangeable Ca-, Mg- and Na- contents (Table 20 and 21).

Table 20 Data of Soil Analysis

Soil samples	*pH*		*E.C*	*O.C*	*Total (%)*		
	pH_{H2O}	pH_{KCl}	mS/cm	(%)	N	P	K
Before applying slops*	4.47	3.64	0.34	3.15	0.11	0.03	1.35
Control **	4.45	3.77	0.21	2.92	0.11	0.02	1.42
Slops – 200 tonne/ha**	4.42	4.05	0.65	2.56	0.09	0.03	1.38
Slops - 400 tonne/ha **	4.75	3.86	0.42	3.11	0.14	0.03	1.26
Slops - 600 tonne/ha **	4.47	3.83	0.81	3.24	0.17	0.02	1.32

Note: *: Soil samples taken before applying slops.

**: Soil samples taken at harvest stage.

Table 21 Data of Soil Analysis (C.E.C, Exchangeable Cations).

Soil samples	*C.E.C* (me/100g)	*Exchangeable (me/100g)*			
		Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}
Before applying slops	22.24	5.98	9.86	9.1	2.01
Control	23.84	5.63	10.47	3.85	1.25
Slops - 200 tonne/ha	21.17	5.16	9.63	3.46	1.34
Slops - 400 tonne/ha	21.34	5.33	9.87	3.45	1.26
Slops - 600 tonne/ha	22.32	5.13	10.06	3.73	1.73

Analytical data of soil at each applied treatment after harvesting show no significant difference at various levels of slops and control treatments, except that E.C. data in Treatment 4 tends to be higher than the 3 remaining treatments. However it is still at a low level and would not affect the normal growth of sugarcane plants. Moreover, the second application of slops to the harvest that coincided with the 5 months duration of rainy season showed that the application of slops has no significant effect on agro-chemical characteristics of soil.

7.2 Influence of Slop Application upon the Growth of Sugarcane

Just two days after the application of slops, the lower leaves of cane plants became yellowish, and this yellowish colour spread gradually towards the higher leaves. The younger sugarcane plants are more seriously affected than the older ones. In Treatment 2 [200 tonnes slop per hectare], only 2-3 lower leaves of the plant became yellowish, and they lengthened further and recovered fully after 10 days. With Treatment 3 [400 tonnes slop per hectare], the discoloured leaves were numerous. In Treatment 4 [600 tonnes slop per hectare], leaf discoloration extended to the top leaves. Moreover in Treatment 4, the discoloured leaves could not recover and finally they completely withered. With Treatment 4, two weeks after the application of slops, some plants died. Thus, the growth of plant was seriously affected by the application of slops in Treatment 4 compared to the 3 remaining treatments, and particularly very badly compared with Treatment 1 [Control/ Blank lot: watering with fresh water]. The yellowing phenomenon happened in both experiments and it was observed that as more slop was applied, more stalks and leaves were damaged. The negative effect of slops application at high dosage upon the growth of sugarcane can be seen clearly by observing the stalk color in the sugarcane field.

Influence of the dosage of slops application upon the height of sugarcane is shown in Table 3. Measurement of plant height was done in 5 fixed plants in a small-scale plot, which was from the ground to the end of the longest top leaf. Plant height measurements were done during the following schedules: 1st measurement (27/12/2001): the first time to add slop; 2nd measurement (30/01/2002): the 2nd time to apply slop; and the following measurements separated 30 days from each other, the last measurement was at harvesting time (25/7/2002).

The height increase of the plant is nearly the same between the Control and Treatment 2 with 200 tonnes slop/ ha. Height-increase was lower in Treatment 3 with 400 tonnes slop/ ha and lowest in Treatment 4 with 600 tonnes slop/ ha. The stalk of the plant and the dried leaves in Treatment 4 could not recover because slops were applied with too high ion concentration (EC = 44 mS/cm) and too large amounts. According to the research on the plant cultivation, a water with EC > 4mS/cm -such as saline water case- will cause bad effect to the growth of the tree (except if the plant is growing in the brackish water). Although after each application of slops the sugarcane pilot field was subsequently watered to wash out slops from leaves and stalk, the withered and dried stalk can no longer absorb water.

The data in Table 22 show that in the first 30 days starting from the 1st slop application treatment, cane plants under Treatments 2 and 3 increased in height just like in the Control plot (no slop). Sugarcane plants under Treatment 4 stopped growing and height decreased due to drying of stalk and withering of leaves. During the 31st to the 59th days cane plants under Treatments 2 and 3 both showed decrease in height. After the 59th day only the sugarcane plants under Treatment 4 decreased in height.

Table 22 Height Increase of Sugarcane Plant from Slop Applying to Harvest.

Treatment	*Days after applying slops (day)*						
	1	30	59	88	117	146	208
1. Control plot	201	247	253	274	306	315	341
2. 200 tonnes/ha	199	249	227	255	298	306	339
3. 400 tonnes/ha	206	249	216	230	282	291	316
4. 600 tonnes/ha	197	192	153	172	239	249	261

7.3 The Vietnam Experience: Effect on Standing Crop

The experience in the Philippines on the use of slops to sugarcane is limited to slop being applied as irrigation water to newly planted cane or newly ratooned cane field. In both cases, the buds on the cuttings or the buds on the remaining sugarcane stalks after harvesting are yet to germinate. Thus, the application of slops improves the water and nutrient availability that will favor bud germination and even sustained healthy growth of young plants. These buds are still protected from damage against heat and drying by the bud sheath covering the primordial plant.

In Vietnam, the experience was to apply slops 3 months after germination of buds from sugarcane cuttings. Considering that raw slops which is high in organic matter was used, there was initial negative response of sugarcane to slops application attributed to high heat of decomposition that normally develops during the decay of organic matter. In addition, with the high activity of organism consuming so much oxygen, the growing sugarcane plants may also suffer from insufficient supply of oxygen needed for plant respiration. Plant uptake of water could also be limited by high slop-EC therefore affecting plant growth.

8.0 SUMMARY AND CONCLUSIONS

8.1 Economic

There are economic benefits in the use of treated slops for irrigation of sugarcane fields though its use should be accompanied by caution and measures so as to not negatively affect the environment.

The benefits for the distillery in adopting the wastewater management alternatives and using the slops for agricultural production is mainly in the form of reduced cost in paying government set fines for polluting the environment and reduced cost of cleaning up the polluted water resources. Also, they benefit from the income generated from additional alcohol production and from the by-products like biogas produced by each option.

On the part of the sugarcane farm, the main benefit from the use of slops as irrigation for sugarcane is the increase in yield by an average of 28 tonnes per hectare. That translates into increase returns. Considering the increase in the sweetness of the juice as validated in the previous study, this sweetness quality if appropriately valued (which is not the case in the Philippines) is an added benefit of slop use.

The cost of adopting the different waste management alternatives varies with each option with the cost generally increasing as more processes and treatments are used to treat the slops before use in the sugarcane fields. The use of untreated slop (WMA 1 or no treatment) was an option for agricultural use simply because of its high nutrient content which is ideal for growing of crops. It had the least investment needed on additional facilities but had the highest river and groundwater clean up cost and also the highest fines and penalty based on the BOD and color. The cost of pollution for Alternative 1 was estimated to value at PHP 88,434 (USD 1,720) and PHP 18,098 (USD 352) for river and groundwater clean up respectively.

On the other hand, Alternative 5 had the least effect on the environment but it would incur the highest investment cost for the distillery as it involved a thorough treatment and processing of slops before use in sugarcane irrigation. Cost of cleaning the river pollution for this alternative is PHP 42,739 (USD 831) and for groundwater it is PHP 8,811 (USD 171) both on a per hectare of slop-irrigated field per year.

Financial analysis at the farm level shows positive net benefits for the sugarcane farms. It yielded a PHP 82,521 (USD 1,605) per hectare benefit for the farms using distillery slops as irrigation to sugarcane.

From the distilleries perspective, they will continue to adopt WMA 1 if the government will be lax in strictly enforcing penalty payments for violation of the standards set for wastewater. However, once strict enforcement of said policy is made, the distilleries will find it more profitable to adopt the higher level of waste treatment, associated with WMA 4 (uses a combined anaerobic and aerobic treatment in series,with recycling and process improvement). This option will avoid the firm's payment of penalty at affordable cost of undertaking the control. will yield the most net benefit. This resulted in the highest net present value and benefit cost ratio among the alternatives.

The social benefit cost analysis, on the other hand had a different result. If all the costs and benefit to the society are included and with the mandatory requirement for firms to undertake cost of clean-up/treatment, the treatment that yields the highest net present value from the baseline condition is WMA 2. This is due to the relatively high investment needed in the other alternatives which the added benefits can not compensate against.

8.2 Industry and Environmental Regulation

The results showed that if fully developed, the agricultural option for slop utilization will afford distillery operators the choice as to what level of waste management is most appropriate to their scale of operation and this does not necessarily mean the installation of expensive wastewater treatment facilities which many of them cannot afford.

The option provided is a potential win-win solution in a situation where distilleries are either forced to close shop for inability to comply with environmental laws or run the risk of being caught for non-compliance.

At the sugarcane industry production sub-sector perspective, the study results likewise provided irrigation water option that likewise leads to nutrient enhancement.

8.3 Policy

While it has been shown that the slop has economic value for agricultural use and that its environmental effect can be mitigated, slop color as contained in the wastewater policy provision remains an issue. In as much as the color standard applies to slop disposal to bodies of water and may not necessarily the same standard to follow for agricultural option, there is now a need for the Department of Environment and Natural Resources-Environmental Management Bureau (DENR-EMB) to review its policy on wastewater color in light of these developments. Current standard for color of wastewater could be lowered if it is to be used for agriculture, specifically as irrigation to sugarcane considering the filtering capability of soil as what previous experiments showed. Lysimeter tests have shown that several passes of the slops through the lysimeter resulted in gradual reduction in color of treated distillery slops.

Another possible agricultural use of slops is for aquaculture where color standards would be lower. Informal interviews have confirmed the potentials of the use of slops for aquaculture. However, great caution has to be observed as some slops may not be suitable for such endeavor, particularly where food safety and human health issues are involved. The slops used in growing fish have undergone extensive treatment comparable to WMA 5 as described earlier.

In the same manner, while there are environmental and industrial policies and program thrusts that partially govern wastewater disposal, none of the said policies look at the slops as a resource, particularly as an agricultural one. This being the case, there is a need to develop a process that takes into account the varying perspectives of the industry (distilleries), the regulatory body (DENR) and other line agencies such as the Department of Agriculture and their attached agencies as well as scientific groups that will institutionalize a mechanism that will govern the treatment of wastewater, particularly slops, for agricultural purposes.

Another instrument that has been recently put in place by the DENR to control and reduce the water pollution in the country is the DENR Administrative Order (DAO) No. 2002-16 or the National Environmental User's Fee (NEUF). The order, aside from providing protection for all water bodies, encourages firms to pursue the least cost means of pollution reduction and also to internalize the philosophy of self-regulation.

Part of the user's fee will be a *load-based fee* that will be based on the pollutant load, i.e. the volume and concentration of a particular pollutant and the current ambient environmental quality and classification of the water body.

Unfortunately, because of the present high cost of treating wastes, the NEUF may be actually encouraging the disposal of waste without treatment, consequently leading to the deterioration of the water bodies. Companies will rather pay the fees than put up a more expensive treatment facility. In the same manner, the NEUF does not effectively encourage the recycling of wastes, which may still be of use.

The NEUF covers only disposal of wastewater into water bodies but is silent on the disposal or application of wastewater on both productive and idle lands. Regulated disposal of these wastewaters on productive and idle lands offers an additional dimension to the NEUF that can provide a more economical and sustainable option that is more attractive for concerned industries.

8.4 Vietnam Component

The Vietnam experiments, just like the previous study on slop usage in the Philippines, focused on the irrigation effect of slops.

The adverse effect of the raw slops on standing crops was due to the high organic matter content. The organic matter decomposes when applied to the soil and uses oxygen in the process, competing with the oxygen needed by plants for respiration. Moreover, the high slop-EC limits the plant's ability to absorb water, causing negative effects on plant growth.

There are also early indications for possible adoption of the slop irrigation for sugarcanes and the need for an initiative for the creation of policy-making body that will regulate the use of the said technology. This is very important as slop irrigation affects many sectors of the community which include the industry, the farmers, and the environment.

9.0 RECOMMENDATIONS

The study further confirmed the technical and economic soundness of the slop utilization for irrigation, not to mention the added benefit of nutrient content. It is, however, deemed necessary for the protection of both the farmers and the environment that a regulatory body be created to help regulate slop utilization on a wider scale.

The shift in viewing slops as a resource rather than a waste however requires a process involving various stakeholders from the farming populace, industries, line agencies, academe and concerned groups. The said process will lead to the institutionalization of slop evaluation as a potential resource material for agriculture (Figure 2), and will ensure protection of the farmers as well as the environment. The said process' implementation should be taken care of by an organized body created solely for this purpose. Once operational, the said procedure should not be limited to organic wastewater and should be applicable also to other waste materials, namely: from piggeries, poultry manure, and similar wastes.

9.1 Long-term or Cumulative Effects of Slop Irrigation

On the basis of lysimeter study, it was clear that soil has limits in its capacity to retain slops. In excess of this limit, any additional slop applied to soil will go directly to ground water and/or be subject to seepage and/or runoff. It was therefore recommended that should slops be regularly used in sugarcane production, seasonal monitoring of soil at least once a year (preferably immediately after harvest) must be done to avoid exceeding the maximum capacity of soil to retain slops.

9.2 Effluent Flow Problem

Slops obviously need to be stored given that its production is on a year round basis and demand for it is seasonal. Therefore, in this case, seepage or leaching remains a problem in the handling of slops. The key to solving the problem is to expand the utilization of slops to other crops. Slops were proven beneficial to paddy rice. If the demand for slops application on paddy rice is established, it may eliminate, substantially if not totally, the need to store slops since slops requirement of rice is higher and almost year round, given two or even three croppings per year. Aside from rice and sugarcane, slops are expected to give good results when applied to many tropical fruit trees.

9.3 Suggested Procedure on Slops Assessment for Agricultural Purposes

In the absence of definite standards on slop utilization for agriculture, a concerted effort among academe, industry, concerned groups and community will initially establish the quality of slop either as a waste that need to be disposed or as a resource (irrigation and nutrient) material. This concerted effort could take the form of a resource material council whose head is endorsed by a national crop science group where each of the above-mentioned sectors are represented as members.

During the assessment phase, the waste material could either be ruled out as lacking in agricultural resource potential and is, thus, fit for disposal, or as meeting resource potential and could therefore be used for agriculture. Once approved for agriculture use, it will then pass through the nutrient management group of DENR, DA and FPA. The FPA will play a critical role as it will provide the empirical data for the efficacy of organic waste material appropriate for agriculture. These empirical data should be generated by a science-based study, and should lay the policy groundwork for the amount, placement, form and timing of application of the resource. The result of this study is but just a starting point.

Once the waste material passed through approval, the control of application will be under the stewardship of the local government unit (municipality/barangay) ensuring that farming community's welfare is taken care of. Applicability to a wide variety of crops and soil types need be established to arrive at a comprehensive policy for agricultural waste option.

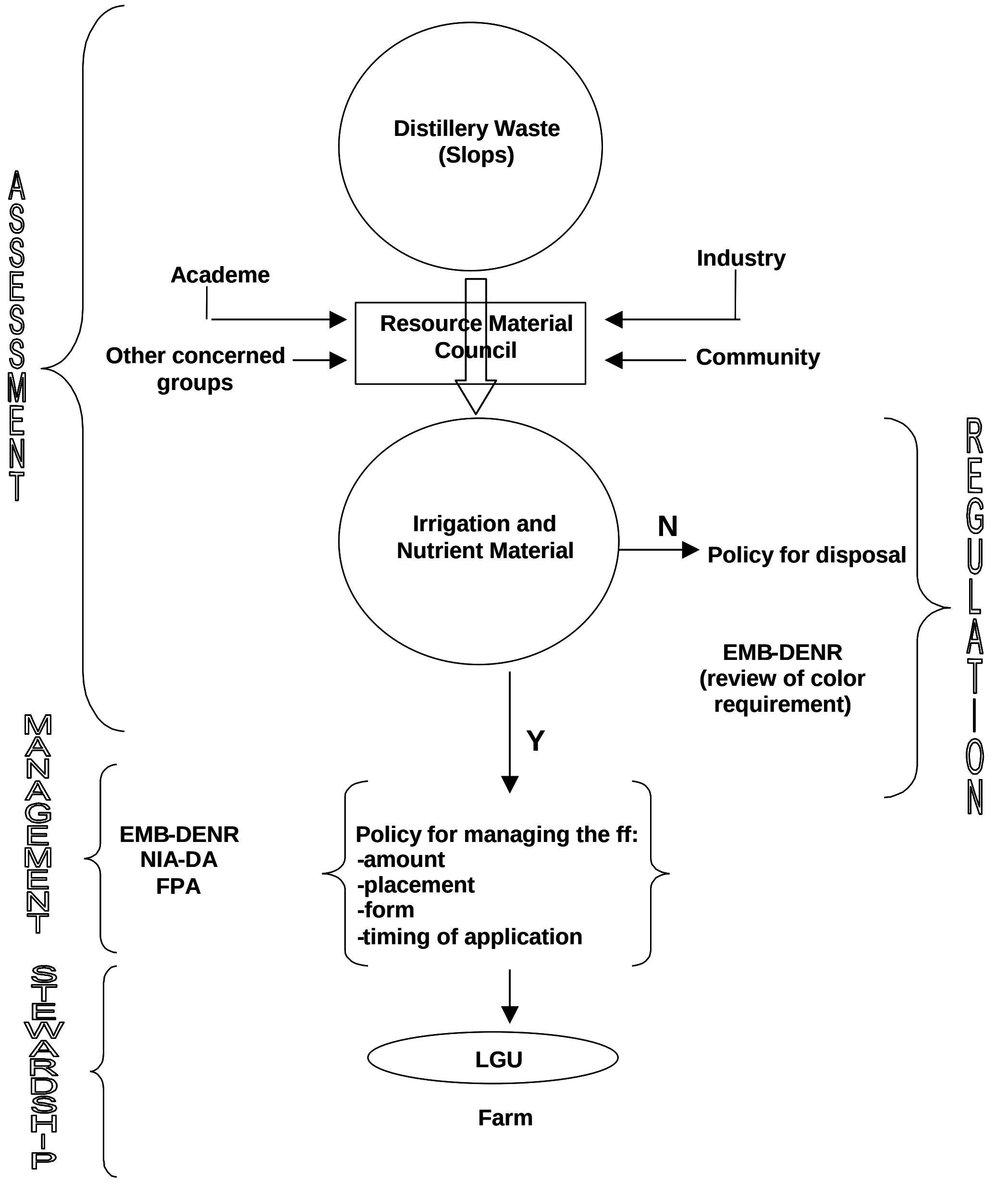

Figure 3 Recommended Process of Assessment and Management of Slops as Resource Agricultural Material.

Note: NIA-DA – National Irrigation Administration-Department of Agriculture

FPA – Fertilizer and Pesticide Authority

In due time, guidelines on slop utilization and management would have been established and policies that will help regulate the technology's adoption hopefully formulated. It is then passed on for regulatory development and implementation.

The project recommends the shift from the regulatory stance of the government in controlling the disposal of slops to the establishment of a more responsive partnership among the industry, the government, and the community. This will require phasing out the policies penalizing the industries on the discharge of slops and setting up new standards for the recycling of slops as irrigation water for the farm, with nutrients and soil improvements as additional benefits.

The project was able to show that technically, economically, and environmentally, slops as irrigation for the farm is highly viable. Nonetheless, the shift to such a policy will require a thorough study on the “fate and transport” of slops once applied to the soil. The long-term effect of slops application has not been completely established. Also, strict monitoring guidelines will have to be put in place once the scheme is adopted.

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APPENDIX

SOCIO-CULTURAL COMPONENT OF SLOP IRRIGATION

i) Farm Characteristic

Table 23 shows the average farm size and the yield per hectare of the different types of sugarcane farms. On a per farm basis, those using untreated slops as irrigation has the largest area planted to sugarcane with 2.4 ha per farm. Non-users of slops with 2.0 ha followed it and users of treated slops have the smallest area with 1.5 ha per farmer.

Table 23 Selected Farm Characteristic of Sugarcane Farms by Type of Farm.

Characteristic	*Without Slops Irrigation*	*Slop Irrigated Farms*	
		Treated slops	*Untreated slops*
Farm size (hectares)	2.0	1.5	2.4
Yield (tonnes per hectare)	95	110	123

The yield of the sugarcane farm also varied from users to non-users of slops and also by the kind of slop used for irrigation. Fields irrigated with untreated slops yielded the most canes per hectare with 123 tonnes. Not far are those that used treated slops with yield of 110 tonnes of cane per hectare. Non-users of slops expectedly had the lowest yield of only 95 tonnes of sugarcane per hectare.

ii) Demographic Characteristic

Age of farmers who are irrigating their sugarcane farms with slops ranged from **25 to 83** years old with farming experience ranging from **10 to 53 years**. Majority of them finished elementary education while some had college education.

iii) Farming Practices with Inclusion of Slops for Irrigation

Irrigating slops to both newly planted and ratoon cane requires additional labor cost to cover the time for overseeing the actual slop application. The distillery plant handles scheduling, delivery and application of slops to individual farms for free.

Application of slops to farms was accomplished in two ways. Tanker can load, transport, and spray slops to individual farms. The slop can also be pumped from lagoons and conveyed directly to individual farms using rubber hose. Farmers near the distillery plant lagoons are served with slops using rubber hose. With slop use, some farmers decided to reduce fertilizer application but not all.

Except for the application of slops at planting or after harvesting (for ratoon cane), farm operations remain the same (Table 24). Since farmers receive slops for free, the only added cost on the part of the farmer will be the time for overseeing the slop application, which may take between one to two days depending on the distance of the farm from the source. It was also observed that because of fertility and moisture availability improvement upon the application of slop, the weed growth was also enhanced so farmers spent additional labor for weeding.

Table 24 Farming Practices of Traditional Sugarcane Farms and Slop-irrigated Farms.

Farm Practices	*Without slop application*	*With slop application*
Cropping system	Ratoon cropping (2-3 cycles)	Ratoon cropping (2-3 cycles)
Irrigation	Plain water at the time of planting	With slop at time of planting and after harvesting (at least $200m^3$)
Planting material	Local varieties	Local varieties
Type of irrigation	Rain-fed/ shallow well (pumped)	Slop-irrigated
Weed control	Common weed control practices	Increase weed control activity due to increase in weeds brought about effect of slop (additional 2-3 man-days)
Crop rotation	Rotated with rice	Rotated with rice
Field management	Regular monitoring of crop status (fertilizer needs, pest and diseases, etc.)	Same with standard plus added labor on the overseeing of slop application

iv) Product Marketing

Harvested sugarcane were loaded into trucks and brought to Don Pedro Sugar Central, located in the municipality of Nasugbu, thirty minutes away from their farms. The number of picul sugar per tonne of cane (ps/tc), determined by the milling company, is the basis of payment to farmers who brought their cane plant to the company.

Palay and vegetables are produced mainly for home consumption.

v) Slops and the Farmers

Farmer's Acceptance – Utilization of Slops as Irrigation Water for Sugarcane

Increases in yield of sugarcane and savings from not buying fertilizer are the major reasons cited by key informant farmers on why they are willing to irrigate their farm with distillery slops. In their opinion, the savings and increased income from improvement in yield is more than enough to offset the extra cost incurred in weeding and overseeing the application of slops.

Regarding the type of slops they prefer to use, the respondents specified treated slops because it is odor–free and not as dark as untreated slops. The farmers also perceived the untreated slop as the "dirtiest" water since even the distillery cannot recycle it for their own use.

Major concern raised by the key informant-farmers for not using slops was past incidence of pollution both in the river and water table. They suspected that runoff from farms irrigated with slop pollutes the river while slop seepage into the soil caused the off-color and off-odor of water pumped from artesian wells.

In general, the farmers are willing to use the slops as irrigation water because of the benefits derived from it. But according to them, its application should be regulated in order not to pollute the river and the community's supply of potable water. The regulation could come in the form of prescribed volume and rate of application as well as determine the suitable location of farms where the slops can be utilized as irrigation water. In addition, the farmers are asking if there is a remedy to "too much weeds" in the farms irrigated by slops.

Social and Institutional Changes Brought About by Slop Application

Traditionally, sugarcane farmers do not irrigate their farms, especially in San Diego where irrigation facilities are not available. With the free distribution as irrigation water sugarcane farmers experienced the benefits of using the slop to irrigate their farms but the technology also showed its negative effect, that is, polluting the source of potable water supply in the two barangays.

As the benefits of using the slops are becoming popular more farmers wanted to use the slops. To put order in the slop distribution, a distribution scheme evolved among the distillery firm, tankers, farmers and the local authorities.

The tankers delivering slops organized themselves employing a coordinator who pre-determines the location of farm and volume of slops to be distributed. The coordinator also seeks approval from the barangay captains to unload the slops in their area of jurisdiction. The local government requires a financial bond from the slop haulers for the said bond will be used for cleaning up purposes.

The resultant system in the distribution of slops is an enterprising activity, which provided additional employment opportunities like hauling and overseeing slop application in the farm. The utilization of the technology also created environmental safety awareness and accountability, which gave rise to a protocol of securing approval before the tankers can unload the slop as irrigation water in sugarcane fields.

Presumed Impact on Income of Farmers Using the Slop as Irrigation Water

Barangays Bungahan and San Diego have farmer population of 270 and 328, respectively. Of these numbers, 52% and 45% are tenants for Bungahan and San Diego, respectively, and they share the cost and income with the landowner for producing sugarcane.

The prevailing arrangement among farmers and landowners is the sharing scheme. It is where the tenant shoulders all the cost of farm labor for planting, harvesting and plant management while the landowner bears all the cost of transporting the harvested sugarcane and half of the cost of inputs. After deducting the production cost from sale proceeds of the crop, the net revenue is equally shared by the tenant and the landowner.

By virtue of this sharing scheme the benefits from slop application, namely, savings from fertilizer and increase in revenue from improve yield, accrue to both tenant and landowner.