# Environmental performance of Agro-Industry in Thailand: Fruit-vegetable Case Studies*

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**Abstract:** This paper aims to investigate environmental performance of agro-industry in Thailand. Four case studies in small and medium-sized fruit-vegetable processing companies in Chiang Mai province are selected to be representative samples. The paper starts with the introduction to the fruit-vegetable processing companies with geographical profiles of the case studies in section 1 to give the overview of their location. In section 2, socio-economic profiles give the detail of their production processes and environmental profiles to give current environmental problems from the production processes. Then, it is followed by the environmental improvements showing the model for prevention and minimization of waste generating of the firms. Moreover, roles of actors and institutions in implementation of the model are analyzed within economic, policy and societal network in section 3. The last section, section 4, is conclusion and recommendation of the case studies' performance.

## 1. Introduction:

Thailand is an agricultural country, particularly, its northern region producing huge volume of produce which necessitates the processing of farms products into a storable nature. 25 food processing industry as a whole has contributed to a substantial value added to the domestic raw materials which in turn account for 80-90% of all raw materials. Canned and processed fruits and vegetables are the leader in food industry in terms of contributing great value-added proportion (Table 1). Northern region of Thailand has the largest industrial share of small and medium-sized vegetable and fruits processing companies (MoID, 1996) because its climate and land features are favorable for almost every kind of vegetable and fruit tree cultivation.

The vegetable and fruits processing factories selected for the present case studies are located in the rural upper northern region of Thailand, two being small-sized and the other two being medium-sized to capture the differences in their performance due to scale of operation and thus to arrive at the recommendation for improvement toward environmental friendly production process and management.

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**Table 1** Value-added of Thai food industry in 1995 and 1996

| Type of Industries | 1995 | | 1996 | |
|---|---|---|---|---|
| | **Value-Added** | **Proportion** | **Value-Added** | **Proportion** |
| Processing and canned seafood | 19,557.9 | 11.0 | 20,356.9 | 10.0 |
| Fruit and vegetable processing and canning | 5,267.4 | 2.9 | 9,000.5 | 4.4 |
| Processing of animal products | 7,093.8 | 4.0 | 7,018.4 | 3.4 |
| Seeds and Tuber | 21,578.2 | 12.2 | 27,493.8 | 13.3 |
| Sugar | 20,626.1 | 11.6 | 25,441.6 | 12.3 |
| Feed Livestock | 7,019.3 | 9.0 | 9,716.9 | 4.7 |
| Beverages | 80,471.7 | 45.3 | 88,213.7 | 42.8 |
| Others | 15,922.4 | 4.0 | 28,929.2 | 9.2 |
| **Total** | **177,536.8** | **100.0** | **206,171.0** | **100.0** |
| **Proportion in Industrial Sector** | 13.8 | | 14.9 | |

* 1 Euro = 47 Baht (September, 2003)

## 2 Food Processing Companies: Production and Environmental Implications of Case studies A, B, C and D

### 2.1 Geographical Profiles

Every factory under studied is located on its own land in the periphery of Chiang Mai City. Its site selection criteria include the isolation from community settlements, adequate space, ease of transportation of both raw materials and finish products to market. However, on the fringe of the factory area is usually a rural community from which the factory workers are derived because of the ease of community to work place. One exception is Company C that has to recruit its worker from neighboring province (Lumphun) due to the absence of nearly human community and the presence of large farming area. Nevertheless, the site of these factories are progressively becoming closer to other communities as a result of urbanization process in which more and more people settle to live in the former rural area. This implies the difficulty for any factory to expand its land area and business scale in the future.

Apart from the above-mentioned criteria for factory site selection, infrastructure is another decisive factor particularly the electricity service as most processing plants are situated in sub-urban area and hence cannot benefit from the allocation of electric power for industrial purpose as in the case of various industrial park zones. Every factory under studied has to face a major problem of power failures necessitating the installment of its own power reserve or back-up system. This is particularly true for companies C and D, which employ high level of technology for their production and waste treatment processes and thus great demand for electricity input.

As every factory is located outside the service area of the Water Work Authority, each has to depend on its own groundwater supply and pays water charge by use volume monitored by a water meter to the Department of Artificial Wells to be contributed to the Groundwater Development Fund[1]. The

[1] The Groundwater Development Fund has the corporate objective to conserve and develop groundwater, a natural

expense incurred by the factory on this part includes the electricity payment[2] and groundwater fee[3] per cubic meter at the rates set for industrial use. The water will be treated to satisfy the quality standards for different utilization purposes such as water for cleaning raw materials, equipments, and for chilling at stabilized temperature. This part of water quality control involves only the problems of sediments, pH level, and chlorine treatment. On the part of water that will enter the consumption process namely that is used to prepare syrup or pickling, its quality must be treated to an accepted standard through carbon of resin filtration processes. Wastewater from the production process of every factory except factory A will be drained to a pond for treatment before draining to public water bodies. Factory A disposes its wastewater through hiring a private agent to drain off and dispose the wastewater elsewhere since the company has no treatment facility of its own.

**2.2 Socio – economic profiles**

Factory A was established 25 years ago by the owner and his wife, operating as a household industry. Factory B has been in operation for 20 years as a second generation of this business which was initially a family firm and then transformed into a joint-venture investment among siblings. Factory C was setup 15 years ago as a registered company from the beginning and presently has a clear division among different business section, for environmental management. Factory D was established 13 years ago and has operated in the similar nature as C. Companies A and B turn out their outputs mainly for domestic market, have small investment capital no more than 10 million bath, and no more than 50 permanent workers. Companies C and D are medium-sized industry with 10-15 million bath investment capital and more than 50 workers. They also employ high level of production technology mainly with the use of imported machinery and have their major markets in Asian countries followed by the USA, Canada and certain EU countries.

All factories with the exception of D use fruits and vegetables grown in northern Thailand as raw material inputs. Factory D produces a wide variety of products and hence has to procure raw materials from the other regions of the country. The procurement of raw materials is generally undertaken by each company itself, including its purchase from middle-agents who fulfill its order at specified time and quantity. The exception is Company C which procures its raw materials through contract farming system in which contract farmers are provided with (GMO) seeds[4], fertilizes, and pesticides supply and are assured for the purchase of all outputs at guaranteed prices. Other raw materials such as salt, sugar, and chemicals including packaging materials for each factory will be supplied by various suppliers since their production origins are in the central region of Thailand.

Most factory workers have completed compulsory education, and receive a daily wage of 130-200 baht/day depending on gender, skill, work year experience, daily work hours and responsibility functions. Most are unskilled labor in each specialized task. Those with greater experience will be multi-skilled labor capable of working in different tasks at the same time. The number of workers in each division varies with the nature of works and the urgency for work completion in the production process or season. At the peak of fruit and vegetable season, the demand for labor may be twice the normal labor requirement and the extra workers are normally fulfilled by causal hire of female labor due to their lower wage rate. Apart from factory workers each company employs some office workers who are bachelor degree graduates in relevant fields, earning a beginning salary of 6,000

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resource, for the overall environmental protection.

[2] The Provincial Electricity Authority has established different payment rates for eight categories of users. Industrial users will be charged at the rates according to the average energy demand in the defined period, specifically as small, medium, and large scale users. For each category, the rates will also be progressive in blocks of unit use and time of use whether on-peak or off-peak. In addition, 7% value added tax is applied.

[3] Groundwater charge is payable four times a year to the Department of Artificial Wells which renamed from the Groundwater Resource Department. The rates are different for rural area and urban/its periphery area. Factories rural area with no public water service will be entitled to a reduction from the 3.50 baht/litre[2] groundwater charge, at varying levels depending on the size and type of industry. The factories under this study on the average pay groundwater charge at 1.05 baht/ litre[2].

[4] In Thailand, no legal permission in using GMO seed in cultivation except imported to be raw material in processing. However, in this case it is only used in contract farming and the products are mainly exported to international market.

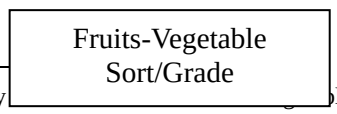
bath/month or above, and with social welfare benefit. They constitute above 5% of all workers in a company. Meanwhile, the principal administrators of these companies are the owner, relatives of the owner, or their co-investors.

### 2.3 Environmental Profiles

**Input:** All companies are in fruits and vegetables processing business using such raw materials as mango, lychee, longan, peach, garlic, etc., which are grown in the northern region of Thailand. The only exception is company C that emphasizes on baby corn products and hence depends on various input sources. Meanwhile, company D which also processes outputs according to order may require different raw materials from elsewhere but still the domestic sources. Other raw material inputs are sugar, salt, vinegar and chemical additive to enhance crispiness. Factories A and B depend on gas and electricity as main energy input while C and D use fuel oil/bunker oil and electricity. All factories pump groundwater from their own wells for use.

**Production Technology:** The production processes of all factories are demonstrated in figures 1 and 2, reflecting the some differences in level of technology and type of machinery equipment as well as the packing/packaging process. The fruits and vegetables are rid of the rotten of disqualified parts[5] dressed into a form ready for further processing, namely by peeling, pitting, etc., and then cleaned. At this stage, if the products are to be pickled of preserved in syrup, factories A and B will add another prior process by soaking the prepared raw materials in brine at various concentration levels for 15-30 days before preserving in syrup and filling into such containers as glass jar, plastic box, etc. The canned products are also subject to the similar process except for the last dew steps when fruit or vegetable pieces are filled into can before the adding of heavy or light syrup. Then the cans are sealed and passed through pasteurized process which time and temperature are varied by each product. After pasteurized by high temperature, the cans have been cooling off and dried. Then, they are labeled and packed in bulk container as the last step.

**Fig. 1** The production process of Fruit-vegetable processing of Company A and B




[5] Factories A and B order partially [illegible] bles to reduce the steps in the production process and to minimize wastes otherwise occur at the factory site such as reduction in water use, peels and leaves, other residues, etc.

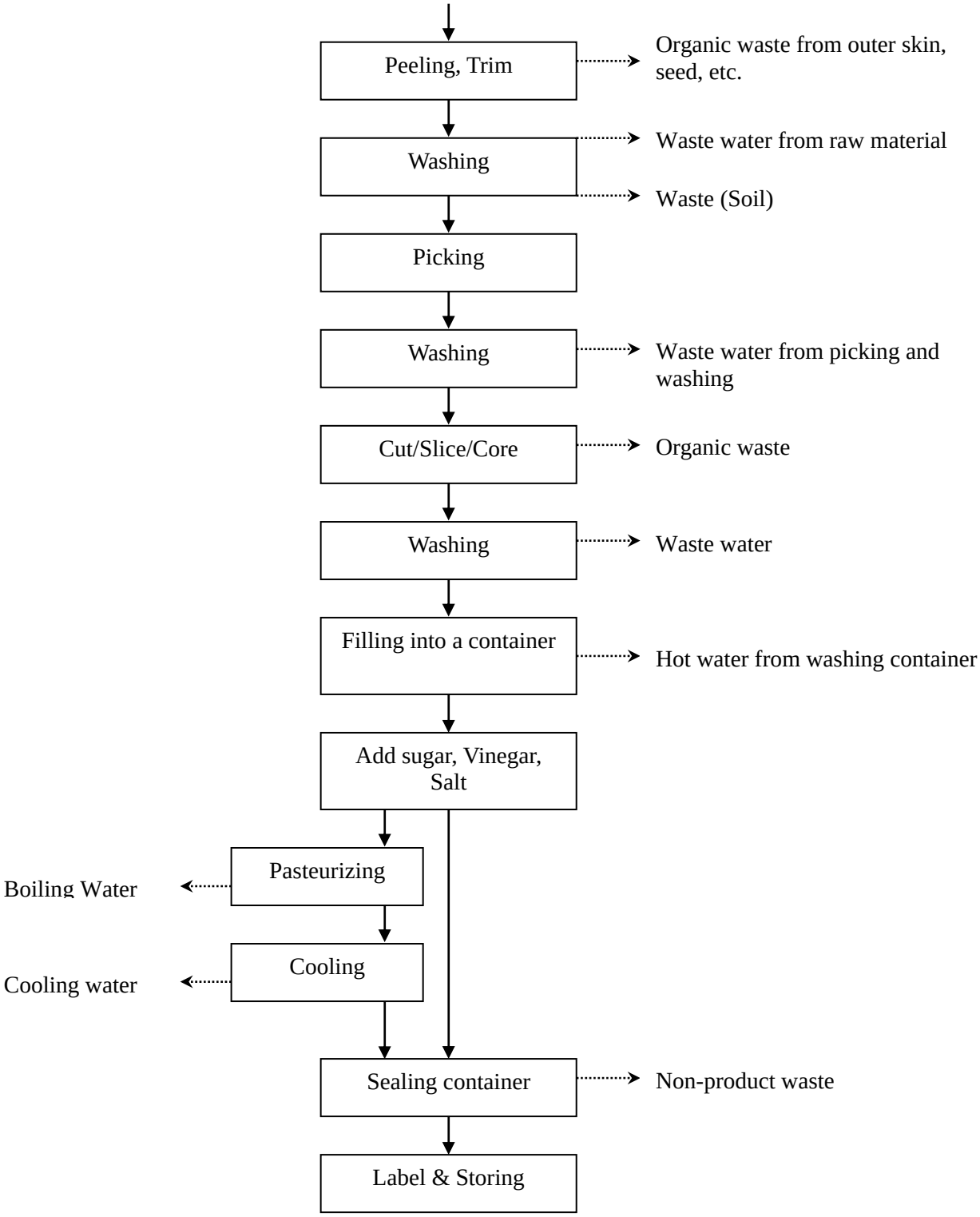
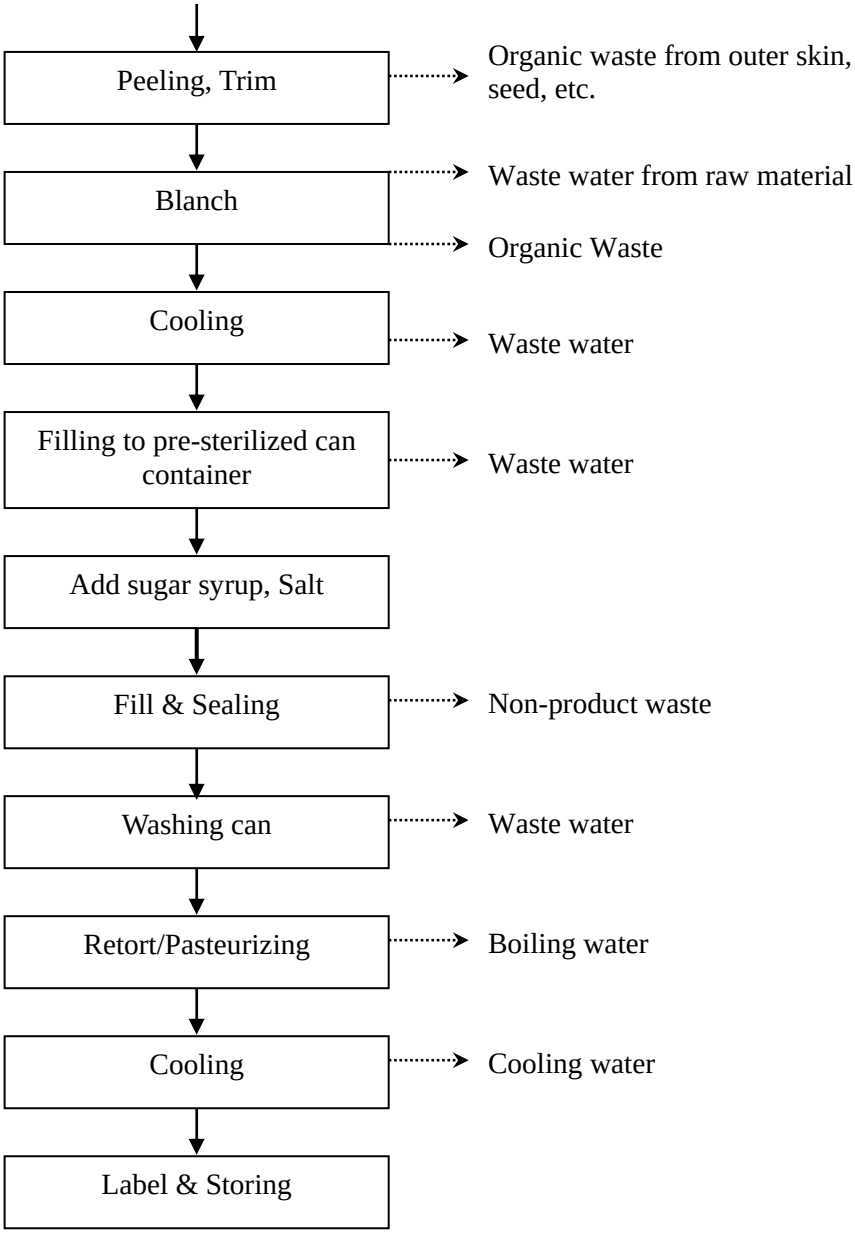



**Fig. 2** The production process of Fruit-vegetable processing of Company C and D

Fruits-Vegetable Sort/Grade




**Environmental Implication:** It is found from the production process of each factory that the major industrial waste is the wastewater from large volume of water usage, which also varies with the production capacity, factory size and type of technology. Wastewater is derived from raw material cleaning, pickling brine, and tools and equipment cleaning, etc. It is drained into a collecting pond. In

the case of factory A, some wastewater is directly drained off into a public area behind the factory site while some in very bad nature be kept in the collecting pond to be disposed of once a week by a private firm which is hired to do so. Factory B has an oxidation pond but it does not have the wastewater quality check before the release into the public water body nearby the factory site. Factory C has a closed wastewater treatment system in which all wastewater is treated by separation/filtration of solid waste before entering the activated sludge process for sedimentation and draining the water after quality check into public water ways. The sludge or sediment is removed once a month for utilization in nearby farms. Factory D has an open wastewater treatment system in which all wastewater after the infiltration process will enter the treatment system. Here, the water is subject to aeration, and organism addition to reduce malodor and to accelerate digestion of sludge. The remaining solid waste will settle itself into sediment and the treated wastewater be transferred to a resting pond before being drained into public water bodies. The sludge is removed every six months to be used as fertilizer in fruit orchard.

Apart from wastewater, the next main processing waste is solid matter coming from cutting, trimming, or dressing works, such as peeling, seeding, pitting. Solid wastes are managed and treated differently among different factories. Companies A and B engage private firms to remove the wastes for disposal elsewhere. Solid wastes from company C are collected by local agricultural cooperative for use as animal feed and those from company D be removed to use as fertilizer for perennial trees in farmers' field. Other solid wasted like metal and plastic scraps are sold for recycling purpose. The remaining processing wastes and garbage are taken away by private firms hired for this purpose, for disposal at garbage dumping area in town. The factories sometime burn part of their wastes and garbage on site which can cause air pollution as well.

It should be noted that part of wastewater which receives no treatment is normally released into nearby and public water bodies without control measure, giving rise to the water quality problem in both surface and underground sources as well as flooding in low-lying areas.

**Table 2** Balance of input and output materials (without water and energy) of fruit-vegetable processing companies in Chiang Mai province.

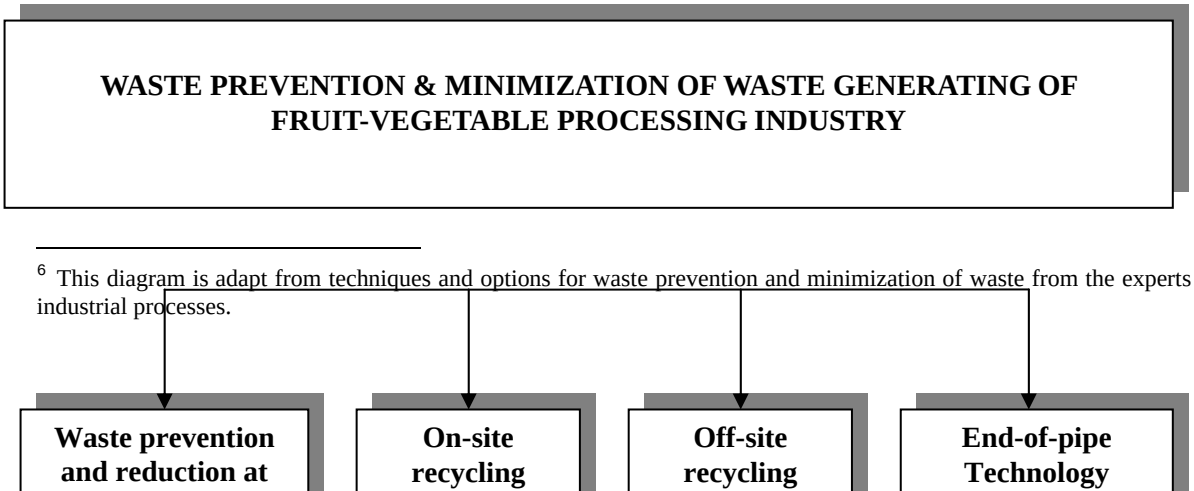
| **Materials** | **Inputs** | **Outputs** |
|---|---|---|

| Food Industries | Raw material | Product | Waste |
|---|---|---|---|
| **Company A** | Fruits/Vegetables<br>Sugar<br>Vinegar<br>Salt<br>Chemical<br>Jar, Wrapping Materials | Dried fruits<br>Chutney fruits<br>Pickles fruits<br>Pickles vegetables<br>Salted fruits<br>Salted vegetables | Waste fruit<br>Waste vegetables<br>Waste water<br>Wrapping materials |
| **Company B** | Fruits<br>Sugar<br>Vinegar<br>Salt<br>Chemical<br>Wrapping Materials | Dried fruits<br>Chutney fruits<br>Pickles fruits<br>Pickles vegetables<br>Salted fruits<br>Salted vegetables | Waste fruits<br>Waste vegetables<br>Waste water<br>Wrapping materials |
| **Company C** | Vegetables<br>Salt<br>Chemical<br>Chemical<br>Can, Wrapping Materials | Fresh vegetables<br>Fresh fruits.<br>Brine vegetables<br>Canned tropical fruits | Waste fruits<br>Waste vegetables<br>Waste water<br>Air pollution<br>Heat<br>Wrapping materials<br>Sludge from treatment plant |
| **Company D** | Fruits<br>Sugar<br>Vinegar<br>Salt<br>Chemical<br>Can, Wrapping Materials | Fresh fruits<br>Brine vegetables<br>Canned tropical fruits<br>Vegetables in water | Waste fruits<br>Waste vegetables<br>Waste water<br>Air pollution<br>Heat<br>Wrapping materials<br>Sludge from treatment plant |

### 2.4 Environmental improvements of the firms

As described in section 2.3, different factory has different ways to handle its industrial wastes depending on production volume and type as well as technology. This section will describe in more detail about the management of wastes from fruits and vegetables processing activities, which can be demonstrated in the following diagram[6] in Fig. 3.

**Fig. 3** The waste prevention and minimization of waste generating of fruit-vegetable processing industry




[6] This diagram is adapt from techniques and options for waste prevention and minimization of waste from the experts in industrial processes.

**Preventing and Minimizing the generation of wastes**[7]

**Wastewater:** This is the major component of industrial wastes generated by the factories under study as a result of washing and cleaning raw materials, equipments, and floors. Wastewater from different activity contains different effluents and contamination level. However, wastewater from all sources is drained into the same resting pond and treatment pond. Because cleanliness is the basic requirement among various quality control measures to meet industrial standards for food products, it is unavoidable to use huge quantity of water in the production process to assure food safety. However, from direct observation at the sites, most factories use water resource for excessively and imprudently in every stage of production due to the absence of good plan and control and the fact that private resource cost is low as a result of pumping groundwater from their own wells. Although water for cooling process may be reused, this method has been applied only to a small extent and by some factories. Therefore, if water use can be cut down in certain production processes and the treated wastewater is used for cleaning floors, the demand for fresh water as well as the wastewater volume can be minimized.

Recycling or reuse of water is in fact a method difficult to implement particularly in small-sized factories which normally have no wastewater treatment system on site. Although there is a central wastewater treatment facility in Chiang Mai City[8], this facility can serve to treat liquid wastes originated from domestic and household industrial sources in the urban and municipal area only. Most fruits and vegetables processing plants are located in suburban or rural area with much distance away from the central treatment facility, making the connection of their wastewater drainage pipes with the facility impractical, if not impossible. Moreover, the construction of a common facility is not feasible as different factories are not clustered into an economic area unlike the case of industrial estate area. Consequently, end-of-pipe treatment technology becomes the reasonable choice for each factory to treat its wastewater before releasing for other uses such as crop irrigation, fish pond farming, to increase food supply for factory workers, etc. The appropriate system for this type of factory can be the activated biological treatment technology applied sludge system with aeration device. Beneficial organisms may be added to the system to accelerate digestion and sedimentation process as well as reduce malodor. Water after the treatment will be kept in resting pond before being removed for farm use or discharged to public water bodies.

Cleaner Production[9] is another alternative for pollution prevention as it can reduce the wastes from original source. Waste minimization at factory site starts from turning in prepared certain procedures together with the use of good housekeeping principle in the prudent use of raw materials, water and energy resources. Furthermore, waste toxicity must be removed/reduced from the production process

[7] This model consists of good housekeeping, input material change, technological change, product changes, direct reuse, indirect reuse, and treatment system to prevent and minimize wastes from original source.

[8] The Chiang Mai wastewater treatment plant used as facility since 1997 to reduce pollution problems in Ping River.

[9] Cleaner Production/Cleaner Technology/Green Production use 3P-Pollution Prevention Pays-in implementation for the industry. Its idea is to prevent pollution at the source in products and manufacturing processes, rather than remove pollution after it is created. It proposes 4 goals: (i) reduction of environmental burden; (ii) conservation of resources; (iii) improvement of technologies; and (iv) reduction of costs.

such that air, water of residues can be reused. Occupational health and safety is also another important consideration.

**Solid waste:** This includes peels, pits/seeds, pulp or residues after juice squeezing, vegetable bits and residues from dressing, which are perishable and need timely and appropriate management. The non-perishable solid waste comes from container or wrapping materials, metal and can bits, as well as sludge from wastewater treatment.

The organic-decomposable solid waste should receive a better management. Certain companies handle this problem by having farmers supply prepared or ready-to be-processed raw materials to reduce production stages and cost such as reduction in fresh water use, labor cost, and residues. This is a type of clean technology which helps reduce wasted from production process. Nevertheless, consideration must be given to the spread of effluents into the environment without control. In addition, solid waste can be processed into bio-fertilizer, try fermentation of organic waste and sludge, which can be sold in market or distributed to the company's contract farmers. This process can save production cost; reduce problems of malodor from rottenness and diseases transmission by kitchen flies which occur in the case of waste disposal at garbage site or fruit orchards; as well as eliminate the problem of sludge disposal.

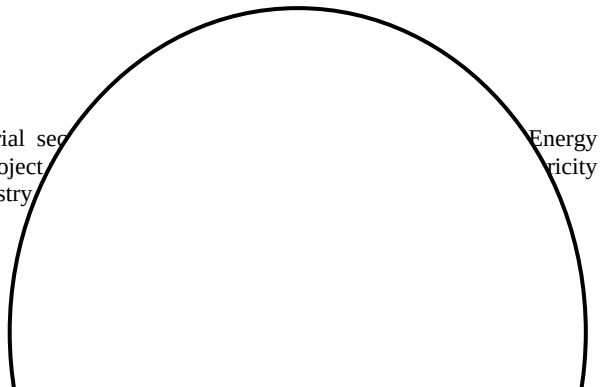
Problems of inorganic solid waste can be solved by reuse and recycling strategies to maximize the use value of resources. Furthermore, factory labors should be trained to be mindful to reduce waste of inorganic raw materials. To save energy, every factory should take measures and actions to control energy leakage. In case high production technology is in use, the company can adapt the technology system to reduce energy consumption, for example, the rotary use of hot water which save not only energy for boiling but also fresh water. Another possibility is to install a regulator to control the consumption of electricity not to exceed a special level as the electricity for industrial use is charged at progressive rates for different blocks. This technological device can save electricity cost for the company as well as energy consumption for the country[10].

## 3. Actors and Institutions of Fruit-vegetable Processing Companies

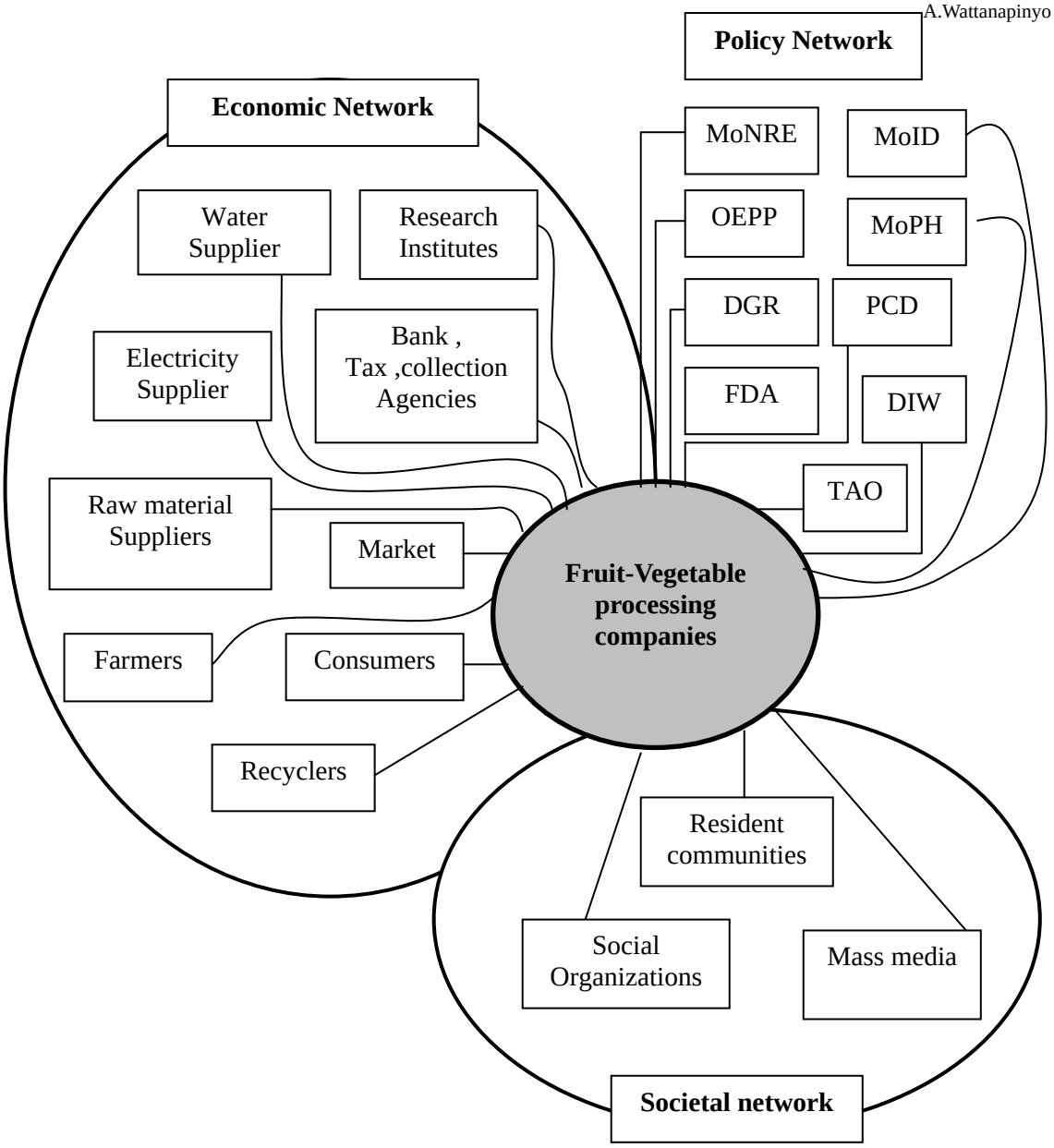
The previous description and recommendation on alternative ways to improve production process of various fruits and vegetables processing firms are primarily theoretical. In practice there are a number of factors whether triggering, facilitating, enforcing, or sustaining that can influence the decision of the entrepreneur to take certain measures, direction or actions most appropriate under their circumstances. In recognition of the influence of socio-economic context of an industrial firm on business decision-making, it is crucial to understand the roles of actors and institutions in the decision-making of fruits and vegetables processing firms regarding the use of production methods and technology, as well as the management. This can be portrayed through the analysis of economic, policy and social network of the firm.

The Network embedding fruit-vegetable processing companies of the purpose preventing and Minimizing of waste model is presented in Fig. 4.

**Fig. 4** Network embedding fruit-vegetable processing companies.



[10] There are some governmental project to support industrial sec Energy Efficiency Helping SMEs to save on the costs of electricity project ricity Generating Authority of Thailand and the Department of Industry




### 3.1 Economic network

In the economic network, the following analyzed interactions are conducted: (i) the relationships between fruit-vegetable processing companies in a product chain by looking at the vertical interactions from input suppliers to producers and consumers; (ii) the relationships between fruit-vegetable processing companies and other fruit-vegetable processing companies, or via branch association; and (iii) the interactions between fruit-vegetable processing companies and other economic agents and research institutes.

**Vertical interactions from input suppliers to producers, recyclers, and consumers**

***Input Supplier*.** Input suppliers for fruit-vegetable processing companies include farmers, raw material and chemical suppliers, water supplier, and electricity supplier.

*Farmers.* All of input for the processing is fruit and vegetable cultivated in the northern part of Thailand. The companies A and B order fruit and vegetable by season and process all the year round. They have signed an unofficial contract agreement with farmers to send raw material in ready to use form. It means that they can reduce some of organic waste from the primary process of preparing raw material. In this case the responsibility for take care of the environmental is turn over to the providers

or farmers. For company C, this is a special case; they have a kind of contract farming in 6 provinces of the North. They give GMO seeds and fertilizer to the farmers. So they have an on schedule qualify raw material on fixed price for their processing. In the case of company D, they buy fruit from all farmers around and nearby the firm because the main products of this factory are made from lychee and longan, which the main cultivated are in Chiang Mai, Lumphun, and Chiang Rai. The amounts of company's productivity vary upon the supply of fruit. However, sometime they produce product by special order that make them to contact providers for special kind of fruit.

*Raw material and chemical suppliers.* Other raw materials such as sugar, salt, and chemical materials are purchased from domestic market with economic contracts, in which the amount and quality of raw material, the supplying schedule, and the price are indicated. They ordered raw material from different suppliers with different contracts up to the price and quality. Certainly, the higher quality of raw material mean to the higher efficiency and the lower of waste from the production process that cost lower treatment of waste.

*Water supplier.* Water for production activities of these companies is mainly supply from their own groundwater wells. Although they get it from the well in their companies, they have to pay for water consumption to the Department of Artesian Wells. However, the price is lower and does not attractive for the producers to minimize wastage of water. The recorded of water usage is only for payment of water consumption, no pay attention for auditing of minimizing water usage. They state that they have to use a large amount of water to reach a standard of GMP[11]. On the other hand, because of the large amount of bill payment, some companies tried to recycle the cooling water for cleaning machine and floor but it is a little amount of the whole water consumption of the companies.

*Electricity supplier.* Electricity is produced and distributed by Provincial Electricity Authority. The government decides on the electricity price via electricity purchase. The price of electricity[12] varies depending on kind of business, the voltage level and demand hours in progressive principle. The higher voltage and off-peak time[13] of use are the main index to the cheaper price of electricity. This makes producers pay attention to saving electricity. Some try to contribute of the saving energy program of governmental department that be monitoring now. But they said the result is not clear enough in saving their cost.

***Recyclers.*** Recyclers play an important role in the reduction of generated wastes and make a material flow of waste. They include agricultural co-operative and compost producer.

*Agricultural co-operative.* The agricultural co-operative at local level can play a role in minimizing organic waste from preparing process. Waste from outer skin, seed, and so on are carried to feed animal farm and livestock. They still want more for the amount of this kind of waste because the companies give them free of charge. Both of them take an advantage from this activity; also the companies can get some kind of familiarization from community.

*Compost producer.* At present, no compost nor fertilizer production company has been constructed to compost organic fertilizer from non-product solid material that come from the production process of the companies. The organic waste from the companies is returned back to the surrounding fields and gardens every time when the processes are continued with free of charge. In fact that farmers usually use natural composting consisting of leaves and plant bodies after harvesting, added by chemical fertilizer. This situation shows the demand and possibility of reusing non-product solid waste from the companies for composting. It is a good opportunity both for companies to reduce organic waste

[11] Good Manufacturing Practice (GMP) came from general principles of food hygiene, which is international standard for food processing. This regulation is implemented by Ministry of Public Health.

[12] The normal tariff schedule is applicable to a business enterprise, business enterprise cum residence, industrial and state enterprise or the alike, including its compound, with a 15-minute maximum integrated demand up to 30 kilowatts through a single Watt-hour meter.

[13] On peak time of use is Monday – Friday from 09.00 AM to 10.00 PM. Off peak time of use is Monday – Friday from 10.00 PM to 09.00 AM. And Saturday, Sunday and Normal Public Holiday (excluding substitution holiday) from 00.00 AM to 12.00 PM.

and for farmers to have organic fertilizer for improving soil structure in a low cost.

***Consumers/Customers.*** The consumers of the studied companies divided to 2 groups. For company A and B, their consumers are domestic market especially in the northern and central part of Thailand. Therefore, no need for the certificate except some guarantee about the quality of product[14] such as food healthy logo from Ministry of Public Health, prize from governmental organizations, provincial brand[15], etc. This means the products are over standard required from that organization and it is notified that these criteria also link with environmental management in their factories. Nowadays these companies need to pass for GMP standard that be strict for implementation on July 2003.

In the other hand, the customers of company C and D are international markets. For exporting, they have to pass at least HACCP standard[16] to guarantee that their products can export to some countries such as Europeans Union, North America, and Japan, beside Asian countries' market. It implies that customers have more power to enforce the companies to manage their production processes to meet the higher standard.

**Horizontal interactions between the producers and other fruit-vegetable processing companies, enterprises, or via branch association**

Company A and B compete with each other and have many competitive companies in the same size and kind of product for domestic market. They do not cooperate on common interests such as marketing, technology development, or waste treatment. They learn to manage their business by themselves. Now they have no incentive to improve their performance to protect environmental problem except for pass GMP standard only. However, they have some contracts to produce the products to be raw material for the other companies. For this case, they have to improve their production efficiency and product quality. If they share each other's experiences, they could not only improve their production efficiency but also reduce environmental impacts. Moreover, it represents common interest towards customers and government as well.

Company C and D, these companies do not collaborate with each other on technology development in production processes, also in waste treatment. Both of them have their own wastewater treatment system with difference treatment technology. They do not learn from each other's experiences to improve their technology or treatment system. However, they tried to improve processing technologies and quality of products for export by themselves. These are revealed in their plan of upgrading their technology production, applying HACCP standard for other products, applying quality management system ISO 14000, providing staff training, reducing cost of energy, and investment in composting plant.

**The interaction between the companies and other economic agents and research institutes**

***Economic Agents.*** Economic agencies consist of banks, tax agencies, insurance company, the Thai Chamber of Commerce, and the Federation of Thai Industries. The companies have to follow legislation of State Banks on interest rate on loans and other activities dealing with currencies. The

[14] The logo that they used on the label for food, it means that they are checked up by the relevant government organizations about their process and their quality of product. Some criteria of the checklist are link with environmental pollution control. For example, the checklist about the factory – site and situation- has to be in good condition and good environmental management.

[15] The Chiang Mai Brand started since 2002 to guarantee the products produced within the province for the quality and taste.

[16] HACCP (Hazard Analysis Critical Control Point) is a system used to identify and control contamination in food processing. In Thailand we don't have the enforcement of HACCP standards. However, the exporting industry have to pass this standard for their exporting to the foreign countries such as Japan, USA, Canada and EU countries. It implies that it is the first starter point to get more environmental friendly performance of the firms.

interesting point is establishment of SME Bank[17], reorganized from the Small Industry Finance Corporation in 2002, for supporting SMEs in profitable project. This is a new channel for industry to get loan for their investment. However, the limitation is investment for environmental management gets back an indirect benefit in the long period. By Law, the companies are responsible for paying tax including value added tax (VAT), import duty, export duty, personal income tax, etc. The companies, which import raw material and equipment, have complied with the Law on Import Tax and Export Tax. So far, no existing law and regulation provided any incentive to encourage the companies to apply cleaner production and pollution prevention measures. For insurance companies, they are mainly related to health insurance more than risk insurance for industries. Although some insurance companies have a kind of industrial insurance[18] – Business Protector - for accident in property, health and machinery but it does not for industry risk related in environmental issues. Also for being member of the Thai Chamber of Commerce and the Federation of Thai Industries, they only accept economic information from membership publication[19].

***Research institutes.*** The companies have technical services and investment consultancy on the production from government research institute such as Department of Industrial Works, Department of Renewable Energy and Energy Conservation, Thailand Institute of Scientific and Technological Research (TISTR), Department of Medical Sciences, Food and Drug Administration, Health Systems Research Institute, etc.

Besides, cooperation with other research institutes such as the research centers in Chiang Mai University[20] and Mae Jo University, Scientific Research Centers, National Food Institute, etc. are always helpful for improving the efficiency of existing processes, increasing productivity, and improvement of by product reuse and recycling. For example, "Energy Saving Project" the cooperation of Faculty of Engineer, CMU and Ministry of Energy, "Management of Industrial Pollution Project" the cooperation of Faculty of Engineer, CMU and Ministry of Industry, "Environmental Management System for Small and Medium-sized Enterprise" the cooperation of Faculty of Engineer, CMU, KU and CU and Ministry of Industry, etc. The production improve program in companies generated from involving in training program or attending in seminar managed by the cooperation between research institutes and government agencies.

### 3.2 Policy network

In this section, the roles of actors and policy institutions at different level are analyzing to see how they can govern and push the fruit-vegetable processing companies to prevent and minimize waste from their production processes.

At national level, the state agencies link with environmental management are Ministry of Natural Resources and Environment (MoNRE)[21], Ministry of Industry (MoID) and Ministry of Public Health (MoPH). At regional level are Office of Environmental Policy and Planning (OEPP), Pollution Control Department (PCD), and Department of Industrial Work (DIW). At provincial level are Department of Artesian Wells (DGR) and Provincial Food and Drug Administration Office (FDA). And at local/commune level is Tambon Administrative Organization (TAO).

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[17] SME Bank is a bank for small and medium-sized enterprises, upgraded and expanded the role from the Small Industry Finance Corporation into a special-purpose bank for investment of SMEs. The amount of credit would depend largely on the potential of each project.

[18] They have many risk insurances for SMEs in Thailand such as for major property, product, energy, and casualty, etc. However, for public liability insurance have not been serviced yet.

[19] Sometime they have some supporting projects for industry but it is still in commercial issue such as innovation for industry, introduce agency for financial loan, and introduce successful case in business.

[20] Chiang Mai University research institutes consist of Institute of Science and Technology Research and Development, Multiple Cropping Center, National Research Center for Environmental and Hazardous Waste Management, Center of Waste Treatment and Utilization and Institute for Small and Medium Enterprises Development, etc.

[21] A new governmental organization established since October 2002 following the Bureaucratic Restructuring Act, B.E. 2545 (2002). In fact, it was detached from the former Ministry of Science, Technology, and Environment (MoSTE) which now is the Ministry of Science and Technology (MoST).

The environmental management of production activities in Chiang Mai province is under direct and indirect management of FDA and DIW at province level and MoNRE at national level. In general, the role played by MoNRE and MoID are mainly on EIA appraisal and promulgation of legislation related to environmental protection. In fact, the implementing and monitoring are mainly in a responsibility of each department at province level. The companies have to apply for set up their factories with approval from MoID and MoNRE. For their products, they have to apply to FDA(MoPH) for approval and guarantee in food safety as well. FDA also monitoring the approval of GMP standard, which indirect link to environmental performance of the companies on their production processes. OEPP and PCD take a responsibility for checking environmental pollution around the firms and DIW work inside the firms. Due to lack of human resources and overload of work, the monitoring is irregular probably once a year or longer. For TAO, the new government agency established in 1997, which has full authority to manage and monitor for environmental protection at local level. By now, it plays any role in this kind of work.

Company A and B have no environmental management section because both of them are private enterprises that everything are controlled and managed by the owners. The owners contacted and involved in meeting, conference, and practical seminar managed by governmental agencies as much as they can. They try to improve and adapt their activities toward the regulations. At present, their performances change from insolation to ecological adaptation considerably.

Company C is the only firm that has it own separated environmental management section, controlled by chief of technical section. They work together with the consultant from Faulty of Engineer, CMU. The system is partly complete although they mainly focus on wastewater treatment. They tried to develop and use technology to reduce waste. It is not surprised because they have a closed contact with research institutes and export products to the customers that realized with environmental management. Therefore, it is crucial that this company can apply the model of preventing and minimizing the generation of waste. Also, they used resources from environmental agencies in improve their treatment technology and exchange know-how from research institutes to adapt their production processes to be more green.

Company D does not have a separate environmental management section in its organizational structure. It is responsible by chief of the technical section of the company. The scope of environmental protection activities consists of managing and maintaining wastewater treatment plant, collect wastewater from the plant and send the sample to test quality at Science laboratory in CMU, and discharge wastewater after treatment to the earth pond. After once complaint from resident community via TAO, they have more contact with environmental officers and a consultant for solving this problem.

Nevertheless, the government agencies have changed their policy-making by asking for more cooperation from the industries. Many projects have been taken place and done with cooperation of industry, environmental authority, and research institutes. In conclusion, for all cases it can be stated that the relation between the government and the fruit-vegetable processing industry on environmental reform change from neglect to participate in environmental issues to involve in the environmental policy-making, frequently contact with environmental policymakers and the rules of environmental policy-making changed considerably. It can say that the producers are forced to spend resources and time on environmental politics and reform.

### 3.3 Societal network

The influences of a societal network play a role via public pressure. For this analysis the societal network involving fruit-vegetable processing companies, consist of resident communities, mass media, and social organizations.

***Resident communities.*** Although the companies located in rural area, but now some are surrounded by residential areas that expand to suburb. So far, there are no direct complaints from surrounding

residents to the government official for several reasons. First, people around these companies work as permanent and temporary workers at the companies. Second, the companies tried to get involve in community affair such as give organic waste to farmers, give free uses of groundwater, join in protection program for environmental problems with community, etc. Third, compared to the different kind of industry, these companies cause less serious environmental problems to the community.

However, some of surrounding residents have complained with bad smell of wastewater from wastewater plant and sometime from organic waste. And other complaints are wastewater flow over and discharge to the ground without any treatment. These complaints were solved at local level by contacting directly with the companies. The solutions are company A drained the wastewater out from the ponds in rainy season before it flowed over. Company B moved the factory to the new location and tried to treat wastewater before draining. Company C has its own treat plant in a closed system and check the quality of wastewater every month. And company D hired a consultant company to solve the problem from their wastewater plant. This is the result from power of the surrounding communities affected to the production processes of the companies. The companies are forced to be more environmentally friendly by communities' power.

***Mass media***. At present, mass media such as television, radio[22], and (local) newspapers do not play an important role in environmental improvement of the fruit-vegetable processing company. They just report in general about environmental issue around country. It is suggested that environmental agencies at local level should collaborate with these mass medias to introduce good practices in reuse and recycling of waste, cleaner production, and environmental performance. This is the way to help both producers and residents to learn about how to produce and reduce waste in environmental friendly performance with little cost.

***Social organizations.*** Social organizations within Chiang Mai province consist of NGOs[23], Consumer group[24] and Women association. So far, the roles of these organizations[25] do not take a responsibility for this issue only. They concern for the environmental as a whole and if there is any evidence that link to their scope of work then they will take action about that problem. For example, The Chiang Mai Consumer Society Right takes a major action in consumers' complaints about the quality of good and product. Sometimes the complaint link with food safety issue, so they contacted and passed the issue to Public Health officers to solve the problem. They act as they are organizer or coordinator between Government and the companies more than to solve the problem by themselves. Therefore, these actors could play more role in helping community to complain to the Government and push pressure to companies in changing or improving the production processes.

## 4. Conclusion

From these case studies, it implies that cleaner production, waste exchange and ideas of preventing and minimizing the generation of waste are valuable in greening fruit-vegetable processing industry for many reasons. First, reusing all waste generated from fruit-vegetable producing industry is a

[22] It has a radio program in Chiang Mai, "Ruam Doui Choy Khan" means helping together, that report and coordinate to related agencies for solving communities' problems which some be related to environmental management especially in urban area. It will be an example of mass media that can play a role for environmental management of industry.

[23] There are many groups of NGOs link with environmental issue in Chiang Mai province such as For Chiang Mai group, The Chiang Mai consumer society right, The committee for protection of Ping river and environment, Project for the development of alternative agriculture producers-consumers network in upper northern Thailand, Urban development institute foundation, etc. However, they are not only focus on environmental problem from industrial sector.

[24] This group received some financial support from Ministry of Public Health so sometime they can't take more action for against the rule. But it's helpful in playing a role as supporter in training people for environmental perception, also as coordinator between GO and the firms.

[25] They have no authority to check up and monitor the regulation by themselves. Therefore, as soon as there is a complained case, the more they could do is to inform the relevant officer to do the job.

useful method to protect environmental problems without or less investment. Second, introducing cleaner production measures to the producers, it can reduce the amount of wastewater discharging and reduce the amount of fresh water used or reduce wastewater generation in the same time. This is mean that not only the producers can get the economic benefit by reducing cost of wastewater treatment and cost of fresh water used but also they can show their performance to the environment protection and natural resource conservation. Finally, end-of-pipe technology still important for treatment wastes before discharge to environment. Moreover, checking wastewater discharge with loading of contaminants together with concentration is the best way to reduce environmental pollution. The technological options and organizational schemes are different vary from small to medium scale company. This would make the producers in minimizing waste from their production as more as possible.

For producers, they still need assistance for financial and expertise for improving their environmental performance such as for construction, operation, and maintenance of wastewater treatment system and composting plant. Meanwhile environmental authorities should not play too much role in further implementation of the preventing and minimizing the generation of waste because of their priorities of work and the limitation in resources. The collaborative relations between producers and environmental authorities in implementation of environmental protection activities are needed.

At present, community driven regulation does not play a significant role and might be limited in the future besides it has environmental impact affect directly to the community's interest. So far, the role of community must be increased in forcing the implementation of environmental activities and law and regulation via TAO at commune level and government authorities at provincial and national level in the future. In this case, mass media can take action in giving knowledge and information about protection and prevention of environmental problems. Both resident communities and producers can get benefit from the environmental awareness together collaboration with environmental authorities.

Moreover, the driven force from external competition, for example from larger companies or foreign producers, might set the cooperative of the industry to exchange information about increasing product efficiency and reducing cost and waste. In addition, they have to open new international market that make them have to apply for another standard of food safety and management system such as HACCP, ISO 9000 and ISO 14000. These standards are direct and indirect method for environmental protection as well. Finally, economic and policy instruments such as appropriate pricing of water used, adding financial sanction on existing environmental regulations, and strong implementation of existing environmental standards, would encourage the producers to apply the proposed model for preventing and minimizing the generation of waste.

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