BENEFIT-COST ANALYSIS OF FAECAL SLUDGE MANAGEMENT OPTIONS IN PERI-URBAN AREA

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Abstract: *Septic tank has been widely used in urban and more popular in peri-urban areas in Vietnam. That leads to more and more amount of septic sludge, which has been created. Faecal sludge management (FSM) is a big challenge in today's rapid urbanizing Vietnam. More than 50% of household with farming activities wish to reuse sludge for garden or crop. There are many options of FS treatment such as drying bed, dewatering, anaerobic digestion, co-composting or vermicomposting, in which FS treatment integrating into existing farming will be feasibility option. In order to better understand a) household demand for emptying services; b) costs of desludging services, particularly with respect to transport; c) drivers of private sector participation the sanitation value chain; and d) treatment and safe disposal/reuse of sewage, a Benefit Cost Analysis (BCA) study on FSM models have been conducted to compare treatment, disposal and reuse options. BCA result shown that inner return rate (IRR) of FS private emptier, household with farming activities and FS feeding worm farm are 8%, 14% and 207% respectively. It also shows that vermicomposting business is promising option for FS treatment in order to safe reuse of FS and nutrient recovery.*

Keywords: *Benefit-cost analysis, faecal sludge, nutrient source, vermi-composting.*

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1. Introduction

Almost 35% of the population of Vietnam lives in urban and peri-urban areas, and urban population is expected to continue increasing by 1 million people annually [1]. Vietnam as other low and middle income countries centralized sewer-based sanitation systems have been recommended for areas with high population densities, however, onsite systems have also simultaneously been promoted (e.g. pit latrines, septic tanks). Both centralized and onsite systems producing sludge (respectively referred to in this report as faecal sludge), which require appropriate management strategies to protect public and environmental health. Faecal sludge management (FSM) is a big challenge in today's rapid urbanizing Vietnam. Neither Vietnamese city nor peri-urban area has currently a well-functioning FSM system including sucking, transporting, treating and disposing of FS from on-site sanitation systems [2]. Most households only empty their septic tanks if they become blocked or overflow, at a mean estimated frequency of somewhere between three to ten years [3].

Most of the time FS is directly disposed of in the environment after collecting at the septic tank. This has a significant negative impact on public health as people get in contact with soil or water contaminated by FS, which contains a high pathogen concentration. It is, therefore, urgent to find an appropriate treatment method to sanitize FS. In Vietnam, around 44% of its population is infected with healminth [4]. This high infection rate is a consequence of poor sanitation conditions.

A septic tank is composed of several chambers, but should have at least two [5]. The infrequent emptying causes a fact that solids from the sludge are washed out with the supernatant when the tank is full of sludge. Thus, regular desludging is needed to maintain the performance of a septic tank [6].

Several Urban Environmental Companies (URENCOs) provide services for both faecal sludge and solid waste collection and transport. Therefore, they commonly dispose of faecal sludge in landfills that they operate.

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People in rural areas widely apply untreated faecal sludge as a fertilizer, and there is a good potential for enduse of faecal sludge in Vietnam [7]. Indeed, it is common that emptying companies discharge faecal sludge in agriculture fields or aquaculture ponds. The Ministry of Health is currently drafting guidelines for composting human excreta into reusable fertilizer, based on the World Health Organization's 2006 [3].

As field survey results on sanitation in peri-urban areas at Ninh Binh province, the majority of toilet was flush toilet with septic tank (94%). There were few households using vault toilets and biogas. Black water from septic tanks in most cases goes to open ground (62%). The proportion of 26% of total household connected to the drainage canal nearby. The 5% of household directly discharges black water to backyard or open water, such as ponds or lakes [8].

A lot of the respondents say that they do not know how to manage the septic sludge, for the reason that the septic sludge has never been filled up, accounted for 52%. The other respondents would call for septic sludge empty services when the septic tank is full. Only 2% of household is directly using septic sludge without further treatment [8].

Through the interviews with local environment officers, all interviewees agreed that at both district and communal level there is not anyone particularly assigned to manage this kind of activity. They had no idea about where faecal sludge is discharged and/or disposed hence there was no complaint heard by them from the people. Therefore, the local governance officers have no plan for faecal management as well as sanction for illegal discharge/disposal of faecal sludge.

The survey results revealed that there was few providing septic tank emptying services in surveyed areas. When there are demands, the service provider uses a specialized tool to draw faecal sludge into its container and transports to an empty area or some open channels/ditches for disposal. In another scenario, the drawn faecal sludge will be discharged to the household's yard for reuse. 56% of households with livestock had the demand of reutilizing faecal sludge in various purposes and planting, 24% of households with livestock would like to reuse faecal sludge for cropping and perennial crops, whilst other purposes such as fish feeding and fertilizing took up the rest of the answers [8].

Reusing feacal sludge for agriculture will help to alleviate expenditure of farmer for crop and help communities to grow more food and conserve precious water and nutrient resources. The additional advantages of nutrient use from feacal sludge as fertilizers are that this "product" is less contaminated with industrial chemicals than when wastewater is used. Reuse of faecal on arable land secures valuable fertilizer for crop production and limits the negative impact on water bodies, air emissions and the impacts on soil.

An overview of treatment technologies, together with their treatment objectives and functionality, there are 4 steps for FS treatment in popular, which is shown in Figure 1. It is important to realise that for the conversion of FS into a product that is safe for end-use or disposal, several processes need to take place. FS typically contains large volumes of water and hence needs to be dewatered, which can be achieved on its own, or in combination with solid / liquid separation. Depending on the end-goal, further treatment needs could include converting organic matter into a stabilized form and/or pathogen reduction. If the final goal is to make a dry product that can be reused in agriculture, then particular care has to be paid to dewatering and pathogen reduction.

Vermicomposting (vermis means "worms" in Latin) is one of stabilization/further treatment, which is composting process that includes mass production of suitable earthworm for degradation of organic waste. Earthworms constitute 80 per cent of soil invertebrate population, having been long recognized as an effective soil conditioner, especially in tropical ecosystems. Earthworms' role in vermicomposting is involved in physical/mechanical and biochemical processes. In terms of physical/mechanical processes, earthworms are known to aerate and mix substrate due to their movement and actual grinding, therefore maintaining

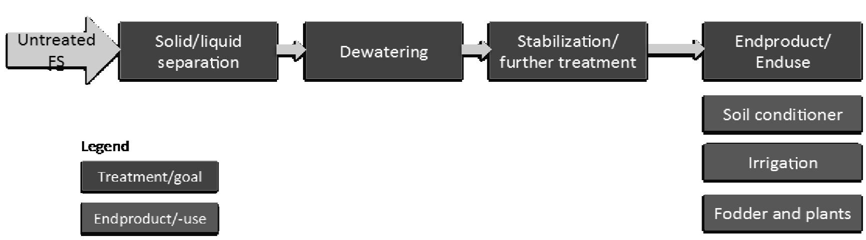

Figure 1. *FS treatment steps [9]*

aerobic condition in the mixture. For biochemical processes, they consume organic waste as "food" and convert a proportion into their biomass, and expel the remaining as a stabilized matter with fairly high amount of absorbable nutrients.

The digestive processes also result in an odour-free and hygienic compost as pathogens are killed when passing through worms' gut, whilst earthworms also release coelomic fluids which has anti-bacterial properties. A field testing by [10] showed that vermicomposting could reduce faecal coliforms by 6.4 log scale, specifically reducing salmonella spp by 4.9 log, enteric viruses by 4.6 log and helminthic eggs by 1.6 log, comparing to 4.9 log, 1.9 log and 0.6 log reduction, respectively, in the controls without worms.

The product of vermicomposting is valuable, marketable as a high quality plant growth medium [11]. Vermicomposting is determined as a low-cost resource recovery treatment, yet similarly to any other waste treatment method, it requires a close monitoring scheme to maintain an optimum condition for worms.

The vast majority of interviewed households showed their readiness to pay for septic tank emptying service as per market price, accounting for 80%, specifically. Only 9% of the interviewed households did not wish to pay for the service, as they wanted to do the job manually if needed [8]. In this case, de-sludging business is potential market

Private companies discharge the faecal sludge contained in their trucks in agriculture (e.g. familial farmland). The private emptier interviewed also stated they discharge faecal sludge in vegetable gardens, fish ponds and fields. Based on the Ministry of Agriculture and Rural Development (MARD) Decision 04/2007-QG, this is illegal, as waste products issued from animal or human should not be used as amendment for the growth of vegetables [4].

Due to the lack of regulatory framework and strategy for faecal sludge management, local governments have no incentive to promote faecal sludge management. They invest scarce resources in operating the few existing treatment facilities, or to support such projects once ODA project funding ends [7].

With the criteria for evaluating the profitability of feacal sludge management business models, the research team conducted a cost-benefit analysis of business models base on survey data peri urban areas in Ninh Binh and worm feeding farms thence the FS entrepreneur ship can define their business model canvas.

2. Material and methods

Benefit-Cost Analysis (BCA) will be conducted to compare treatment, disposal and reuse options. In BCA model, financial indicators as NPV (Net Present Value), IRRs (Inner Return Rate) are used to calculate the financial performance of selected models. Cash flow have been identified through analysis of the business activities of three FSM models: (1) emptier and operator enterprises; (2) household with farming activities; (3) worm feeding farm. Developed financial flows have been discussed with component of each FSM models for verifications.

2.1 Emptier/operator

The financial analysis model for the sludge empty service household will be analyzed to look for gaps and provide incentives. Currently, empty service is not well developed because the demand for sludge in households still low. Base on interview result, assumption that the private emptier has 50 customers per year, investment cost is about USD250 (with expenses for cart, pipe, pumps…) with analysis time is 5 years so depreciation costs of USD140, expenditure for operation for example: truck rent of USD5/trip; labor cost consists of two parts, the cost of outsourced labor is calculated according to the trip with the cost of USD10/trip and the cost of labor for one main person per month with time spent on this job is 50 % of working time in the month with the minimum salary of USD170 according to Decree 153/2016 / ND-CP [12]. Costumer has to pay for one time of de-sludging USD60.

2.2 Household with farming activities

Gia Tran commune, in 30 households with livestock, only 20 households have the main income from pig production with an average number of pigs of 15. Chicken feeding to provide food for themseft. Cow feeding account for a small percentage of interviewed households.

In 11 farming households, only 5 have income from cultivation, the rest only enough to provide food for their life. Seven households have both livestock and cultivation, mainly pig feeding and rice cultivation.

Gia Thanh Commune, among 18 livestock households, more than 70% of pig feeding households with an average number of 27. Same as Gia Tran commune, only a few households raise cows, small amount of chicken served food for their life. There are only 8 households with crops, of which 5 have both husbandry and cultivate.

A financial analysis model for households with crops and livestock with the average data from the survey of 40 pigs that be raised in 65 m^2 of pig's lodging and cultivating with 1800m^2 (5 sào) of rice fields selected. With that farm size, the investment cost for lodging and pump for cleaning is USD1600, with 5 years of analysis time the depreciation cost is USD320. Expenditure for operation includes: lodging repair expense of USD100/year, monthly labor expense for 2 persons of USD300, that cost is calculated according to Decree no.153/2016/ ND-CP [12], salary will be increased of 10% annually.

2.3 Worm feeding farm

The financial model was applied for a worm-feeding household to sell worms, breed worms, and humus soil, and also use worm product for feeding chickens and tortoise in the the peri-urban of Hanoi city. They had 70m^2 worm farm, 20m^2 chicken lodging and 20m^2 tortoise. Annual revenues from worm, chicken and tortoise breeding are USD7,500, USD500 and USD2,500 respectively. In surveyed worm farm, the investment cost including lodging for worm, chicken and tortoise ex… as total is USD1350, with the 5 years of life cycle the depreciation cost is USD220. Worm also supply for breeding of chicken and tortoise, so annual revenue from selling of chicken and tortoise are 100kg and 200kg respectively.

2.4 Determination of financial flows

The following financial flows have been identified and further quantified for the surveyed households, enterprises and involved stakeholders. Analysis Algorithm for 3 selected models are shown in Figs. 2, 3, 4.

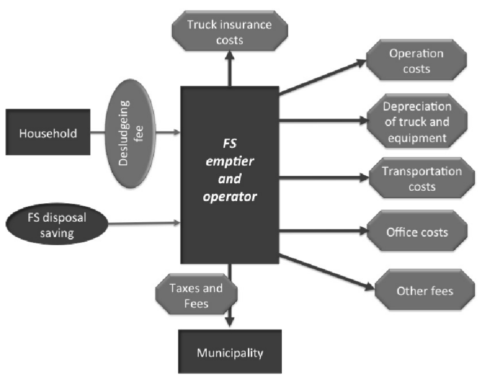

Figure 2. *FSM Business Analysis Algorithm*

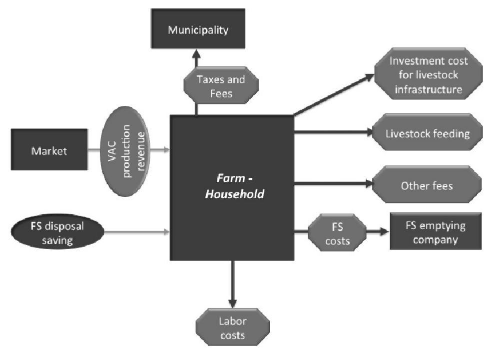

Figure 3. *Household with farming activities Analysis Algorithm*

3. Results and discussion

3.1 Emptier and Operator

Financial analysis implementing for private emptier show that it is unskilled occupations, not managed by any authorities. With low investment, high profit margin but the annual net profit is very low with USD58.5 in the third year, so the private can not lives with only this job. Figure 5 below shown cash flow of third year of business life cycle, it also shown that the private empty enterprise have not profit by provide this service. They keep this service to get more income sources, get wage as their profit. The demand for sludge emptying of households is not high so although there are few investors but revenue from this activity is still low and can not become the main business of the firm because net profit still at low amount. The only revenue source of operator is small fees from household makes this activity not really a viable

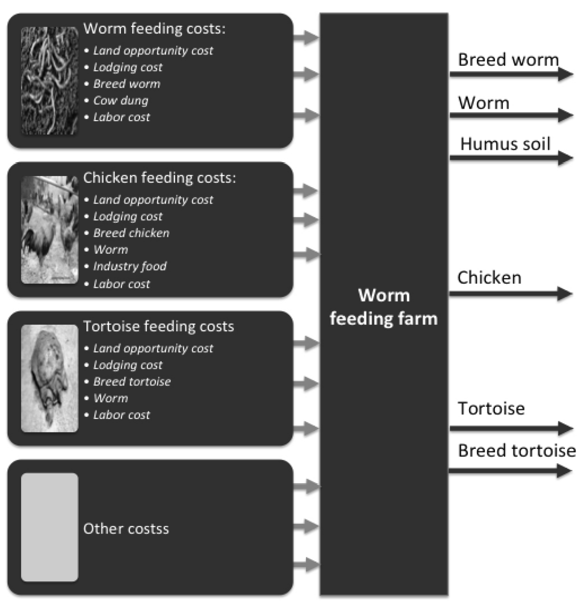

Figure 4. *Worm feeding Farm Analysis Algorithm*

job. If operator considers sludge to be a reusable resource for production activities in the next cycle, such as worm feeding and fertilizer... revenue and profitability will increase.

3.2 Households with farming activities

Figure 6 below shows cash flow of third year of farmer life cycle. Farmers with crop and livestock depend a lot on market prices. These households discharged huge amount of manure. The situation of devaluation or overcapacity is usually the case, leading to pure farm-based models that are almost unprofitable to farmers.

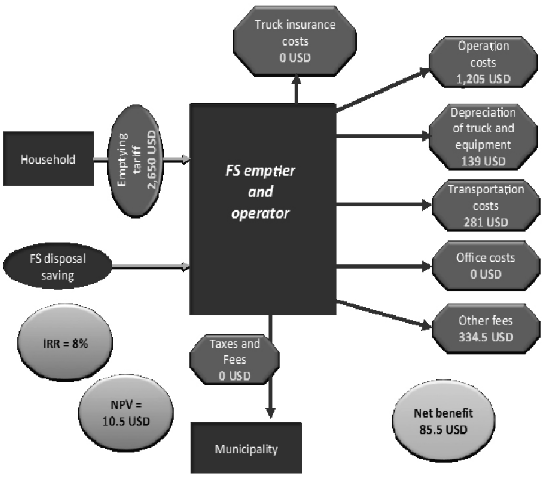

Figure 5. *Cash flow analysis for FS Emptier*

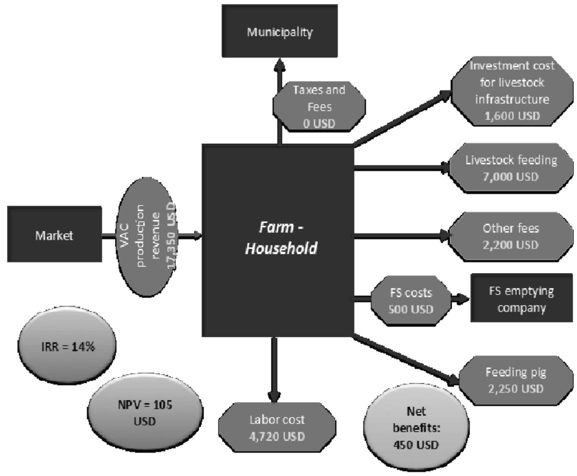

Figure 6. *Cash flow analysis for HHs with farming activities*

BCA for them is shown that, the inner return rate is low of 14%, net profit from only USD50-700 per year, not enough food for their live. However, this indicator does not reflect the effective of re-use of sludge, which depends much on the price of agricultural products.

3.3 Worm feeding farm

Cash flow of third year of worm farm life cycle in Figure 7. Worm feeding farm financial model showed higher economic efficiency compared to operator or farming activity household due to profit from worms and livestock are very high. Net present value is high with USD9,790. The result of financial analysis shown that IRR of this business model is very high (207%), so this business model can be initial option for farmer who want to reuse FS for their purposes (livestock, crop…).

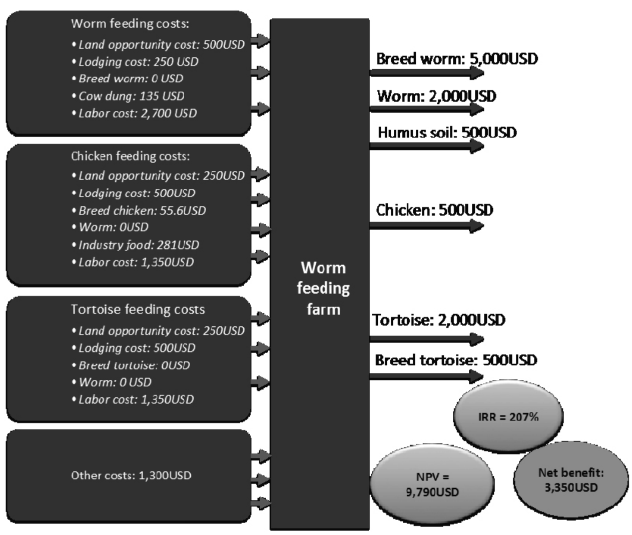

Figure 7. *Cash flow analysis of worm feeding farm*

4. Conclusions and recomendations

Money flux analysis (MFA) of households with farming activities has shown average IRR 14%, while net profit is as low as ranging from VND 1 to 14 million per family per year.

Faecal sludge emptying and transportation service is provided by private enterprises. MFA results show existing FS emptying and transportation business has no profit, while IRR is less than 10%. Service providers often have other business activities but FSM.

MFA at worm farm feeding cow dung has shown high IRR, 207%, while net benefit is relatively high. At the 3rd year of business, net benefit is VND 67 million per year.

Local government should involve in the management of sludge empty activities, which will facilitate the participation of households in the implementation of this service legally and financially, contributing to the socialization of environmental protection.

Worm farming is a profitable business. However, there is a need of sufficient land area, knowledge on worm raising technology, and market for the end products.

Reuse of FS for recovery of nutrients for crops is promising. However, suitable technology is needed with local context consideration. There are different technologies for FS treatment, and some FS emptying techniques. Local enterprices and relevant stakeholders lack of information about FSM technologies selection.

To make resource recovery from FS feasible, integrating FSM activities into existing farming practice seems a feasible and promising approach. Vermi-composting is a promising FS treatment alternative enabling nutrient recovery and safe reuse of FS in peri-urban areas.

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