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Contents

Research article

Humanitarian Assistance to Decreasing Vulnerabity in Flood-Prone Village: A Case Study in Boeung Leas Village, Steung Sen District, Kampong Thom Province, Cambodia

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Abstract Flood is the most severe disaster in Cambodia because the country locates in the flood plain region. To tackle this national challenge, the Cambodian government has been developing policies and programs on disaster risk reduction. For supporting disaster-affected populations, various organizations provide humanitarian assistance before and after the disaster. However, due to country's vulnerabilities, a number of Cambodians still suffer from floods, such as food insecurity and health problems. To decrease its vulnerabilities, community should build community resilience through build back better based on their past experiences, while receiving humanitarian assistance to enhance their capitals. As women are among the most vulnerable victims in post-flood situation, the study tried to understand existing major community capitals as well as gaps between humanitarian assistance and needs of vulnerable women. Totally 53 people consist from 33 female villagers and 20 key informants mixture of male and female were selected as respondents for Focal Group Discussions (FGDs) and Key Informants Interviews (KIIs) through purposive and snowball sampling approaches based on their status and experiences. The study concluded that humanitarian actors better to focus more on activities to enhance insufficient physical, natural, and financial capitals of the village for decreasing existing vulnerabilities including poverty, weak governance, and insufficient local structure for disaster risk reduction by applying Build Back Better approach, which build resilience of vulnerable areas based on past experiences and impacts.

Keywords community resilience, vulnerability, humanitarian assistance, build back better

INTRODUCTION

Cambodia has a tropical monsoon climate and is known as one of the most disaster-prone countries in the world. United Nations Development Programme (UNDP) (2012) reported that 53% of 2,050 disaster-related deaths between 1996 and 2011 were caused by flood in Cambodia. Women are

among the most vulnerable groups without their participation opportunities to share their experiences and needs in decision-making process of authorities. Even though the Cambodian government has policies and programs on disaster risk reduction, villages still have vulnerabilities to hamper community resilience. Vulnerability normally generated due to insufficient capacity for preparation, response, adaptation, resistance, and recovery from hazard impact (Winsner et al., 2004). As Human Policy Group (2006) specified that disasters are caused by human vulnerabilities rather than hazard per se, decreasing vulnerability is a key to reduce disaster impacts. According to Sendai Framework (2015), identification of vulnerability is essential for proper humanitarian assistance. It is because that vulnerability will be decreased when the community improve their capacity to cope with disasters because these two factors are interrelated (Cannon et al., n.d.).

Humanitarian assistance aims at lifesaving and damage alleviation during and after disasters, as well as strengthening preparedness for future hazard (Development Initiatives, n.d.). Ideal humanitarian assistances decrease vulnerability while promoting community resilience and capacity to mitigate impacts of future hazard. From this point, Build Back Better is one of appropriate approach for humanitarian assistance because it is an process to improve resilience and capacity of the disaster-affected communities, while reducing their vulnerability based on their experiences (Mannakkara and Wilkinson, 2015). Schilderman (2010) also specified that the experience with owner-driven reconstruction has been more positive than with donor-driven reconstruction.

Therefore, this paper attempts to analyze existing community's five-capital as well as gaps between emergency response and needs of vulnerable women to decrease vulnerability in Boeung Leas village.

MATERIALS AND METHODS

Study Site

Study site is the Boeung Leas village, which is the one of four villages in Ou Kantor commune in Steung Sen district in Kampong Thom province, Cambodia (Fig 1). The village has 130.89 hectares of land with 88 households with population of 354 including 182 females. Main income resources of the residents are fishery, rice production and harvesting naturally grown morning glory (Ipomoea aquatica) because the village has big lake in the southern part of village, which stream from the Tonle Sap Lake. Due to its location in low terrain near Steung Sen River and Tonle Sap Lake, the village is the most vulnerable village to regular flood among four neighboring villages. Especially southern part of the village suffers from severe flood impact annually. Chronic impact of severe floods and droughts in whole year make the villagers poor. In 2015, 33% of households in the village recognized as poor and received the recognition paper for the poor by provincial government.

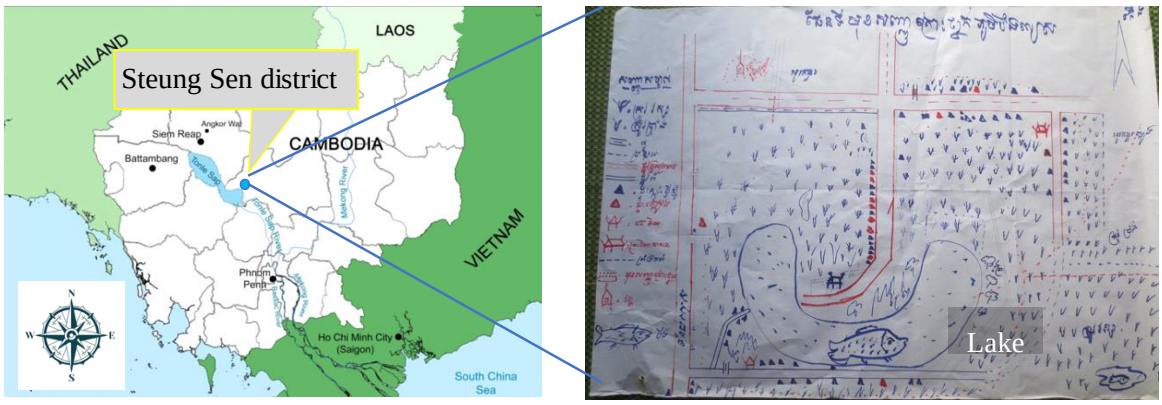

Fig. 1 Map of flood affected households and Boeung Leas village in Kampong Thom province

Data Collection and Analysis

By aiming at understanding existing major community capitals as well as gaps between emergency response and needs of vulnerable women to decrease vulnerabilities in village, the study applied focus group discussions (FGDs) and key informant interviews (KIIs). The study collected data from total 53 samples consist from 33 female villagers, nine members of the Disaster Management Committee in the commune, and 11 key informants who involved in the humanitarian assistance. All samples were purposively selected applying snowball sampling approaches based on their status and experiences. Align with recommendation of Dworkin (2012) for 25-30 participants for in-depth interviews, 33 women which covers 18.13% of female villagers were selected for three FGDs. Men were intentionally excluded to avoid interruption and dominant on answers. Besides, a female and eight male members of the Disaster Management Committee were also invited for another FGDs in order to understand vulnerability and common emergency response in the post-flood situation in the village. Addition to that, KIIs were conducted to purposively selected experts who involved in the emergency response, such as local NGO, the Cambodian Red Cross, and District Health Center.

Collected data summarized and analyzed based on the five-capital asset pentagon of the Sustainable Livelihood Framework (SLF) (DFID, 1999). By setting the five-capital pentagon - human, social, physical, natural, and financial capital- in the key, the framework clarifying mechanisms of vulnerability, shocks, and transforming process. The SLF distinctly emphasizes improving capital assets to reduce vulnerability and enhance disaster resilience (Burton, 2012).

RESULTS AND DISCUSSION

General Information and Conditions

Although the villagers suffer from flood annually, after 2000, severe flood damaged the villagers in 2000, 2001, 2011, and 2013. Especially the Southern part of the village is vulnerable to flood due to its location along or in paddy field (Fig 2 left). Interviewees shared their experience that water level drastically increase to reach the house floor and occasionally cause water runoff to the house with the raised-floor style. It causes villagers in flood-prone areas to evacuate to higher road and stay in temporary tent for a while (Fig 2 right).

Villagers have similar flood-induced impacts in the post-flood situation, such as food insecurity, health problem, financial shortage, lack of accessibility, and loss of human lives and livestock. Due to lack of portable water, people reluctantly drink flood water, even though it may cause diarrhea and other health issues. Children generally suffer from diarrhea and accidental drown due to unsafe and high-level water. Many villagers also critically suffer from income shortage without accessibility to the big lake southern part of the village as well as Steung Sen River, where people gain profit from morning glory and fish sales.

Fig. 2 Shelter in flood-prone areas along paddy field (left) and higher road to evacuate (right)

Humanitarian Actors and their Roles

The study identified four main key humanitarian actors that provide assistances to the Boeung Leas village. These are local government including the Commune Disaster Management Committee, district health care institution, local NGO, the Cambodian Red Cross.

In cooperation with local NGO, local government of Ou Kantor commune established Disaster Management Committee that consist from representatives of four villages based on the national disaster risk reduction (DRR) policy in 2011. The committee consists from five female and 12 male members who were nominated based on their status, such as commune chief, village chiefs, senior villagers, and school director and teachers. The main task of the committee is to identify needs of the poor for humanitarian assistance and coordinate with humanitarian agencies and provincial government. Networking effort successfully receive a project to improve community roads by Ministry of Rural Development and Asian Development Bank (ADB).

Local authority also collaborates with district health care institution to enhance accessibility of the poor to medical services by disseminating "the recognition paper for the poor", which initiated by Ministry of Planning and Ministry of Interior. This certificate aims to improve accessibility of the poor for social services including exemption of medical services.

On the other hand, local NGO named Help Old Ages and Miserable People Organization (HOM) also closely work with poor communities since 2000. With financial support from ActionAid and Oxfam, HOM works for food security and livelihood, school education, gender, natural resource management, DRR, Climate Change Adaptation (CCA), water, sanitation and hygiene (WASH) and sexual harassment. HOM also supported local government to establish the disaster management committee through workshop on hazard map and action plan development. Reflecting their limited budget for providing humanitarian assistances, they supported villagers to form a village saving groups for pooling money for emergency use. In addition, HOM also contributed to the establishment of an early warning information system in cooperation with the International Cocoa Organization (ICCO).

The other actor is the Cambodian Red Cross (CRC), which works for community resilience, clean water and shelters, microfinance, security, and community-based health development program since its establishment on 1994. The organization provided humanitarian assistances for more than 20,000 flood-affected families in Kampong Thom province by 2011. CRC normally provides assistances based on the request of local authority and selected CRC volunteers in the village. Both relief recipients and assistances are decided by local authority and volunteers based on specific selection criteria including poverty level and family structure.

Capitals and Vulnerabilities of the Boeung Leas Village

Based on the five-capital or asset pentagon of the SLF, this section summarizes existing capitals and vulnerabilities of the Boeung Leas village. First, the research revealed that the villagers have skills and basic knowledge on various topics, such as WASH and disaster risk reduction through workshops of humanitarian actors. However, physical capability of villagers, mostly women who take care both the elderlies and children, are incapable of having different livelihood measures except production and selling of morning glory, rice, and fishing. Second, the village has appropriate social capital because there are existing disaster management groups in village and commune level (Fig 3 left). Not only local authorities and disaster management groups, but also community residents have network with humanitarian agencies directly and indirectly through local authorities and CRC volunteers. Third, the village has physical capital including water gauge system (Fig 3 right), irrigation canals, radio emergency information system, and some boats as community's common property. However, the research also exposed that families does not have transportation means such as bicycle and boats that people can use in the flooded condition to access markets, health facilities and school. These physical capitals are what women eager to receive as humanitarian assistance because they can continuously use in the flooded condition for access health services, income generation, and food purchase. Pao Pisey temple is also one of physical capital because displaced people are allowed to stay at their 5 buildings and use 4 toilet

facilities until flood water drain. The temple also provides stock of foods such as rice and canned fish to displaced people. Fourth, natural capital of the Boeung Leas village is limited because the village regularly suffer from flood and have challenges on acquiring safe drinking water and food resources. Besides, most of interviewees of the study stated that they have limited sources for livelihood (rice production and naturally grown morning glory harvesting as well as fishery) due to their educational background. Although the village has paddy fields, these are owned by the rich and not allocated for the vulnerable families to harvest agricultural crops. Fifth, financial capital of the village and household level is limited because local authority does not have enough finance to provide facilities that requested by dwellers, such as community toilet and boats. That is why residents collects savings and request provincial government to provide toilets. When we consider about individual level, the most vulnerable families who live along or in the paddy field mentioned that financial shortage is the key factor why they continuously stay in the flood-prone areas. They do not have money to move, do not know where to move, and do not know what to do for livelihood in other areas.

Fig. 3 FGDs with Disaster Management Committee (left) and water gauge system (right)

According to Kafle (2017), South Asian countries have following seven major vulnerability factors; (1) high population density, (2) weak governance, (3) climate change, (4) high rate of urbanization, (5) ineffective DRR structure, (6) poverty due to high unemployment of women and youth, and (7) population increase and natural resource degradation. The research also identified some of these causes in the Boeung Leas village. For example, majority of households in the village face poverty and most of male adults migrate to other cities/ countries for earning more income. Due to limited amount and frequency of remittance, adult female responsible to earn income and take care family members simultaneously. Although people recognize vulnerability of the living area, they helplessly stay in the same area due to their financial shortage. People also specified that they cannot prepare anything without financial surplus, even though they receive lectures on disaster preparedness. For the community level, local authorities and village leader also suffer from financial shortage and does not have adequate amount of budget to invest for disaster risk reduction. Therefore, commune strongly depend on financial support of National Disaster Committee. Another example is weak governance and ineffective local DRR structure. Inappropriate decision-making of commune council chief and paddy field owners deteriorate the flood situation because they delay water release from paddy field. Although residents suffer from high-level water and water runoff in their houses, the commune council chief does not release water until receiving request from landowners because flood water make paddy field fertile. It was also revealed that early warning information dissemination of the disaster management group is inadequate, and people obtain information more from television and radio, and direct information sharing in the local authority. Besides, most of decision-making on recipient selection and assistance components were decided by local authorities and specific volunteers without needs assessment and any participation of the vulnerable households. It accumulated frustration and doubt about corruption of local authorities to injustice selection of receivers.

Gaps between Humanitarian Assistance and Needs

The study identified four main gaps between humanitarian assistance and needs of vulnerable women to decrease vulnerability in Boeung Leas village.

First gap was inconsistent humanitarian assistance with prior needs of people. Women eager to receive long-term aids, such as boat, bicycle, fishing net and other materials that people can utilize for income generation and enhance their accessibility to facilities including school, hospital, market. However, focus of humanitarian actors in post-flood situation is prevention of hunger for few days, and that is why they normally distribute short-term aids, such as 25 kilogram of rice, canned fish, noodle, fish sauce. Sometimes they also distribute blue tarpaulin to reinforce damaged roof. This inconsistency of aids happens due to lack of needs assessment before decision-making on humanitarian assistance consist of financial and human resource shortage of humanitarian actors, even though De la Torre et al. (2012) stated that accurate needs assessment is crucial for achieving maximizing the benefit of distributing relief goods.

Second gap was distribution approach. Villagers expects equal distribution of humanitarian assistance among flood-affected households immediately after the occurrence of flood. But it is difficult for humanitarian actors because of financial and human resource shortage. Unequal distribution generally caused jealousness and doubt for local authority among villagers who could not receive humanitarian assistance.

Third gap was different priority among commune council chief, paddy field owners, and flood-affected people. It is clear from the findings that prolonged water release of paddy field that affect houses was decided by commune council chief in order to fertile paddy soil. In other words, the local authority set their priority to benefits the rich rather than the safety of the flood-affected families. In addition, villagers hesitate to claim commune council chief directly because they afraid criticism of local authority and the rich.

The last gap was ineffective recognition of the poor with “the recognition paper for the poor”. The purpose of this paper is to improve accessibility of the poor for medical and other social services. However, some medical facilities reject the poor to exempt their payment, or sometimes request recommendation letter from community leaders. Ineffective recognition of the poor and limited financial resources for transportation keep people away from medical services.

CONCLUSION

According to the results and discussion done in this study, it is identified that Boeung Leas village is vulnerable to flood and annually suffer from flood-induced issues, such as food insecurity and health problem. The village has adequate human and social capitals specifically knowledge on DRR, network, the disaster management group in the village or the commune. By contrast, both the village and individual households have space for improvement on physical, natural, and financial capitals because these shortages induce food insecurity, limited accessibility and income generation in post-flood situation. Besides, the village has common vulnerability causes similar to other South Asian countries, specifically on poverty, weak governance, and insufficient local structure on disaster risk reduction.

The study also identified main gaps between humanitarian assistance and needs of vulnerable women to decrease vulnerability in Boeung Leas village. First, there are inconsistent humanitarian aids with prior needs of people due to lack of needs assessment and dependency on limited local authority and villagers. Second, financial and human resource shortages of humanitarian actors limit equal distribution of assistances to flood-affected people, even though villagers expect equal distribution among them. Unequal distribution and limited humanitarian assistance distribution created jealousness and doubt of villagers on local authority. Third, there are gap between priority of commune management chief, paddy field owners, and vulnerable women. Although they could help flood-affected households by release water from paddy field, authorities prioritize benefit for paddy owners to fertile paddy soil. The study also identified the cases that ineffective recognition

of the poor and limited financial resources for transportation keep people away from medical services.

For improving resilience of the Boeung Leas village for future flood, attention should be paid for Build Back Better, which is the process to improve community's resilience and capacity, while reducing their vulnerability simultaneously. Specifically, the study recommends humanitarian actors to focus not only on short-term assistances for few days, but also enhancement of local governance and local systems on disaster risk reduction including participatory decision-making system for pre- and post-flood affected condition. It is because that reflection of past experience and challenges contributes to create evidence-based disaster risk reduction and management structures in the village. Poverty reduction through creating alternative livelihood options is also vital components to improve community resilience.

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Research article

Properties of Lightweight Concrete Using Expanded Polystyrene as Aggregate

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Abstract When large structures are built on the soft ground such as paddy field, the demand for lightweight concrete will be high. However, issues related to quality control of lightweight aggregates, decline in the tensile strength of lightweight concrete, the economic problems, and so on, have been inhibiting the promotion of its development. There are some conventional methods of construction to cast the large size of expanded polystyrene (EPS) blocks near the surface of soft ground. But there is concern that the EPS block will float up by liquefaction in case of earthquake. In this study, the strength properties of lightweight concrete which uses EPS waste as fine aggregate have been investigated. The above-mentioned concern could be wiped out by mixing EPS as aggregate in concrete aggregate. This EPS aggregate is manufactured product, but there is extremely little number of the factories. The volume of this aggregate was reduced by being irradiated the extreme infrared radiation to utilize the stockyards effectively. This aggregate is ecological because its origin is the industrial waste of EPS. That the absorption of water is zero is one of the merits as the aggregate for concrete. The author has obtained experimentally the mix proportions for the concrete that have the compressive strength enough to be used as structural material. As the results, the treatment of EPS using extreme infrared radiation was found to be effective in improving the strength of EPS concrete.

Keywords lightweight concrete, expanded polystyrene, strength, density

INTRODUCTION

In Japan, the annual discharge of industrial waste is over 400 million tons which is about 8 times that of general wastes (Japan Environmental Sanitation Center, 2000). About 80 million tons of them are discharged from the construction industry. After the recycling law was enforced, development of technologies for effective use of the waste has been much desired.

The main objective of this study is the successful utilization of expanded polystyrene waste (EPS for short) as fine aggregate to produce lightweight structural concrete. The quantity of EPS production in Japan is about 200,000 tons, which accounts for about 10% of the total global production. Only 64% of them have been recycled, the rest being incinerated or reclaimed. Various technologies have been developed for the reduction of EPS volume. Although structural lightweight concrete can be produced using artificial lightweight aggregates, the major drawback is the high cost of these aggregates. Using EPS as aggregate makes the production of lightweight concrete economical and environmentally friendly. In addition to the lightweight property, EPS has other beneficial properties such as high thermal insulation, high sound absorption, and super low water absorption.

There are extremely few studies on EPS concrete except the case study as non-structure material (Nagase et al., 2000). There are some studies on structural lightweight concrete which were confirming the basic properties and trying a multifunctionality, however the artificial aggregate is expensive (Kuku et al., 2000), (Onishi et al., 2000). Then the originality of this study is to use this EPS for structural concrete, and the objective of this paper is to quantify the basic properties of density and strength.

METHODOLOGY

a) Property of EPS Aggregate

Fig.1 shows the EPS used in this study and a section of an EPS concrete cylinder. Table 1 gives various physical properties of EPS aggregate. Methods of reducing the volume of EPS waste are extreme infrared ray irradiation processing, a new technology, has been performed on this EPS. In this method, firstly the EPS is roughly crushed, and inorganic powders are sprinkled on its surface using small amount of resin adhesive. Then, the volume is reduced to about 1/20 by irradiation of extreme infrared rays before being ground again into fine pieces. With this processing, the strength and the Young's modulus accompanying the increase of density is more than that of the conventional EPS. Because the processing is done in a low temperature of 120-130 degrees-C, generation of unpleasant odour is limited. Loss percentage of mass was 0.55% as shown by the stability examination (Test method for soundness of aggregates using sodium sulphate, JIS A 1122). The resistivity against aging deterioration was confirmed to be as high as that of aggregates for normal concrete.

In the case of conventional lightweight concretes, the limit of weight reduction has been about 1.5t/m^3. ALC (Autoclaved Lightweight Concrete) has been put into practical use to advance further weight reduction. In this case, if water from rain etc. is absorbed into air spaces, the density will increase greatly. There is little study on using EPS as aggregate for concrete (Matsuo et al., 1994, 1995, 1996, 1997).

b) Experimental Details

The key points in using a lightweight material like EPS are suppression of segregation, evaluation of fresh condition, and to control the decrease of strength. In the experiments, the relation between the density and the strength of specimens accompanying the change in the quantity of EPS and water cement ratio (W/C) was investigated first. The mix proportions were selected based on the result anticipating a compressive strength of 30N/mm^2 in the super lightweight domain. Segregation must be prevented in order to stabilize the strength. For this, adequate mix proportions of EPS concrete that could control the segregation and have good workability were established by obtaining the relationship between the segregation and viscosity of the cement paste prior to the strength tests.

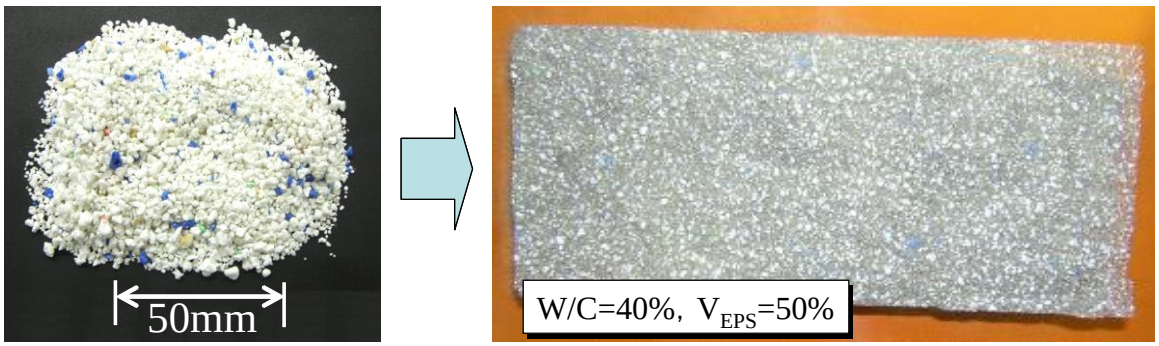

Fig.1 EPS and the section of an EPS concrete cylinder

Table 1 Properties of EPS

Density (g/cm^3)	0.53
Maximum size of sieve (mm)	4.0
Percentage of solid volume (%)	64.8
Fineness modulus	3.02
Water absorptivity (%)	0
Quantity loss of aggregate (%)	0.55

Strength properties and the density of EPS concrete were investigated and compared with past studies (Matsuo et al., 1994, 1995, 1996, 1997). Mix proportions that can control segregation were selected based on the results mentioned previously. The variation in the strength of EPS concrete was also examined. Admixtures were not used so that the most fundamental properties could be investigated. Additionally, the effect of a super plasticizer was also confirmed. It was also confirmed from preliminary experiments that segregation could be controlled even without the thickening agent (thickner, or viscosity increasing agent).

c) Mix Proportion and Casting Method

The material used here is the same as the one mentioned previously. The representative mix proportions are shown in Table 2 which can control segregation and have a small density difference. V_{EPS} means the volume ratio of EPS in concrete. Mixing was done using a mortar mixer/force mixer. Experiments were carried out using EPS concrete prisms (4×4×16cm) and cylinders (φ10×20cm). The prisms were compacted 40 times in two layers, and the cylinders were compacted 25 times in 3 layers. A table vibrator was used as required. Specimens were removed from the molds one day after casting and they were cured in water until the strength test.

Table 2 Representative Mix Proportions

Name	W/C (%)	V_{EPS} (%)	Unite Weight (kg/m^3)			Theoretical Density (g/cm^3)
			C	W	EPS	
A	30	40	972	292	212	1.48
B	40	50	697	279	265	1.24

RESULTS AND DISCUSSION

a) Relation between V_{EPS} and Strength

An instance of density change of EPS concrete with the increase of V_{EPS} is shown in Fig. 2. The density decreases linearly as V_{EPS} increases. Since the difference of theoretical density and actual density is very small in all mix proportions, it can be inferred that EPS waste had not been compressed with cement paste during the mixing and hardening.

Fig. 3 shows the relationship between V_{EPS} and the compressive strength. The compressive strength decreased with the increase of V_{EPS}. Even if V_{EPS} is about 50%, a compressive strength of 15-30N/mm^2 can be obtained with small water cement ratio. The fact that a compressive strength of 19-45N/mm^2 can be obtained for V_{EPS} as small as 20-30% suggests that EPS concrete can be broadly used as structural materials as well as non-structure materials.

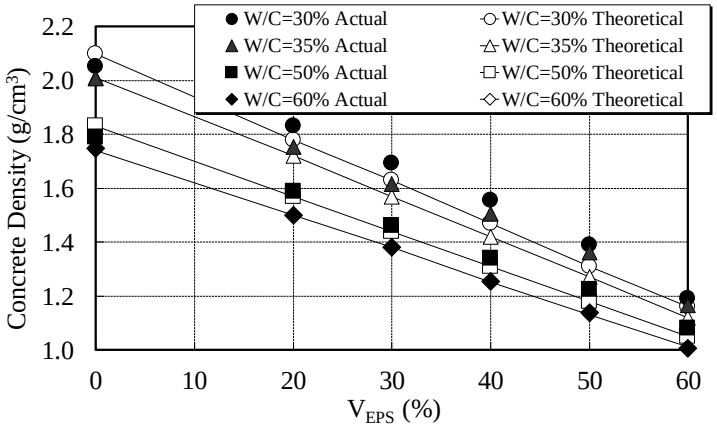

Fig. 2 Relationship between V_{EPS} and concrete density

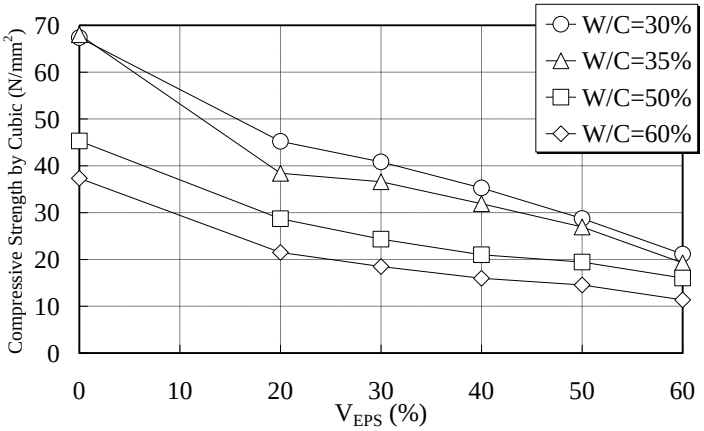

Fig. 3 Relationship between V_{EPS} and compressive strength

b) Density and Strength

Fig. 4 shows the relationship between concrete density and compressive strength for cubic EPS concrete specimens. The results for every V_{EPS} and compared with a previous study (Matsuo et al., 1994). For given concrete density, the strength of EPS concrete is larger than that of the previous beads-type EPS for all V_{EPS}. This reflects the effectiveness of the volume reduction method using extreme infrared ray to EPS is relatively more effective regarding the strength. Furthermore, it is also estimated that the increase in the strength can be attributed to the increase of adhesion strength between the paste and EPS due to the complexity of the surface shape of EPS.

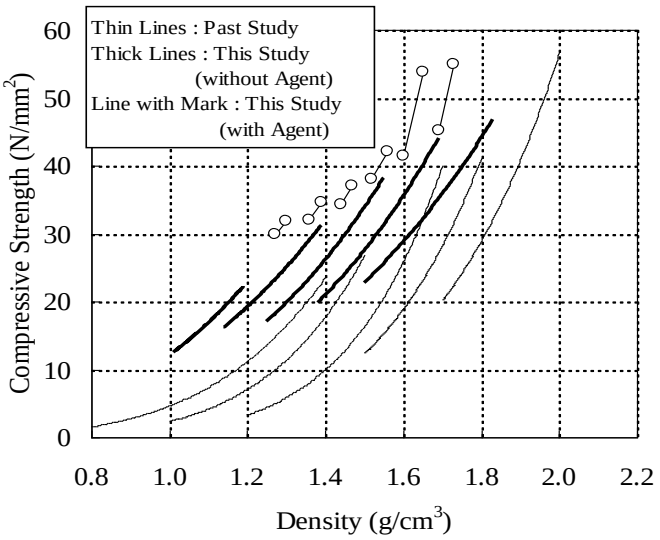

Fig. 4 Relationship between concrete density and compressive strength

Bache's equation was used in order to determine the mix proportion which can utilize the strength of EPS more effectively (Bache, 1967). Bache expressed the strength of concrete as Eq. (1) in case that the strength of aggregates is weaker than the matrix. This is empirical and has the general tendency to underestimate the strength of the aggregate to be calculated. The effective mixing ratio of the aggregate is said to be in the range of 0-0.5. There are various views regarding the effective range concerning the strength ratio of the aggregate and the matrix (Murata et al., 1968).

$$\sigma_c = {\sigma_{EPS}}^{V_{EPS}} \cdot {\sigma_p}^{1-V_{EPS}} \quad (1)$$

Here, σ is the compressive strength (N/mm^2), *c* means concrete and *p* means paste.
Eq. (1) can be expressed as

$$\sigma_{EPS} = exp\left\{\frac{\log\sigma_c - (1-V_{EPS})\log\sigma_p}{V_{EPS}}\right\} \quad (2)$$

Substituting the result of Fig. 3 in Eq. (2) the compressive strength of EPS for all mix proportions can be found. In practice, since the strength of EPS is constant, the authors think that this calculation value is the resistance which EPS shares with the cement paste matrix to the acting compressive stress. Here, it is called "estimated strength". Change of estimated strength of EPS with V_{EPS} is shown in Fig. 5 for different water cement ratio of paste. The estimated strength of EPS changes not only with the paste matrix strength but also with V_{EPS}. Mix proportions with V_{EPS} about 40-50% and high paste strength can use the EPS strength advantageously. These mix proportions are closely in agreement to the ones which control segregation discussed previously.

Stress-strain curves for various V_{EPS} are shown in Fig. 6 with 35% of water cement ratio. The elastic modulus obtained from this figure is shown in Fig. 7. It is observed that the elastic modulus decreases linearly with V_{EPS}, a trend similar to that shown by the compressive strength.

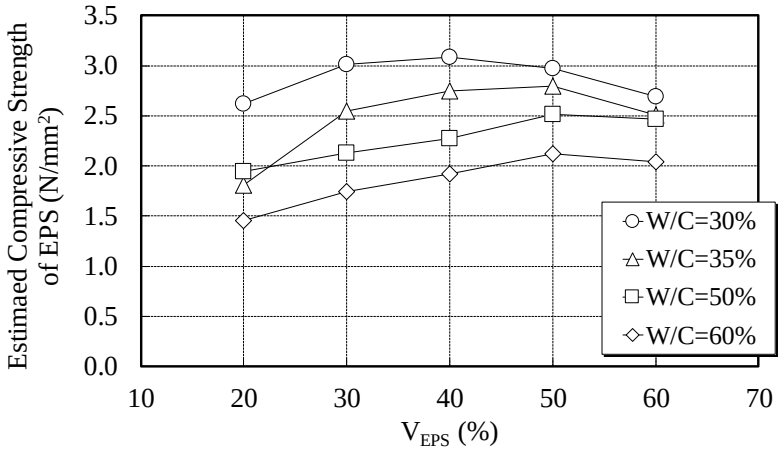

Fig. 5 Estimated compressive strength of EPS

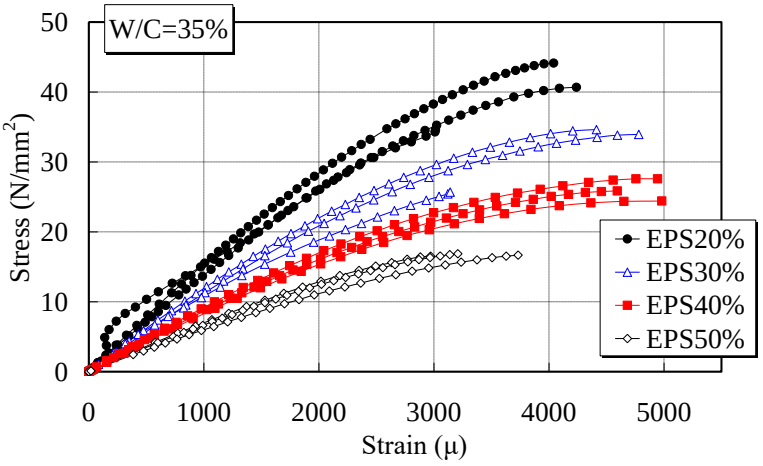

Fig. 6 Stress-strain curves

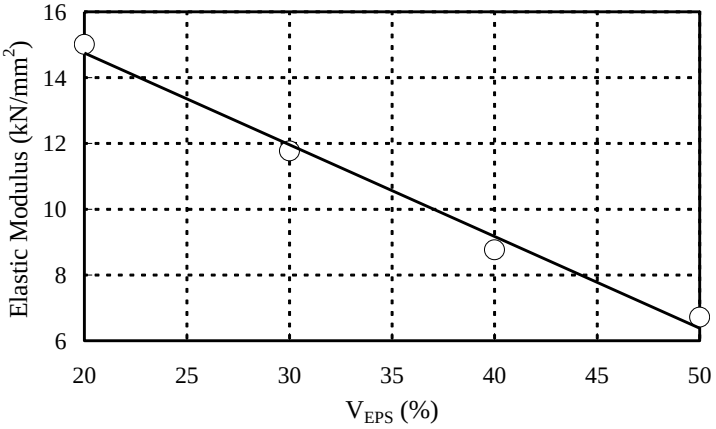

Fig. 7 Relationship between V_{EPS} and elastic modulus

CONCLUSION

In this study, fundamental strength properties of lightweight concrete using EPS as fine aggregate were investigated. The main conclusions are as follows.

(1) Irradiation of EPS by extreme infrared rays is effective in improving the strength of EPS concrete.

(2) The mix proportions which authors propose are "W/C=40% and V_{EPS}=50%" for weight reduction, and "W/C=30% and V_{EPS}=40%" for high strength.

Drying shrinkage is the subject for a further study in case of the applicability of this concrete in a large scale. It is necessary to quantify the adequate amount of shrinkage reducing agent.

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Research article

An Assessment of Soil Chemical Properties and Yields of Black Gram, Using GIS, in a Selected Area of Myanmar

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Abstract In Myanmar, pulses are a very important crop with great potential for export. Black gram (*Vigna mungo* L.) is one of the predominant pulse species grown, with planting after the harvest of monsoon rice in the winter season. Understanding the spatial variability of soil chemical properties is critical for improving the productivity of pulses and ensuring sustainable farming practices. However, a systematic assessment on the spatial variability of pulses yield has not been conducted. Therefore, this study was carried out to examine the variability of black gram yields in relation to soil chemical properties, at Kyee Inn Village, Pyinmana Township, central Myanmar from May 2017 to March 2018. Eighty composited soil samples were collected across the study area and analyzed for common soil chemical properties. Sixty seven farmers were surveyed as sample respondents to determine yields and management practices. Interpolation allowing overlay mapping of variations in black gram yields on soil chemical properties was accomplished using ArcGIS software. It was observed that these soil chemical properties and black gram yield varied considerably throughout the study area. Slight variability was observed in total nitrogen content. The pH value of the soils was moderately acidic to moderately alkaline with pH values of 5.48 to 7.58. The fields were characterized by low levels of soil organic matter and total phosphorus. The variation in black gram yields, ranging from 0.16 to 1.97 ton per hectare, is probably a result of the high variation of total soil nitrogen and phosphorus content. The results suggest that to improve soil fertility and sustain and improve black gram yields, it is very important to apply organic matter, nitrogen and phosphorus in parts of the study area.

Keywords black gram, GIS, overlay mapping, organic matter, total nitrogen and phosphorus, yield, sustainable farming

INTRODUCTION

In Myanmar, pulses are an important crop with great potential for export, and the rapid growth in production has been driven by a huge demand from India. Black gram (*Vigna mungo* L.) is one of the most favored species farmed in Myanmar, in terms of acreage and production output. Pulses are important for crop intensification, diversification and conservation of natural resources as well as the sustainability of farm production systems, because of their short growth duration, dense crop canopy and versatility (Katiyar and Dixit, 2010). However, black gram is generally produced in fields that have a high degree of variability in soil type, topography, soil moisture and other major factors that can affect crop yield.

GPS based soil fertility maps have been prepared by a number of different government and private sector organisations for different areas of Myanmar. Remote sensing (RS), geographical information systems (GISs) and geo-statistics are tools becoming progressively more central to fields of research like agriculture (Bocchi et al., 2000; Basso et al., 2001). Scientific information relating spatial variability to distribution of soil properties is critical for farmers attempting to increase effectiveness of fertilizer use and maximize crop productivity. Fertilization of a crop based on specific parameters of soil fertility, should also result in minimalizing fertilizer inputs without reducing yield (Jalali, 2007). Geo-statistics have been used to analyse the spatial variability of soil properties and crop yield (Stevenson et al., 2001). However, a systematic assessment on the spatial distribution and variability of pulse yields and soil chemical properties has not been conducted in Myanmar. Evaluating the spatial variability of pulse yields in relation to the chemical properties of soils allows micro-adjustments that are essential for regional planning purposes, promoting sustainable pulse production and increasing levels of productivity.

OBJECTIVES

The present study was carried out to examine the current status and spatial variability of soil chemical properties and the relationship of this to black gram yield. Maps of the study area were generated to illustrate this relationship.

METHODOLOGY

Study Site and Data Collection

The research was carried out in central Myanmar. The study site is Kyee Inn Village, Pyinmana Township, which lies between 19°70'66" - 19°72'62" N and 96°22'43" - 96°25'73" E and examined a total study area of 486 ha, from May 2017 to March 2018 (Fig. 1). Farmers in the study area usually practice what can be described as a monsoon rice-pulse cropping pattern. The mean annual rainfall is approximately 1420 mm and daily mean temperature, 26.8°C. The study area was superimposed with 300 m × 300 m geographic grids using geographical information system (GIS) tools, and comprised 80 sample grid points (Fig. 2). Among these 80, only those grids where farmers had cultivated black gram were included in the survey. Accordingly, 67 farmers were selected as sample respondents and information about average yield per acre and crop management practices was collected through interview and structured questionnaire. For soil analysis, each grid had three soil samples taken, these at a depth of 0-15 cm. The 3 samples from each grid were combined to give a composite sample. To avoid undesirable effects due to fertilization in the growing period, samples were taken after harvest.

Sensors were on a DJI Phantom 4 drone and Litchi software was used to interpret information. Flight altitude was 120 meters and the drone images were combined and processed using pix 4D software for digitizing and relating these to the digital base map of the study area. ArcGIS software from Environmental Systems Research Institute (ESRI) was used to produce maps of the spatial distribution of yield and soil chemical properties. Interpolation and overlay mapping were generated using Inverse Distance Weighting (IDW) and the Radial Basis Function (RBF) which are deterministic interpolation methods in the Arc GIS 10.5 software according to Meng et al. (2013).

Statistical Analysis

All relevant data were subjected to analysis using the Statistix 8 program. Mean, standard deviation, and standard errors were determined for each of the soil properties considered as well as soil moisture content and yield of black gram, using descriptive statistics. The variability of each property was measured by coefficient of variation (CV) expressed as a percentage.

Laboratory Analysis

Laboratory analysis was conducted for the composite soil samples. This involved air-drying, pounding, and sieving (2.0 mm sieve) and storage at 4°C in a cool room. Soil pH was measured using a digital pH meter in soil to water solutions, consisting of a 1:5 suspension, after 30 minutes of mixing (Hesse, 1971). Total soil nitrogen was determined using the Kjeldahl digestion, distillation and titration method (Bremmer, 1982) whereas total soil phosphorus was analyzed using spectrophotometer measurement of blue molybdatephosphate complexes under partial reduction with ascorbic acid (Jackson, 1958). Soil organic matter was determined using the wet digestion method (Walkley, 1934).

Fig. 1 Location of the study area

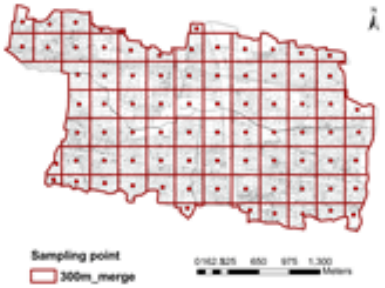

Fig. 2 Grid sampling points

RESULTS AND DISCUSSION

Spatial Variation in Soil Chemical Properties

The coefficients of variation (CV) were grouped into three categories; these being, least variable (<15%), moderately variable (15-35%) and extremely variable (>35%). That is, the higher the CV the more variable the soil property measured. Data were subjected to analysis by descriptive statistics to determine significant differences between the black gram yield, soil moisture content (MC) and soil chemical properties. A large variation in soil chemical properties was observed across the study area. In terms of variation in soil properties, total nitrogen shows the highest variability with a CV of 68.52%, followed by soil organic matter with a CV value of 34.56%, whereas variations for soil pH and total phosphorus show least variability with CVs of 5.13% and 6.25% respectively (Table 1). The results indicate that there is natural variation, which is often compounded by nutrient management practices used by farmers. This has implications for black gram production since soil chemical and soil water content variability can be expected to lead to variability in crop yield.

Soil pH

Table 1 Descriptive statistics of yield, soil water content and soil chemical properties

Variables	Unit	Minimum	Maximum	Mean	SE	SD	CV%
Estimated Yield	ton ha^{-1}	0.160	1.970	0.840	0.043	0.364	43.348
pH	-log $[H^+]$	5.480	7.580	6.244	0.038	0.320	5.127
Soil Water	%	1.790	9.640	4.928	0.182	1.545	31.358
Organic Matter	%	0.200	1.700	0.893	0.036	0.309	34.562
Total Nitrogen	%	0.010	0.330	0.114	0.008	0.078	68.520
Total Phosphorus	%	0.017	0.024	0.019	0.001	0.001	6.249

SE: Standard error; SD: Standard deviation; CV: Coefficient of variation

The soil pH of the study area was found to be acidic to slightly alkaline and ranged from 5.48 to 7.58 (Table 1). Black gram prefers soil with a pH in the range 5.5 - 6.5, tolerating 4.5 - 7.5 (Katiyar and Dixit, 2010). Thus, the variability of soil pH may be assumed to not represent a major contributing factor to variation in black gram yield.

Soil Organic Matter and Soil Water

The estimated average yield for black gram in the study area was obtained through surveying farmers, by both interview and structured questionnaire. From the sample plots, black gram yields range from 0.16 to 1.97 ton ha^{-1} (Table 1). These data were overlain on to maps of soil organic matter and soil moisture for the study area (Fig. 3a and 3b).

The black gram cultivars commonly used in Kyee Inn Village, Pyinmana Township are Yezin-2, Yezin-5 and Yezin-6 (Fig. 2). In general, yield exhibited the following characteristics. The grid points in the eastern part of the study area produced higher yields, ranging from 0.99 to 1.48 ton ha^{-1}. Moreover, the sample grid points where the black gram cultivars were Yezin-2 and Yezin-6 had higher yields than area where Yezin-5 was planted. According to the Department of Agricultural Research (DAR), the potential yield of Yezin-5 (1.6 - 2.0 ton ha^{-1}) is lower than that of Yezin-2 (2 - 2.4 ton ha^{-1}) and Yezin-6 (2.4 - 3.2 ton ha^{-1}) when grown under same conditions. Thus, the study affirms that Yezin-2 and Yezin-6 should be grown instead of Yezin-5 in upcoming seasons to increase productivity.

Soil organic matter and soil water have very important functions that correlate positively to nutrient availability and retention. It should also be taken into consideration that the nutrient input from soil contributes considerably to crop nutrition (Fu et al., 2010). The amount of soil organic matter is highly dependent on a range of ecological factors such as climate, soil type, vegetative growth, topography in which it occurs as well as land use and management and tillage of the soil and intensive cropping (Rawal et al., 2018). The spatial distribution of organic matter and soil moisture (in percent) exhibits a gradual percentage increase from the northeast portion to the southwest portion of the study area, where the highest content for both are found. One possible reason for this is the slightly higher elevation of the northern portion with accumulation of organic matter and moisture often favored at lower levels. The average soil organic matter content of study area varies from 0.2 to1.7% with a mean value of 0.893%, which is very low when soil organic matter greater than 2.6% is considered to provide good nutrient storage (Purdie, 1998). In the overlay mapping, all sampling grid plots had insufficient levels of soil organic matter and there is high variation in percentage content. This suggests the low yields for black gram, and spatial variability of these yields may be attributed to the poor crop management practices, with a failure to systematically apply organic and inorganic fertilizers.

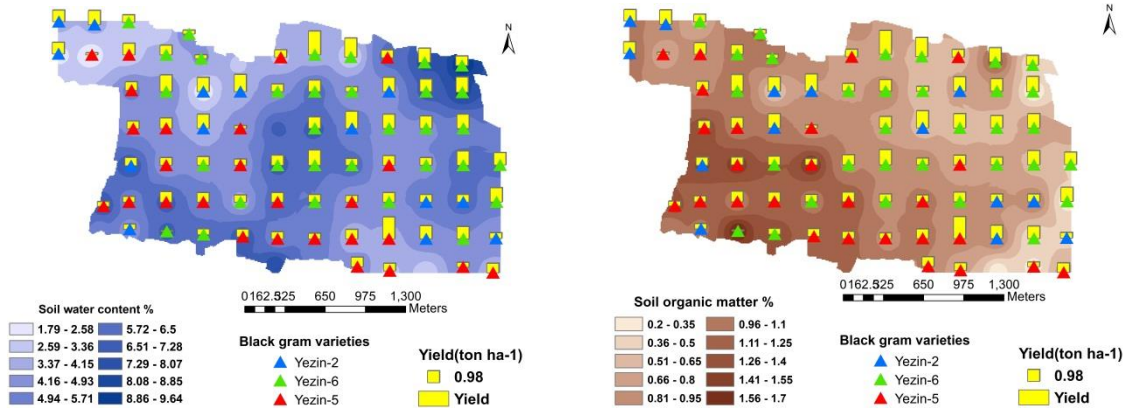

Fig. 3 Overlay mapping of distribution of yield and cultivars for (a) soil water content and (b) soil organic matter in Kyee Inn Village, Pyinmana Township, 0.98: mean yield of black gram in ton ha^{-1}

Total Nitrogen and Total Phosphorus

Soil fertility is one of the major constraints to agricultural production in tropical countries, including Myanmar. Examining the current soil fertility status is important because it could provide valuable information relating to crop research (Khadka et al., 2017). Soil nitrogen is one of the most important plant nutrients, and of all nutrients, the most frequently deficient (Havlin et al., 2010). The total nitrogen content varies from 0.01% to 0.33% with the mean value of 0.114% in this study (Fig. 4a). The critical value of total N in soil is 0.12% (Shah et al., 2008). The overlay mapping, show most of the sampling grid plots have low levels of total nitrogen. This low nitrogen content may relate back to the insufficient level of soil organic matter content in the study area.

The percentage value of total phosphorus ranges from 0.017 to 0.024% with a mean value of 0.019%. In most soils, P content is very low in the surface layer and represents less than 1% of total P. However the total P content of a soil may vary widely and depend on factors such as organic matter content, climatic conditions, parent materials and application of fertilizers (Mansour et al., 2014). In the overlay mapping, about half of the sampling area is medium in range, whereas the rest of the study area is in a lower range for phosphorus content (Fig. 4b).

The yield variations in black gram already mentioned also may be related to the variations in soil nitrogen and phosphorus content. Low levels of phosphorus can be ameliorated by replenishing with fertilizers which contain high amounts of available phosphorus. In the overlay mapping of Fig. 4.a and Fig. 4.b, it can be seen that most sampling grid plots not only have low levels of soil nutrients but are sown with different black gram cultivars. Therefore, results suggest the spatial variability of black gram yield can be attributed to the poor crop management practices, such as the insufficient application of nitrogen and phosphorus fertilizers, in combination with the selection of poor yielding cultivars for planting.

(a) (b)

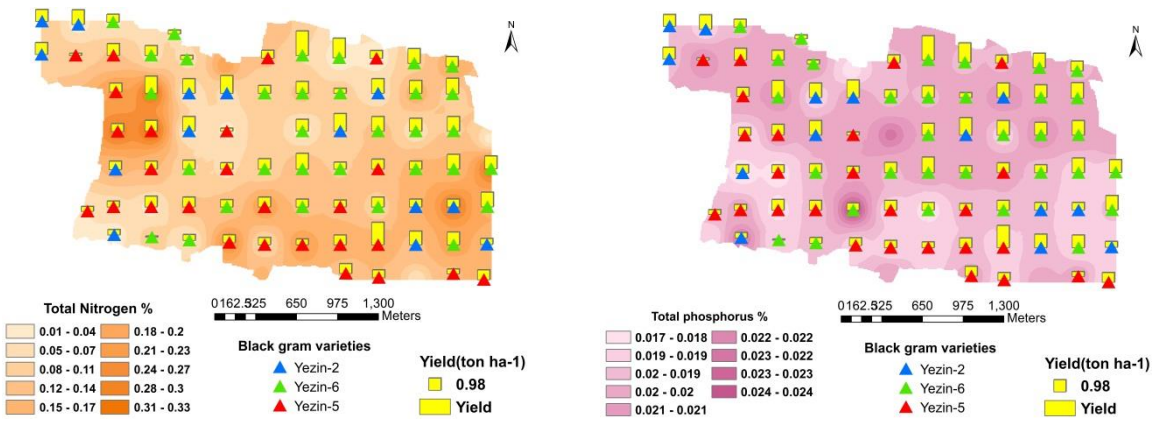

Fig. 4 Overlay mapping on distribution of yield and cultivars on to (a) total nitrogen and (b) total phosphorus in Kyee Inn Village, Pyinmana Township, 0.98: mean yield of black gram in ton ha^{-1}

CONCLUSION

Results clearly show that most of the area under black gram cultivation has low levels of organic matter, with total soil nitrogen and phosphorus also below desired levels. Due to continuous tillage and the failure to add organic matter, and with minimal nutrient supply from either natural or artificial sources, low levels of these nutrients pertain in the study site. The pH range of soils in the study area should not present a problem for the black gram cultivation, and cannot be assumed as a major factor contributing to the spatial variation in yields of black gram. The results suggest that to improve soil fertility and sustain black gram production, it is very important to apply organic matter and phosphorus, particularly in certain parts of the study area. The overlay maps provide a

readymade source of information about the status soil fertility and can serve as a spatially accurate decision making tool for successful black gram cultivation. It can be concluded from the present study that GIS based soil fertility maps help farmers by providing spatially specific recommendations regarding fertilizer application, improving crop production and ensuring greater sustainability.

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Research article

The Spatial Variability of Soil Chemical Properties in a Selected Area of Myanmar

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Abstract Sustainable crop production requires detailed knowledge of the spatial variability of soil properties, such as soil nutrients. The primary purpose of this study was to assess the status of soil fertility by evaluating selected soil chemical properties, at Kyee Inn Village Tract, Pyinmana Township, Middle Myanmar using Geographic Information Systems (GIS). In this study soil samples were collected for the 80 grid references examined. Variables measured were soil pH, electrical conductivity (EC), cation exchange capacity (CEC), soil organic matter, and the total content of nitrogen and phosphorus. Grid size is 300 m × 300 m, covering an area of about 480 hectares, and samples were taken at a depth of 0-15cm using a Global Positioning System (GPS) to determine the coordinates of the sampling points. Soil fertility maps were generated using Inverse Distance Weighting (IDW) interpolation in ArcGIS software 10.5. Interviews were conducted with farmers to match results to soil management practices. The statistical analysis demonstrated a high variability of total nitrogen content with a coefficient of variation of 66.84%, while the soil pH and phosphorus levels showed the minimum variability in comparison to other soil properties. The pH values ranged from 5.48 to 7.58, while for phosphorus, minimum to maximum levels are 0.017% to 0.024%, respectively. Values for EC can be considered normal, with a mean value of 0.095 dS m^{-1} obtained. The CEC values ranged from 2.13 to 11.05 meq100 g^{-1}soil. The low level of organic matter (0.2% to 1.7%) indicated a need to increase the organic matter content to ensure sustainable crop production. This study provides farmers with an effective management and decision-making model that encourages sustainable crop production.

Keywords GIS, GPS, soil chemical properties, spatial variability

INTRODUCTION

Scientists face many challenges in developing strategies to develop sustainable crop production systems (Bakhsh et al., 2000). Assessing the spatial variability of soil chemical properties is crucial in the development of these cropping systems (Mamun et al., 2015). Agricultural sustainability requires that this evaluation of soil fertility should be undertaken periodically (Chimdi et al., 2012). The spatial variability of soil properties includes the variation of soil chemistry, physics, and

biological properties in a given location. Even for the same soil type, soil characteristics may exhibit huge differences within short distances (Li et al., 2012).

A standard method for creating maps of topsoil properties is to sample an area using a grid sampling scheme. The density of sampling undertaken will depend on the heterogeneity of the area. With this information a 'prediction' map can be produced by interpolating the measured property values of the samples (Karydas et al. 2009). GISs are a powerful set of tools and useful for producing soil fertility maps for an area, which will help in formulating site-specific recommendations regarding fertilizer needs, as well as providing an understanding of the status of soil fertility both spatially and temporally (Thakor et al., 2014). Inverse Distance Weighting (IDW) was applied to the data as it is a good interpolator for phenomena whose distribution is strongly correlated with distance (Mustafa et al., 2011).

Soil fertility is one of the primary constraints to agricultural production in tropical countries, including Myanmar. Baroang (2013) reported that there is limited information on the dynamics of soil types and erosion patterns in Myanmar, and what does exist, is largely based on decades-old data. The establishment of monitoring stations and the determination of an appropriate monitoring design would be extremely valuable, as there is an obvious need to update the data concerning Myanmar soils.

OBJECTIVE

The main objective of this research is to generate accurate large-scale distribution maps of the selected soil properties by evaluating the current soil fertility status of the study area.

METHODOLOGY

Study Area and Soil Sampling

The study area was selected after conducting a pilot survey. The study area covers a total of 480 hectares, and is located at the Kyee Inn Village Tract, Pyinmana Township, in central Myanmar, and is situated between 19°42'30"-19°43'40"N and 96°13'30"-19°15'30"E (Fig. 1). Myanmar experiences three distinct seasons, hot, wet and cool, and the study area receives a mean annual rainfall of about 1420 mm and an average temperature of 26.8°C. Monsoon rice and pulses are the main crops, and within the area there is both rain-fed and irrigated farming. The required secondary data and hardcopy of the base-map of fields in this area are from Department of Agriculture and Department of Agricultural Land Management and Statistics. Sampling was done on a grid basis (300 m × 300 m), with samples taken at 0-15 cm depth using GPS to determine the coordinate of the sampling points. Where possible, three soil samples were taken from each grid to derive a representative sample. In total, 178 soil samples were collected from the 80 sampling plots (Fig. 2). All samples were taken after harvest, and before any land preparation for the next cropping season had been made. Interviews were conducted with farmers in order to identify variations in soil management practices in different locations in the sample area.

Laboratory Analysis

The collected soil samples were composited for each grid, then air-dried, pounded, and sieved in preparation for soil analysis. Soil pH and electrical conductivity were measured in the extract of soil: water (1:5) suspension using a digital pH-meter and EC meter (Hesse, 1971). Soil CEC was measured using Bascomb's method (Bascomb, 1964). Total nitrogen was determined by the Kjeldahl digestion, distillation and titration method (Bremmer and Mulvaney, 1982). The total phosphorus was analyzed using spectrophotometer as blue molybdate phosphate complexes under partial reduction with ascorbic acid (Jackson, 1958). The Walkley and Black (1934) wet digestion method was used to determine soil organic matter.

Statistical Analysis and Soil Fertility Mapping

The laboratory results of all parameters measured were subjected to descriptive statistic using Statistix (8th version). The low, medium and high levels of nutrients were determined according to standard ratings. The base-map preparation enabling use of GIS software was accomplished by data obtained from a DJI Phantom 4 drone, with this processed using Litchi software. The photos were combined and processed using pix 4D software for digitizing and incorporated onto the digital base map. A different thematic map for the spatial distribution of each parameter was generated using the Inverse Distance Weighted (IDW) interpolation by ArcGIS 10.5 software.

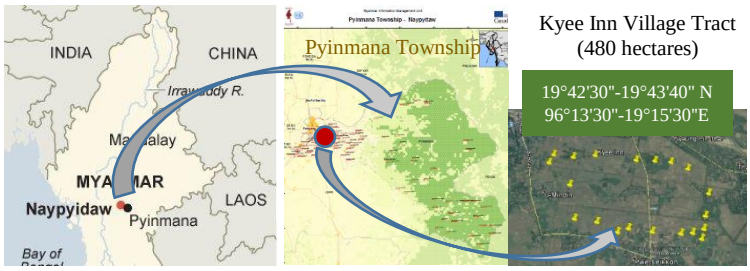

Fig. 1 Location of the study area

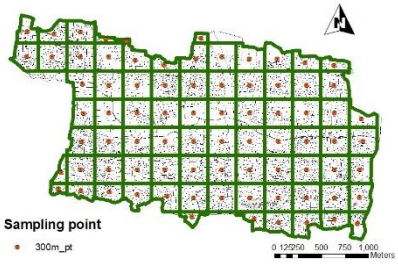

Fig. 2 Grid sampling points

RESULTS AND DISCUSSION

Spatial Variation in Soil Chemical Properties

The results for each soil parameter over the 80 soil sample sites are presented in Table 1. In the study area, there is a large variation in soil chemical properties. Total nitrogen showed the highest variability with 66.84% in its CV (Coefficient of Variation), followed by soil electrical conductivity, with a CV value of 54.36%. However, least variability across sample areas was found for soil pH and total phosphorus, with CV values of 5.08% and 6.68% respectively. Moderate variability occurred for soil CEC and organic matter, which have CV values of 28.02% and 35.93%, respectively.

Table 1 Descriptive statistics of soil chemical properties

Variables	Unit*	Minimum	Maximum	Mean	SE	SD	CV%
pH	$-\log[H^+]$	5.480	7.580	6.248	0.0355	0.317	5.08
Electrical conductivity	dS m^{-1}	0.051	0.506	0.095	0.0058	0.052	54.36
Cation exchange capacity	meq100 g^{-1}soil	2.130	11.050	6.218	0.1948	1.742	28.02
Organic matter	%	0.200	1.700	0.874	0.0351	0.314	35.93
Total nitrogen	%	0.010	0.330	0.113	0.0085	0.076	66.84
Total phosphorus	%	0.017	0.024	0.019	0.0001	0.001	6.68

SE: Standard Error, SD: Standard Deviation, CV: Coefficient of Variation

** Units represent for the columns of minimum, maximum and mean in the table*

Soil pH and Electrical Conductivity

Soils in the study area were found to range from slightly acidic to moderately alkaline, with the mean pH value of the soil being 6.25, with a range from 5.48 to 7.58. The pH of the soil samples can be described as 21.25% moderately acidic, 58.75% slightly acidic, while 18.75% samples were neutral (pH 7) and only 1.25% samples were moderately alkaline (Fig. 3). The variation in levels of acidity could be due the topography of the study area, variations in moisture, or farmers' practice in the use of acid-forming nitrogenous fertilizers.

The values of EC range from 0.051 dS m^{-1} to 0.505 dS m^{-1} (Fig. 4). The observed mean EC value of 0.095 dS m^{-1} indicated that the study area does not have a salinity problem. According to Moore (2001), the observed EC values were only just above the low range of levels for EC values that is between 0.051 and 0.5 dS m^{-1}, a level expected to have a minimum effect on plant growth.

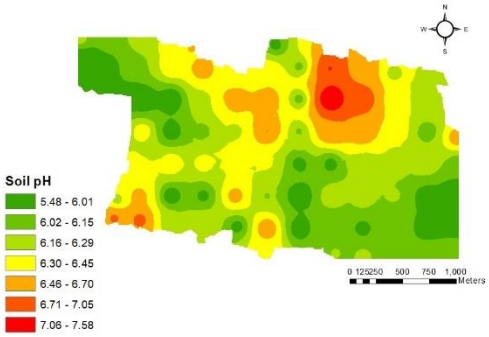

Fig. 3 Spatial distribution of soil pH

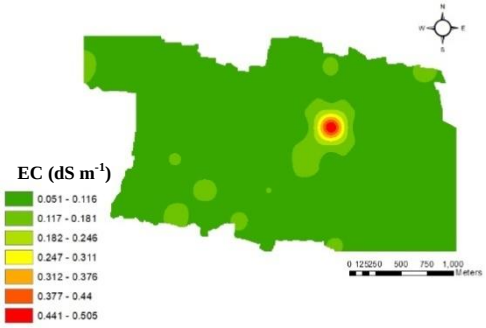

Fig. 4 Spatial distribution of EC

Cation Exchange Capacity and Soil Organic Matter

The observed CEC vary from a low to a medium level, ranging from 2.13 to 11.05 meq100 g^{-1} soil, with a mean value of 6.22 meq100 g^{-1} soil, for the study area (Fig. 5). Using Landon's (1991) classificatory system, 23.75% could be characterized as very low in CEC, while the remaining 76.25% has a low level of CEC. This would indicate that the study area has inadequate basic cations which would be detrimental to plant growth. Ahmed et al. (2015) stated that any CEC of <4 meq100g^{-1} soil indicates a high degree of soil infertility, making it unsuitable for agriculture.

Organic matter content ranges from 0.20% to 1.70%, with a mean value of 0.87%. Figure 6 displayed the spatial distribution of organic matter (in OM%) with lowest levels in the northeast and eastern portion, with content increasing towards the southwest. This may be the result of the slightly higher elevation of the northern portion, as organic matter accumulation is often favored in those areas at lower levels. Purdie (1998) states that soils with organic matter content greater than 2.6% provide good nutrient storage, so it can be seen that the level of organic matter content in all sampling grid plots was very low, affecting good nutrient storage and supply. Based on the survey of farmers' soil management practices, this lower organic matter content may be attributed to poor agricultural management practices, such as the complete removal of crop residues after harvest and the infrequent application of organic manures and organic materials (rice straw, pulses residues, cow dung, etc.) and the burning of crop residues after harvesting.

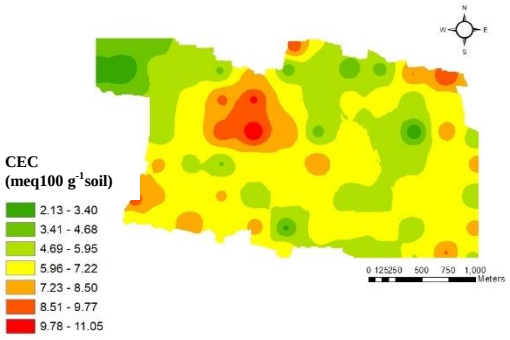

Fig. 5 Spatial distribution of CEC

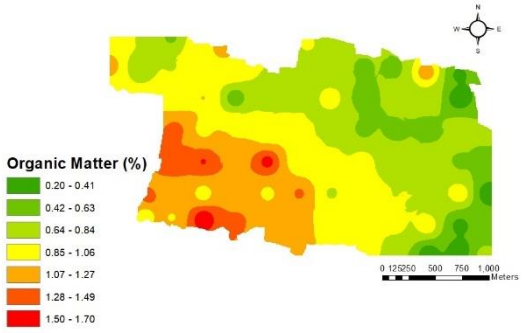

Fig. 6 Spatial distribution of OM

Total Nitrogen and Total Phosphorus

The total nitrogen content varied from 0.01% to 0.33% with a mean value of 0.11% overall. The study indicates that about 25% of the area sampled has 'very low' levels of nitrogen and a further 50% has 'low' levels, while 17.5% of the samples are in the medium range, and only 7.5% have a high range of total nitrogen content (Fig. 7). The low nitrogen content is probably due to the insufficient level of organic matter, which can be depleted by constant cropping and prevailing high temperatures, resulting in the faster degradation and removal of organic matter, with a corresponding drop in the soil's nitrogen reserves. On the other hand, the areas of medium to high level of total nitrogen appear to occur where organic materials have been added (mainly plant residues), and also as a result of nitrogen fixed through legume cultivation.

The spatial distribution of total phosphorus levels appears to be higher, with 43.75% of the sampling area being in the medium range, whereas 56.25% of the samples showed lower levels (Fig. 8). The values of total phosphorus ranged from 0.017% to 0.024% with a mean value of 0.019%. According to research, lower levels of phosphorus may be due to infrequent application of organic and inorganic phosphorus fertilizers. Another reason for these lower levels may be due to nutrient depletion by crops, since this area has a cropping pattern of monsoon rice and dry weather pulses.

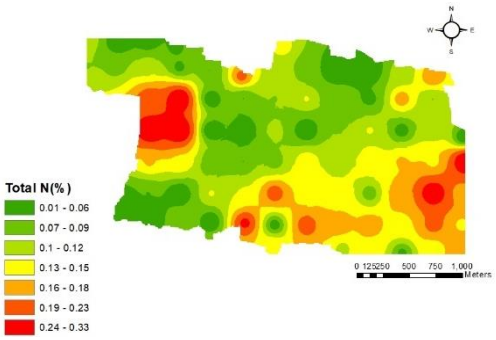

Fig. 7 Spatial distribution of total N

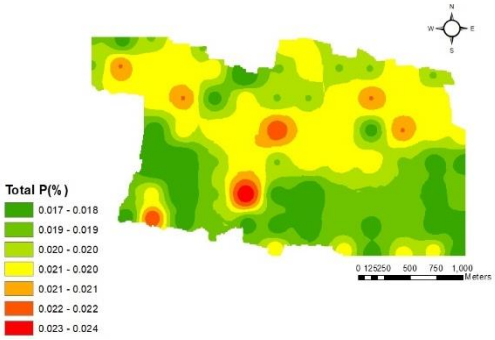

Fig. 8 Spatial distribution of total P

Survey Results for Soil Management Practices

Mostly preparation of land for cropping is mechanized, with only 21% of respondents using both machine and animal power. In this area, the dominant cropping pattern of monsoon rice and pulses is practiced under both rain-fed and irrigated farming. It was found that there is minimal application of organic fertilizers. After harvesting, farmers retain residues from the pulse crop on their fields, but this is done by a minority. About 23% of respondents use cow-dung manure and only 12% of respondents apply pulses residues. The most common types of inorganic fertilizers used by the respondents were urea and compound fertilizers for rice production. There is no evidence of the application of phosphorus and potash fertilizers for crop production. Application of fertilizers is mostly by the broadcast method and top dressing is applied two to three times, at the tillering and flowering stages. Fertilizers do not appear to be applied basally at planting time.

CONCLUSION

Results from the soil analysis show the following characteristics of the soil in the study area; it has low content of organic matter, it has (mostly) low to high levels of total nitrogen, low to medium ranges of total phosphorus, while the level of the CEC is very low to low. Although the measured ranges of soil pH and electrical conductivity ranges should not be detrimental to the crop cultivation, soil nutrient management for sustainable crop production should focus on addressing problems of acidity and alkalinity. As expected, the variability of each soil characteristic exists largely due to the differences in the management practices used by farmers. Therefore, farmers should be encouraged to return as much crop residue as possible to the soil, introducing systematic

practices (sufficient and consistent) that provide for the addition of manure and fertilizers, in order to improve soil fertility levels which will lead to higher crop production. Further, a legume-based cropping pattern should also be introduced and consistently maintained to provide a long-term nutrient supply for better yields and diversify the economics of crop production. This study has shown that the use of new technologies such as GIS and GPS can provide important information for evaluating the current status of soil fertility, and for allowing better management of soil fertility at the farm level.

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Research article

Participatory Risk Assessment of Nong Han Wetland, Thailand

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Abstract Recognised as a Wetland of International Importance, the Nong Han Wetland (NHW), in Sakon Nakhon, Thailand, was selected as a study site for a risk assessment, which is an integral part of wetland management planning. The study demonstrated the process and presented the results of a risk assessment adopted in the NHW. The research postulates a simple risk assessment framework, where stakeholder participation is the key element. Following Ramsar's guideline, tailored to suit the objectives of the study, the risk assessment framework involved (1) identifying problems and risks; (2) quantifying risks; and (3) proposing prevention and mitigation measures. Data were collected *via* focus group and questionnaire. The total number of participants was 217 stakeholders from 49 villages in the NHW. Eleven issues were identified, namely: (1) an increase in aquatic plant growth; (2) sedimentation; (3) degradation of water quality; (4) reduction and extinction of indigenous fish species; (5) non-existence of water laws; (6) land-rights; (7) conflicts of joint natural resource utilization; (8) sufficiency of data and information; (9) flooding; (10) draught; and (11) climate change. Risks were evaluated and ranked in terms of risk perception, and participants from different locations perceived degrees of risk rather differently. Nonetheless, when all the participants were analysed integratedly, the highest common risks shared were an increase in aquatic plant growth, sedimentation, degradation of water quality, and reduction and extinction of indigenous fish species. In addition, a set of risk prevention and mitigation measures was also drawn from the participatory risk assessment process. The results could be employed as a guideline for future plans and interventions of the wetland management following the bottom-up approach adhered to the Integrated Water Resources Management (IWRM) principles. The process not only drew conclusions and recommendations regarding risk management, but also created risk awareness and enhanced the degree of stakeholder engagement.

Keywords Nong Han Wetland, participatory risk assessment, risk perception, Integrated Water Resources Management

INTRODUCTION

Nong Han Wetland (NHW), in Sakon Nakhon Province, Thailand, has been recognized as a Wetland of International Importance (MNRE, 2009). It is the largest natural lake in the northeast of Thailand and the country's second largest after Bueng Boraphet, Nakhon Sawan Province. The NHW connects to the Mekong River *via* the Nam Kam River, approximately 123 kilometres in length. The location of the NHW is shown in Fig. 1. The Nong Han Basin covers the area of 583 km^2, where the wetland covers the area of 123 km^2 with an average depth of 1.9 m., composing paddy fields, grass lands, and village communities (Chaturabul and Pongput, 2013). Abundant in natural resources, Nong Han is a complex and important ecosystem and is vital to the livelihoods of the local communities (MRC, 2017).

The NHW has been managed by various governmental agencies. Due to various factors, mainly anthropic disturbance, various issues have been reported, namely, floods, draught, degradation of water quality, increases in aquatic plants, sedimentation, and the reduction and extinction of indigenous fish species (MRC, 2017). This demands a well-integrated plan for the wetland management, whereas risk assessment is an integral part of the management-planning processes for wetlands (Ramsar, 1999). In addition, prior to this study, a risk analysis had never been conducted on the NHW. This research therefore is a first attempt at a risk analysis of Nong Han by employing a participatory risk assessment methodology, which is a bottom-up approach involving local communities in identifying, deciding solution measures, and implementing and evaluating interventions. It is well noted that participation from stakeholders is important to the success of policy implementation (see for example Erftemeijer and Bualuang, 2002; Trisurat. 2006).

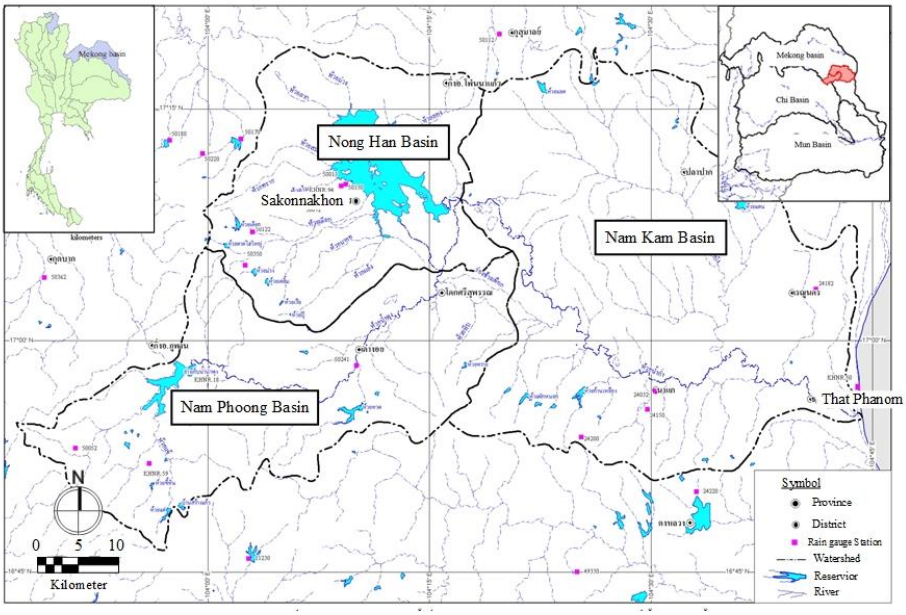

Fig. 1 Location of Nong Han Wetland

OBJECTIVES

The objectives of this study are: (1) to present a comprehensive risk analysis of the NHW; (2) to determine the pressures and impacts on the environment and community livelihoods in the NHW; (3) to propose prevention and mitigation measures of the risks elicited by the participants; and (4) to promote a community participatory approach and capacitate stakeholders with integrated water resource methodology.

METHODOLOGY

The study adopted the risk assessment framework of the Wetland Risk Assessment proposed by the Ramsar Convention Secretariat (1999) tailored to suit the scope of the study, as shown in Fig. 2 below.

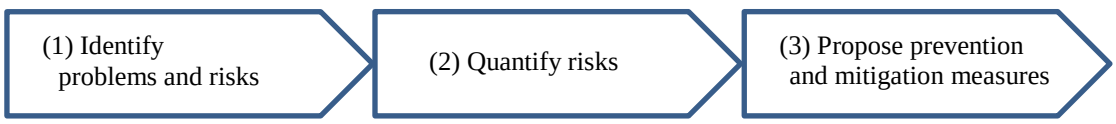

Fig. 2 Risk assessment framework

The analysis combined both qualitative and quantitative methods. Qualitatively, in order to gather primary data, focus groups were organised. Quantitatively, the information drawn was quantified in terms of risk ranking. Stakeholder participation was key in all steps. The process is outlined herewith.

1. Identify Problems and Risks

Closely related, problems and risk identifications were carried out hand-in-hand. Problems can be defined as undesired incidents, whereas associated risks are the corresponding consequences and likelihoods. Problems and risks were initially formulated in a series of workshops, held by a civil society in Sakon Nakhon called the Chomrom Song Serm Kon Dee, consisting of direct stakeholders, including civil servants, business owners, and community residents.

Eleven issues were identified: 1. an increase in aquatic plant growth; 2. sedimentation; 3. degradation of water quality; 4. reduction and extinction of indigenous fish species; 5. lack of water laws; 6. land-rights issues; 7. conflicts of joint natural resource utilization; 8. existence of and sufficiency of data and information; 9. floods; 10. draught; and 11. climate change. These issues were later introduced to the other four workshops organized in the NHW in order to gather agreements and additional issues from the participants.

2. Quantify Risks

Risk perception methodology was employed. Risk perception refers to human subjective judgments about the likelihood of negative occurrences such as hazards and threats to the environment or health (Paek and Hove, 2017). In other words, it indicates the extent to which people know, and what they feel, about threats and likelihoods, and gives a general overview of the status quo of risks pertaining to environmental settings.

There are various methods for quantifying risk perception (see e.g. Weber et al., 2002; and Janmaimool and Watanabe, 2014). This study devised a simple, straight-forward and low-cost method. First, the questionnaire was designed around the issues identified in the previous step. Eleven close-ended questions required the respondents to subjectively evaluate the degree of risks and the likelihood of the issues to occur. Second, response options were coded as "High = 3," "Moderate = 2," and "Low = 1." Then, risk and likeliness were arithmetically averaged, and scaled to the range of 0 to 1.

3. Prevention and Mitigation Measures

During the workshops, the participants were asked to participate in a group discussion and to actively participate and exchange their ideas on the related prevention and mitigation measures.

Table 1 Workshop participants and venues

Venue (all in Sakon Nakhon Province)	Respondent	Village	Sub-district
Phon Na Kaew District Hall, Phone Na Kaew District	50	11	3
Lao Po Daeng Sub-district Municipality, Muang District	57	16	4
Chiang Khruea Sub-district Municipality, Muang District	49	12	3
Sakon Nakhon City Municipality, Muang District	61	10	1
Total	217	49	11

4. Risk Analysis Workshop

Four workshops were organised to collect data from the communities in four different locations around Nong Han during 2016. Table 1 and Fig. 3, respectively, illustrate and report the numbers of participants, villages, and sub-districts they represented. The total number of participants was

217, including direct stakeholders, such as sub-district headsmen, village chiefs and assistants, and village committees.

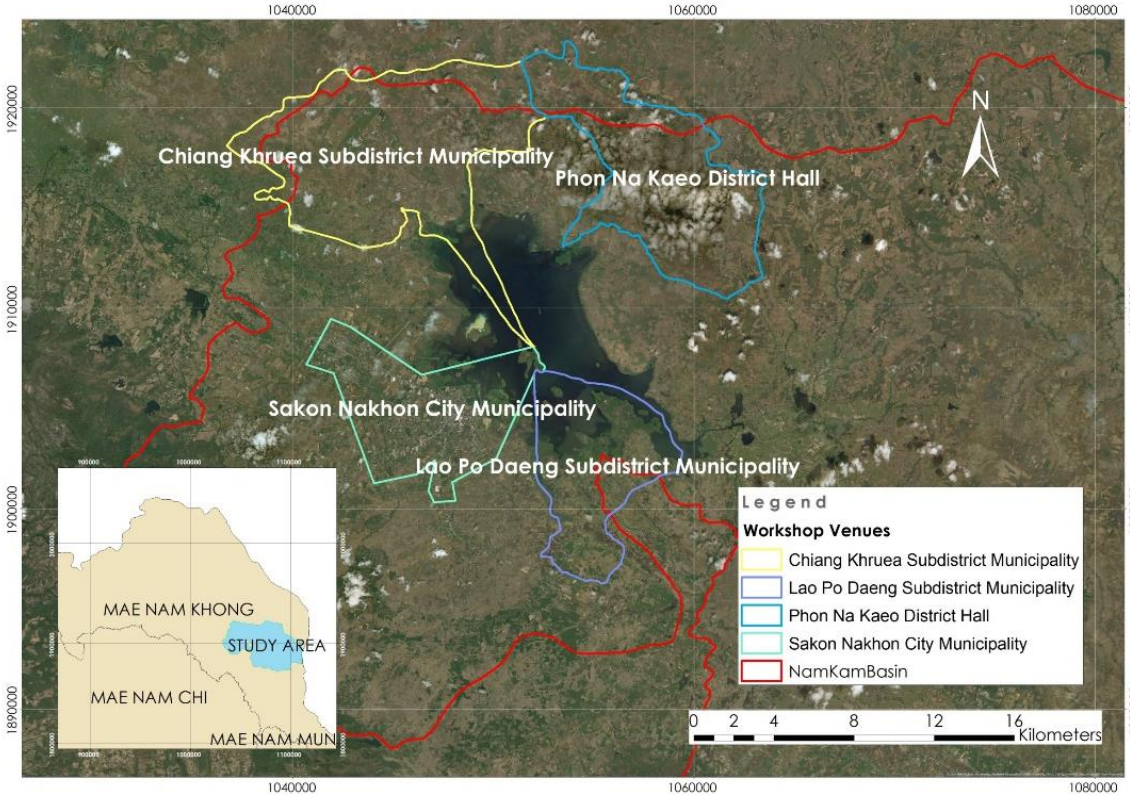

Fig. 3 Study site and workshop venue

RESULTS AND DISCUSSION

This section presents the results; namely, risk logs, prevention and mitigation measures, and discussion.

1. Risk Log

The risk log summarized the results of the risk analysis in terms of likely impacts on the environment and community of the NHW.

Table 2 Ranked risk log

No.	Issue	Impact	Likelihood	Rating
1.	Increase in aquatic plant growth	0.94	0.96	0.90
2.	Sedimentation	0.93	0.94	0.87
3.	Degradation of water quality	0.92	0.93	0.85
4.	Reduction and extinction of indigenous fish species	0.88	0.90	0.79
5.	Land-rights issue	0.88	0.88	0.78
6.	Climate change	0.87	0.88	0.77
7.	Draught	0.85	0.87	0.74
8.	Conflicts of joint natural resources utilization	0.83	0.84	0.70
9.	Nong Han's data and information sufficiency	0.83	0.83	0.69
10.	Lack of water law	0.80	0.82	0.66
11.	Flood	0.80	0.80	0.64

The first four highest-ranked issues were all closely related. Issues such as sufficiency of data and information about Nong Han, lack of water law, and flooding were ranked last, but they were still considered high both in terms of impact and likelihood.

2. Prevention and Mitigation Measures

The proposed prevention and mitigation measures were the result of stakeholder participation in collectively eliciting solutions to the common problems shared. The measures are classified herewith as structural and non-structural. On the one hand, structural measures are fixed or permanent physical constructions for preventing and mitigating risks. On the other hand, non-structural measures do not involve physical facilities. Due to the limited space, the measures are only briefly summarised as follows.

2.1 Structural Prevention and Mitigation Measures

- Build more wastewater treatment plants (at the present, there are only two plants in the NHW).
- Build adequate drainage systems and improve the existing drainage systems.
- Build an embankment/dike, construct more reservoirs to increase water storage, and construct roads surrounding Nong Han.

2.2 Non-Structural Prevention and Mitigation Measures

These non-structural prevention and mitigation measures are grouped into 1) regulatory measures; 2) awareness and education measures; and 3) non-structural modifications.

Regulatory measures:

- Enact and enforce water laws or water resources agreements, namely, Nong Han agreements/laws to conserve fish species and to prescribe penalties for violations.
- Amend the existing law, the Royal Decree of Demarcation of Restricted Land in Muang District, Sakon Nakhon Province B.E.2484 (1941), to solve land rights conflicts in the NHW.

Awareness and education measures:

- Create awareness and involvement, and disseminate knowledge of integrated water resource management and how to use water wisely and equitably.
- Campaign stakeholders to prevent pollution of the NHW.
- Promote organic farming, stop/reduce using chemical fertilizer and pesticides.
- Promote reforestation and preserve the existing natural resources.
- Create awareness and conserve the population of indigenous fish species, and campaign for sustainable fishing.
- Organise discussions between the government and the people in order to improve common understanding.
- Create a data-management centre in order to organise studies and data collection, and to publicise accurate data and information.

Nonstructural modifications:

- Employ natural methods to treat wastewater, e.g., use mosquito fern or water fern to absorb heavy metals and phosphates, and increase herbivorous fish species that feed on aquatic vegetation.
- Remove and control aquatic weed for example through dredging operations and weed removal machines.
- Plant and maintain an appropriate vegetative buffer on the shoreline to prevent soil erosion and sedimentation.

CONCLUSIONS

In addition to the measures introduced above, the participants also recommended developing a Nong Han management plan, which should include draught protection and relief, and flood prevention, protection, and mitigation. On the one hand, engineered structures may eliminate the risk to some degree. On the other hand, non-structural measures are less costly and require participation through a process of behaviour influencing, usually *via* stakeholder capacity building (Taylor and Wong, 2002). Both structural and non-structural measures recommended from this study can be employed as a part of wetland management planning. Importantly, the two measures should be balanced; for structural measures to be effective, stakeholders should be aware, prepared, and duly trained (Bons, 2013). The participatory risk assessment procedures proposed can be employed in different environmental management planning settings. The study not only drew conclusions and made recommendations regarding risk management, but also created risk awareness and enhanced the degree of stakeholder engagement.

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Research article

Development of Ecotourism in North Bandung, Indonesia

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Abstract Ecotourism has been used to be an alternative for tourism activity while maintaining its natural sustainability. The spread of ecotourism in North Bandung that increased by number not only boosted the development of village area but also hoped to be able to improve the welfare of people living near tourist sites. This study looks at the tourism site's development and specializes in discussions on two tourist sites, Orchid Forest Cikole and Taman Bunga Begonia "Glory." Literatures findings suggest awareness about environmental quality, education, and involvement of the local community, becoming a possible substance to be a benchmark of measurement of ecotourism concept. By using that measurement, this study seeks named sites ecotourism management and conditions by conducting in depth interviews with the tourism site owner and site marketing team leader. The result shows that even though some efforts are still in the planning stage, Orchid Forest Cikole has implemented quite several efforts to carry out the value of the ecotourism concept. Meanwhile, Taman Bunga Begonia "Glory" tourist sites, even though the land owned is relatively small and its starting from a hobby, this site applies a lot of the value of ecotourism concept.

Keywords ecotourism, land use, rural development, leisure park, sustainability

INTRODUCTION

While it has been actively promoting around the world, Indonesia has been particularly keen on developing ecotourism, by naming the year 2002 their "National Ecotourism Year." Indonesia is known for its rich biodiversity and cultural diversity. The country promotes ecotourism with the high hope that ecotourism will provide alternative ways to use such diversities sustainably and economically and to improve the living standards of Indonesia's people (Izawa, 2010).

Ecotourism in Indonesia defined as activities of responsible traveling in whole areas or in areas that are named according to the role of nature. The purpose of such activities is: being to enjoy natural beauty involving education, understanding, and supports conservation, as well as increasing the income of the local communities. Its importance is (1) to generate jobs and revenue, which can provide an incentive for preserving natural areas. Then, (2) to raise public awareness of the many products and services provided by natural ecosystems biological resources and respect for traditional knowledge and practices, and (3) to reconcile economic and environmental concerns and give practical meaning to sustainable development (Nirwandar, 2015).

Ecotourism has become a global issue that is often discussed in Indonesia. It is one of the special activities of tourism which its interest is the low impact on natural tourism (Butarbutar & Soemarno, 2013). It has been used to be an alternative for tourism activity while maintaining its natural sustainability. The spread and development of the tourism site certainly provide many positive impacts. However, it may also harm natural resources and does not make a significant contribution to local residents. As Indonesia's international and domestic tourism growth continues, there will be even greater stress on what are, in some cases, already threatened or vulnerable

natural and cultural environments. Places urgency on the need to increase the awareness and practices for sustainable tourism approaches by industry and tourists alike (ILO, 2012).

However, within recent tourism progress, there was a concern whether the northern Bandung area is it still able to maintain its function as a conservation forest. It is nearly difficult to apply forest revitalization as a solution. As the nearest approach to new conditions, the study about it is ecotourism and sustainability may be one option to know the new condition, which will lead to ecotourism that is more environmentally friendly. In this paper, ecotourism in the North Bandung area, especially Orchid Forest Cikole and Taman Bunga Begonia "Glory," will be described. The reason two places become the object of study is because of both popularity and the background story behind the success.

OBJECTIVE

This study attempts to identify available information on ecotourism schemes background and the site's effort to maintain its ecotourism concept by measuring it into its "Environmental conservation efforts," "Cultural preservation efforts," and "Efforts to involve local communities and improve their welfare."

METHODOLOGY

The methodology consists of a literature review, interview, and analysis part. Qualitative methods were used to determine the value of ecotourism in Orchid Forest Cikole and Taman Bunga Begonia "Glory" (from now on referred to as "OFC" and "TBB"), then measure the roles of the tourism sites and the local communities. Interviewing the owner of TBB and marketing team leader OFC was done on 17th July 2018. The interview was conducted by concerning the ecotourism criteria and indicator (Table 1) that Yanuarti and Rosyidie (2008) use as a parameter of ecotourism. The three key indicators were as follows.

Table 1 Ecotourism criteria and indicator (Yanuarti and Rosyidie, 2008)

Environmental Conservation Efforts
Develop eco-friendly tourism facilities using natural materials (wood or bamboo)
Involving tourists to conduct activities
Financial assistance from tourists for conservation activities
Use of alternative resources, such as utilization of water for electricity, wood for fuel, etc.
Waste management, reduce the use of materials that can not be recycled such as plastics, cans, and aluminum that pollute the environment
Engage in ecological revitalization treatment
Cultural Preservation Efforts
Presentation of local arts and cultural attractions
Sale of handicrafts or souvenirs with local nuances
Local Communities Involvement and Welfare Improvement Efforts
Engaging local communities in the planning and development process region
Engagement of people who work in tourist sites
Involvement of the community as an entrepreneur or manager of accommodation services, attractions, transportation, and other supporting services
Involvement of the community as a marketing force, promotion and tour guide
The community is given an opportunity by the owner to obtain education and training of tourism area management

RESULTS AND DISCUSSION

Conditions of North Bandung Area

As mentioned before, the land use condition is also affected by Bandung city development. The high rite of urban sprawl ignites the phenomena of land conversion and becoming an essential issue to environmental change. According to Masri (2009), 28.11% of house development in Lembang is developing at an improper zone for residential lands. The vast area, environmental convenient, road

accessibility, accessibility have a positive correlation to the community choose to stay in the housing development at lousy zone. Traffic jam, water, and air pollution, land degradation, flora, and fauna lose so that decreasing environmental quality.

Current Tourism Development in Orchid Forest Cikole (OFC)

OFC is standing on 14 ha of pine forest land in Cikole Lembang District West Bandung regency, a new tourist destination with a collection of 157 rare orchids from all around the world. The location is approximately 7 kilometers north of Lembang, right before the entrance to Mount Tangkuban Perahu and across the Jayagiri camping site.

This site introduced as a recreation park that started in October 2017, which is located in Jalan Genteng, Tangkuban Perahu Cikole Km.8 Lembang Kab. Bandung Barat. The entrance fee for this site costs 30.000 IDR and 15.000 IDR if the visitor wants to experience some additional attraction. Based on news articles, the average number of visitors is 1000 visitors a day, and it can increase to 10.000 visitors on a national holiday like the Eid al Fitr holiday. The reason why this site becomes an interview target is that this site is targeted not only as of the tourism object, it is also as become center of cultivation, conservation, and orchid flowering. Within the concept of geo-tourism and eco-tourism, Perhutani seeks to preserve nature as well as lifting society's economy. Since it newly opened, the information is limited and cannot be attained due to it still in development progress.

Current Tourism Development in Taman Bunga Begonia "Glory" (TBB)

Before becoming into a recreation park, this parkland bought by the owner; it was an area that was not getting attention and in the form of a corn garden with 1ha areas. An individual land commonly used to hold a night market. Previously the owner was a farmworker in the Netherlands who aspired to be able to manage agriculture in Lembang in his retirement. From the beginning, the owner planned to grow flowers because the climate was suitable for flower planting. Famous for its excellent performance, many enthusiasts interested especially housewives who come and say "this place is like in Europe," take pictures and enjoy the park. The demand for planting begonias also increases.

It is starting from 2013, this site introduced as a recreation park. The entrance fee for this site costs 5.000 IDR back at 2013, and 20.000 IDR today. Its average visitor on a weekday is 300 visitors, 1000 visitors on weekend or national holiday. The owner explained that the management cost for the park is 40% from earned income. The reason why this site becomes an interview target is that is due to its development which started from its owner hobbies to take care of flower and slowly to become a tourism park. The people like the beauty, the amount of interest, and the rapid dissemination of information from social media have changed this location, which was initially a park and greenhouse to be like today.

Evaluation on Ecotourism by Three Indicators

1. Environmental Conservation Efforts

In environmental conservation effort, both sites develop the eco-friendly tourism facilities. In this implementation, OFC facilities are 80% using natural woods from the tourism area site, and also for its construction process, this site not allowed to use any heavy machinery. This site chose and made sure the felled trees are a tree that old enough following the direction from Perhutani (Indonesian State Forest Company). Felled trees are also used to be tourism facilities (sightseeing sky bridge, high rope, others) and supported by other construction hard materials. Limited by its space, as much as possible, TBB does not use massive buildings, and most of the facilities contained here are bamboo-based, except the management office made of fixed buildings.

Even though its form as an attraction OFC provides several activities that can be conducted by the visitor such as outbound facilities (such as flying fox, high rope, zip line, the garden of light), but an additional fee also charged. On the contrary, TBB provides training involve tourists to

conduct activities and direction for flower planting for the prospective retiree as a venue for sharing experiences, learning the place for the student regarding flower and vegetable planting. This site is also open a sharing discussion for local area family empowerment-welfare housewives group.



Figs. 1 and 2 OFC using natural woods from tourism area site **Fig. 3 Restaurant in TBB**

Both sites still depend on third party electricity providers to facilitate maintenance. Although previously TBB had planned to raise cattle to make biogas installations. However, its application is quite inconvenient. The grass for its feed is quite difficult to find based on information from farmers around who have difficulty finding grass in the dry season. Also, there have been no attempts of financial assistance from tourists for conservation activities. Most visitors come for sightseeing purposes.

An effort to reduce the use of materials that cannot be recycled and can pollute the environment, OFC applied it by imposes a ban on bringing food from outside, on reducing the chance of visitors leaving trash in the tourist area. Therefore, provision of coffee shops and canteens facilities which also promote the ecotourism concept by not using styrofoam, and sorting plastic waste. As for TBB, generally, waste from the park is destroyed as compost. The plastic waste and cans are partly tried to be burned with incinerators to break down pollution poisons. The begonia park owns the equipment, but currently, it is still under development so that the temperature produced by the incinerator remains stable.

As for engagement in ecological revitalization, treatment OFC focuses on the ecological revitalization of orchids and also organizes educational tours on orchid treatments. It is also expected to be a lesson to maintain a sustainable balance between orchids and forests. An orchid decorates about 70% of the pine trees found on this site at each tree, and a have facility specifically for orchid cultivation. On the other hand, TBB owner's efforts and expectation by owning this park are to keep and conserve the area as a park, then avoid to build a building is one of his ways to engage in ecological revitalization treatment.



Fig. 4 A tree decorated with orchids at OFC **Fig. 5 TBB that avoiding to build a massive building on it site** **Fig. 6 Souvenir shop corner in TBB**

2. Cultural Preservation Efforts

So far, there has been no preservation of local culture and art in OFC since the site is relatively new. For the future, the manager plans to cooperate with schools and make the students be able to

showcase traditional cultural arts dance at the event held here. As for the official souvenir, it is still in design progress and still in the process of market research.

In the TBB site, there is room to trade local products. There are also plant that is entrusted by the local farmers to sell here. Since the area is only one hectare and relatively small, this park does not have facilities like a stage for performances.

3. Local Communities Involvement and Welfare Improvement Efforts

Both sites were employing 80-90 percent of young staff from residents as an effort to engage local communities. Although for OFC, the planning and development still the leading directors who carried out the process. The collaboration has been carried out primarily with Perhutani. Thus, the involvement of the community in another aspect is still not implemented. However, in the future, OFC plans to be able to collaborate with local entrepreneurs. Therefore, that other workshops can be held and provide opportunities to market products from local entrepreneurs. So far, the promotion has been influenced more by the high interest of visitors due the social media posts of people who have previously visited.

On the contrary, TBB, the owner, involves planning with local people to help each other in to sell plants. For example, with the craftsmen of flower pots, flower farmers around. There are some of the residents also offer services such as offering horse riding services, selling pet products such as rabbits around the park location as the involvement of the community as an entrepreneur or manager of accommodation services, attractions, transportation, and other supporting services.

For involvement of the community as a marketing force, promotion, and tour guide case, since the parking area considered small, it has a problem in the parking area. When there is a difficulty in parking lots from high visitors, residents around the park who have a house yard, vacant land empowered as an alternative parking lot. By this mutual concession, the park owner hopes it can contribute so that they can get additional income. Rather than to the community, the owner is more likely to provide internal education to local staff who are in direct contact with the park to provide better jobs related tourism as allowed by the owner to obtain education and training of tourism area management. As an example, like the application of 5R (Ringkas = concise, Rapi = neat, Resik = clean, Rawat = care, Rajin = persevere) that adapts from the 5S of Japan (JICA, n.d). Due to the lack of general tourism ideas of the local community.

According to the interview obtained data, the comparison between two site's efforts are summarized in Table 2.

Table 2 Interview result comparison

Environmental Conservation Efforts	**Orchid (OFC)**	**Begonia (TBB)**
Develop eco-friendly tourism facilities using natural materials (wood or bamboo)	○	○
Involving tourists to conduct activities	Δ	○
Financial assistance from tourists for conservation activities	X	X
Use of alternative resources, such as utilization of water for electricity, wood for fuel, etc.	X	X
Waste management, reduce the use of materials that can not be recycled such as plastics, cans, and aluminum that pollute the environment	○	○
Engage in ecological revitalization treatment	○	○
Cultural Preservation Efforts		
Presentation of local arts and cultural attractions	Δ	X
Sale of handicrafts or souvenirs with local nuances	Δ	○
Local Communities Involvement and Welfare Improvement Efforts		
Engaging local communities in the planning and development process region	○	○
Engagement of people who work in tourist sites	○	○
Involvement of the community as an entrepreneur or manager of accommodation services, attractions, transportation, and other supporting services	Δ	○
Involvement of the community as a marketing force, promotion and tour guide	X	○
The community is given an opportunity by the owner to obtain education and training of tourism area management	X	○

○ = currently applying, Δ = currently applying it halfway, X = currently not applying.

CONCLUSION

Although there are still efforts that are still in the planning stage, OFC has implemented quite several efforts to carry out the value of the ecotourism concept. Meanwhile, TBB tourist sites, even though the land owned is relatively small and its starting from a hobby, this site applies a lot of the value of ecotourism concept. These indicate excellent attention from the managers of tourist sites, although it is possible that the execution still found many shortcomings and constraints.

For some points that still cannot be applied, here are some suggestions to be considered. The presentation of local arts and cultural attractions is still not implemented due to certain conditions. The presentation can be applied by holding an art show on a small scale, maximizing the available area (e.g., restaurant area), and making the show a monthly routine as a start. The introduction of a plan "one man one tree" can pursue financial assistance from the tourist for conservation activities. The movement is to purchase one tree and plant it in an area that allows planters to see the trees they have planted in the future (planted as decoration in the village open space, as well as on the streets as the identity of ecotourism in Lembang, North Bandung).

It is unfortunate for a massive ecotourism site like the OFC that it still does not apply the involvement of the community as a marketing force and allow obtaining education and training of tourism area management. The reason is most likely due to the relatively new operation of the site, but it would be much better if this were immediately applied. Because it does not rule out, the prepared concept cannot be carried out entirely due to the lack of coordination with the community and the site manager. This effort can minimize errors and shortages of labor when human resources are needed when doing an entertainment project related to nature tourism.

The need for control from the government and the involvement of local citizens in realizing ecotourism will not only avoid unsustainable land use utilization. Ecotourism site connoisseurs are also expected to have an awareness of problems that may arise from the addition of tourist locations. Without eliminating the recreational side, ecotourism visitors are also expected to be more sensitive to the conditions surrounding the ecotourism area as a positive influence of visiting nature-based tourism. Hopefully, by this, we can also protect environmental conditions that are currently being used by residents for other purposes such as agriculture and animal husbandry. On a grander scale, it also can protect the water catchment area and prevent flooding in Bandung city.

This study provides a small picture of ecotourism that developed in the North Bandung area. A review with more objects of study is certainly needed to be able to describe the more general conditions of ecotourism, and arising environmental impact as the result of ecotourism development.

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Research article

Performance Analysis of 325 kW Solar PV Rooftop System Using PVsyst Program

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Abstract The power demand of electricity growing very fast with high concern of climate change and environmental constrains. According to the Thailand Power Development Plan 2015 (PDP 2015) starting from 2015 to 2036, the national target of 30% of renewable energy to total energy consumption by 2036 is to be achieved. Solar photovoltaic (PV) is an important option makes the PDP 2015 meets the target. This paper aims to present the performance analysis of the solar PV rooftop system installed at Sakon Nakhon Rajabhat University. The system consisted of 1,016 polycrystalline silicon PV modules coupled to 13 units of 25 kW grid tied inverter. This system will be installed at the rooftop of the three buildings namely, the Central Building (CB), the Engineering Technology Building (ETB) and the Multipurpose Building (MB). The PV rooftop system is designed using PVsyst program. The PV modules faced tilts and azimuths with 5°/31°, 10°/31° and 5°/16°, respectively. The simulation results indicated that solar PV rooftop system can produce 452.92 MWh/year. The solar PV rooftop system could produce electricity generating from 06.00 - 18.00. The performance ratio of the system is 0.74. The Central Building has maximum power electricity generating as 44.44%. The Engineering Technology Building has high performance ratio because of its tilts and azimuths of solar panels that affect the irradiation. The solar PV rooftop can reduce the peak demand in time 06.00-18.00 of 13.24% and the reduction of greenhouse gas emissions is 263.65 tco2/year.

Keywords climate change, photovoltaic, PVsyst (PV system design program), renewable energy, solar PV rooftop system, sustainable development

INTRODUCTION

Solar photovoltaic (PV) is now widely used for power generation worldwide. According to the Alternative Energy Development Plan (AEDP 2015-2036), the renewable energy is targeted for 30% of total energy consumption in Thailand. Due to its cost competitive and high potential of solar energy in the country, solar power has been promoted and scheduled to be installed at 6,000 MW by 2036 (Tanatvanit, 2003 and Chimres, 2016). Sakon Nakhon Rajabhat University (SNRU) is an academic institute in Sakonnakhon province which located in the northeastern part of Thailand. Sakon Nakhon Rajabhat University has an area of 1.02 km² and there are 50 buildings. This institute has high energy consumption. The electricity cost per year is 20 million baht. The energy block grant project subsidized from the Ministry of Energy is launched in 2018 for the 325 kW solar PV rooftop to promote the use of renewable energy in the institute.

OBJECTIVE

This work was aimed to present the performance analysis of the 325 kW solar PV rooftop. The PVsyst program was employed as a tool to investigate the technical performance assessment, project design and its simulation. The three proposed buildings will be launched in 2020. This study would be useful to predict the performance of the system, financial analysis and the user perspective on a solar PV rooftop system. The study clearly illustrates the potential to use the PV rooftop system to supply basic energy services that is desired in academic building settings.

MATERIALS AND METHODS

The installation of solar PV rooftop system at the Central Building (CB), the Engineering Technology Building (ETB) and the Multipurpose Building (MB) is shown in Fig. 1.

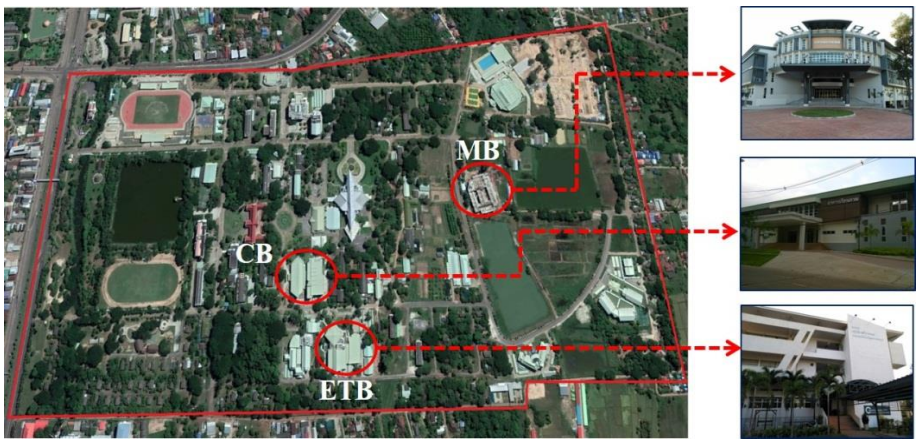

Fig. 1 Research site

Figure 2 shows layout of the solar PV rooftop system. The solar PV rooftop system consists of the following components:

- Polycrystalline silicon PV 320 W_p (1,016 modules)
- Grid tied inverter 25 kW_{ac} (13 units)
- Monitoring system
- Cable wiring

Fig. 2 Layout of solar PV rooftop system

PVsyst Program

The PVsyst program is one of the energy modeling tools. It can show the useful results of solar PV system including the produced power and the occurred losses in the system (Mermoud, 2014 and Boughamrane, 2016). The location site, setting tilt and azimuth, PV module and inverter specifications are the required information for the program as shown in Fig. 3.

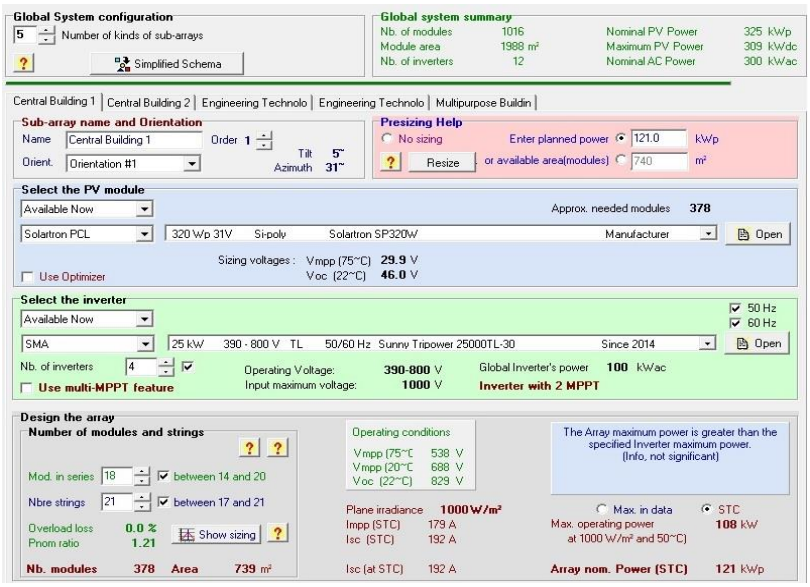

Fig. 3 PVsyst program

Technical Performance Assessment

The parameters for performance analysis of solar PV rooftop system followed by IEC 61724 are shown in Table 1 (Kumar, 2017 and Gurupira, 2017). The following nine parameters are used to analyze the performance of the system: the reference yield (Y_r), the array yield (Y_a), the final yield (Y_f), the array capture losses (L_C), the system losses (L_S), the performance ratio (PR), the array efficiency (η_a), the system efficiency (η_{sys}) and the capacity utilization factor (CUF) (Kumar, 2017 and Yadav, 2018).

Table 1 Equation for technical performance assessment

Parameter	Equation	Unit
Y_r	H_t/G_o	kWh/kWp/day
Y_a	E_{DC}/P_o	kWh/kW_p/day
Y_f	E_{AC}/P_o	kWh/kW_p/day
L_C	$Y_r - Y_a$	kWh/kW_p/day
L_S	$Y_a - Y_f$	kWh/kW_p/day
PR	Y_f / Y_r	-
η_a	$E_{DC}/(A_a \cdot H_t) \times 100$	%
η_{sys}	$E_{AC}/(A_a \cdot H_t) \times 100$	%
CUF	$E_{AC}/(P_o \cdot 24 \cdot 365) \times 100$	%

H_t = Total irradiance at the standard test condition (kWh/m^2/day)
G_o = Global irradiance at the standard test condition (kWh/m^2/day)
E_{DC} = DC energy of the PV system (kWh)
E_{AC} = AC energy of the PV system (kWh)
P_o = Nominal power of the PV array at the standard test condition (kW_p)
A_a = Array area (m^2)

Project Design and Simulation

Table 2 shows the description of PV system installation in three buildings: CB, ETB and MB. The Central Building has the maximum roof areas for PV installation, followed by the Multipurpose Building and the Engineering Technology Building.

Table 2 Description of PV rooftop system

Description	CB	ETB	MB
Location	17.18° N, 104.08° E	17.18° N, 104.08° E	17.18° N, 104.08° E
Structure building	Metal sheet	Metal sheet	Metal sheet
Roof area	1,643.35 m^2	924.42 m^2	1,323.60 m^2
Tilt/Azimuth	5°/31°	10°/31°	5°/16°
PV modules (320W_p)	454 modules	220 modules	342 modules
PV modules area	888 m^2	430 m^2	669 m^2
No. of PV modules (set 1)	series=18modules parallel=21 strings	series =18 modules parallel=8 strings	series =18 modules parallel=19 strings
No. of PV modules (set 2)	series =19 modules parallel=4 strings	series =19 modules parallel=4 strings	
Grid-tied inverter (25 kW)	6 unit	3 unit	4 unit
Total PV power	145.28 kW_p	70.40 kW_p	109.44 kW_p

RESULTS AND DISCUSSION

Table 3 depicts the monthly average energy injected into grid, global incident, greenhouse gas emissions and performance ratio. Among three buildings, the Engineering Technology Building has slightly high performance ratio than other buildings as 0.743 because of its tilts and azimuths of solar panels that affect the irradiation.

Table 3 Monthly average energy inject to grid

Month	CB				ETB				MB			
	E-grid (MWh)	Global (kWh/m^2)	CO_2 (tco_2)	PR	E-grid (MWh)	Global (kWh/m^2)	CO_2 (tco_2)	PR	E-grid (MWh)	Global (kWh/m^2)	CO_2 (tco_2)	PR
Jan	17.94	163.5	10.44	0.755	9.114	171.3	5.31	0.756	13.62	164.7	7.93	0.756
Feb	16.00	147.0	9.31	0.749	7.992	151.4	4.65	0.750	12.10	147.6	7.04	0.749
Mar	18.22	170.1	10.61	0.737	8.967	172.6	5.22	0.738	13.75	170.3	8.00	0.737
Apr	17.79	167.3	10.36	0.732	8.591	166.6	5.00	0.732	13.42	167.5	7.81	0.732
May	17.72	166.9	10.31	0.731	8.435	163.9	4.91	0.731	13.35	166.9	7.77	0.731
Jun	16.82	156.5	9.79	0.740	7.996	153.4	4.65	0.740	12.65	156.3	7.36	0.740
Jul	16.26	151.8	9.46	0.737	7.745	149.1	4.51	0.738	12.25	151.7	7.13	0.738
Aug	15.43	143.5	8.98	0.740	7.413	142.1	4.32	0.741	11.63	143.6	6.77	0.740
Sep	14.30	132.8	8.32	0.741	6.968	133.4	4.06	0.742	10.80	133.1	6.29	0.742
Oct	17.04	158.4	9.92	0.740	8.440	161.8	4.91	0.741	12.88	158.9	7.50	0.741
Nov	16.35	150.4	9.52	0.748	8.263	156.7	4.81	0.749	12.38	151.1	7.21	0.748
Dec	17.44	159.1	10.15	0.754	8.926	167.8	5.20	0.756	13.24	160.3	7.71	0.755
Year	**201.30**	**1867.4**	**117.18**	**0.742**	**98.848**	**1890.2**	**57.54**	**0.743**	**152.07**	**1872.0**	**88.52**	**0.742**

Table 4 shows the results of overall system, it depicts monthly average energy injected into grid, global incident, greenhouse gas emissions, performance ratio, energy saving analysis and economics. The solar PV rooftop can reduce power consumption by 452.92 MWh/year.

Figure 4 shows the normalized PV production, i.e. the collection losses (L_C) is 1.23 kWh/kW_p/day, the system losses (L_S) is 0.09 kWh/kW_p/day and the produced useful energy (Y_f) is 3.82 kWh/kW_p/day. Figure 5 presents the performance ratio of the overall system for each month. The highest performance ratio is 0.76 in January and December. The lowest performance ratio is 0.73 in May. The performance ratio is slightly different in each month with the average performance ratio of the system is 0.74.

Table 4 Results analysis of the 325 kW solar PV rooftop system

Month	Solar PV rooftop 325 kW				Energy demand		Energy conservation		Economic (Bath)
	E-grid (MWh)	Global (kWh/m^2)	CO_2 (tco_2)	PR	06.00 – 18.00 (MWh)	24 hr (MWh)	Save 06.00 – 18.00 (%)	Save 24 hr (%)	
Jan	40.73	165.6	23.71	0.75	241.07	437.08	16.90	9.32	178,804.70
Feb	36.15	148.1	21.04	0.75	210.79	329.45	17.15	10.97	158,698.50
Mar	41.00	170.7	23.87	0.74	323.89	463.39	12.66	8.85	179,990.00
Apr	39.87	167.2	23.21	0.73	295.75	427.83	13.48	9.32	175,029.30
May	39.56	166.2	23.03	0.73	289.59	418.68	13.66	9.45	173,668.40
Jun	37.52	155.8	21.84	0.74	274.01	397.10	13.69	9.45	164,712.80
Jul	36.31	151.2	21.14	0.74	326.00	459.04	11.14	7.91	159,400.90
Aug	34.53	143.2	20.10	0.74	361.17	475.79	9.56	7.26	151,586.70
Sep	32.12	133.0	18.70	0.74	379.70	540.59	8.46	5.94	141,006.80
Oct	38.42	159.3	22.36	0.74	308.30	451.72	12.46	8.51	168,663.80
Nov	37.05	152.0	21.57	0.75	229.92	352.73	16.11	10.50	162,649.50
Dec	39.67	161.4	23.09	0.75	180.25	298.53	22.01	13.29	174,151.30
Year	452.92	1873.9	263.65	0.74	3,420.44	5,051.92	13.24	8.96	1,988,362.70

**** Emission factor = 0.58, Average electricity cost of SNRU = 4.39 Bath/kWh*

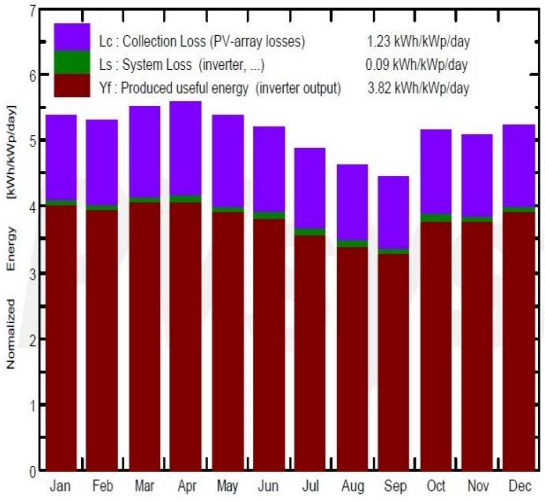

Fig. 4 Normalized PV production

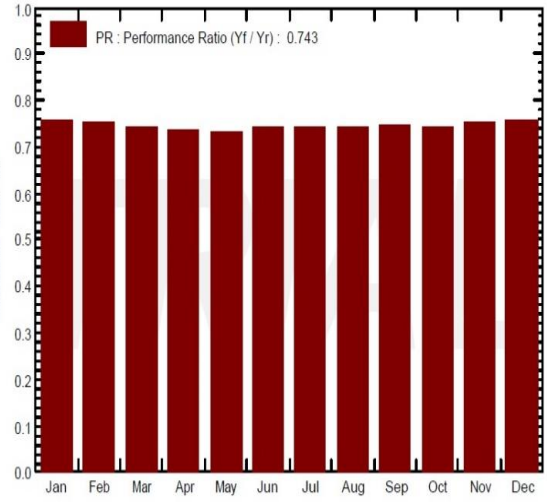

Fig. 5 Performance ratio

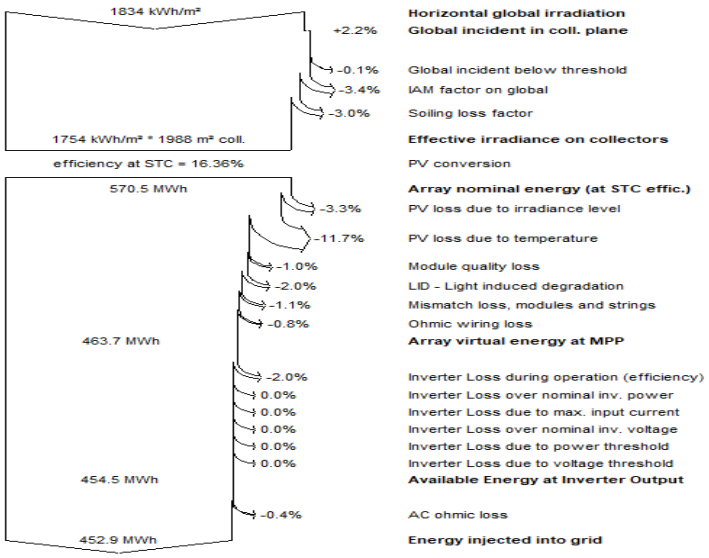

Fig. 6 Loss diagram

Figure 6 presents the loss diagram of the system. The array nominal energy at standard test condition (STC) is 570.5 MWh, the array virtual energy at maximum power point (MPP) is 463.7 MWh. The available energy at the inverter output after the inverter loss was extracted would be the energy injected into the grid is 452.9 MWh. The produced electricity from the solar rooftop system decreases during May to September due to the rainy season in Thailand.

CONCLUSION

The solar PV rooftop system is designed using PVsyst program as a tool. The system is planned to be installed on the roofs of three buildings: the Central Building, the Engineering Technology Building and the Multipurpose Building at the academic institute which located in the northeastern part of Thailand. The Central Building can generated maximum power electricity of 201.30 MWh/year or 44.44% of the total system. The electricity produced during the sun rises (06.00-18.00). The solar PV rooftop system can reduce the peak demand of electricity as 452.92 MWh/year or 13.24%/year during daytime (06.00-18.00). The generated electricity from solar PV energy can reduce the use of electricity by 8.96%/year. The system can save electricity cost throughout the year as 1.98 million baht/year and the reduction of greenhouse gas emissions is equaled to 263.65 t_{CO2}/year.

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Research article

Erosion Control and Slope Stabilization for Loose Sandy Soil by Using Vetiver Grass

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Abstract The root of vetiver grass has been proven to be effective to decrease erosion and increase slope stability for soil slope. The important role of vetiver grass roots in preventing water erosion and mass movement has been well recognized. However, quantitative researches that present the contribution of vetiver grass to erosion control and slope stability are limited, especially in the field study. This article presents the use of vetiver grass to slope erosion control and the role of vetiver root strength on slope stabilization for loose sandy soil slope which is located at north eastern part of Thailand. The erosion was measured in the field and then compared with the prediction from the Universal Soil Loss Equation (USLE) proposed by the USDA Agricultural Research Service. The soil layer and properties were investigated by borehole drilling and Kunzelstab penetration test, which shown the slope was built with loose sandy soil. The root tensile strength of vetivers was tested in the laboratory by using direct tension test. As the diameter of root increase, the shear strength of roots decreases as a function of exponential. The slope stability of slope stabilized with vetiver and without vetiver was analyzed using Infinite slope method. Slope with vetiver has significantly higher factor of safety when compared to slope in bare soil.

Keywords slope stability, erosion control, vetiver, root stabilization

INTRODUCTION

Vegetation is usually used as an effectively protective layer for erosion control and slope stability reinforcement throughout both hydrological process and improving mechanical soil properties. The vegetation affects hydrological balance directly through evapotranspiration, water inception, infiltration, and surface crushing (Morgan and Rickson, 1995). Typically, vegetation roots can anchor the soft layer soil mass into stronger layer and cross zones of weakness to more stable soil. Roots system in the soil mass also provide tensile strength which contribute to improve the shear load resistance of soil.

Vetiver grass (*Chrysopogon zizanioides*) has been widely used in many tropical countries for erosion control and slope stabilization (Hengchaovanich, 1998). As vetiver grass is planted parallel to the slope contour with dense fine vertical deep root (3-4 m), it is effective for nailing soil mass within slope and reducing soil erosion from runoff. In addition, vetiver grass has high tensile strength of roots and high root distribution (Root Area Ratio), which contributes root reinforcement and increase slope stability. Other benefit of using vetiver grass in slope are there is its low-cost, tolerance, and self-repairing ability. As a result, it is popularly used for slope protection in tropical area for both natural slope or man-made slope.

OBJECTIVE

The studies described the engineering of combination root system and result from the field. In this study, the effect of root diameter on the tensile strength of roots was established.

METHODOLOGY

Erosion Control and Slope Stabilization with Soil-Bioengineering

1. Erosion Prediction using Universal Soil Loss Equation (USLE)

The Universal Soil Loss Equation (USLE) is a semiempirical equation developed by the USDA Agricultural Service in the early 1960s. The USE equation is formally used for predicting the erosion losses is crop land or agricultural activity, and then the equation was developed for construction activity such as slope highway, natural slope, and construction site. based on statistical results measured from the field. The USLE considers factors which cover climate, soil, topography, and vegetation cover (Gray and Sotir, 1996). The soil loss from a site is predicted according to the relationship:

$$A = R.K.LS.C.P \quad (1)$$

where A = is predicted soil loss (ton/ km^2 /year), R = is rainfall factor, K = is soil erodibility value, LS = is slope length factor, C = is vegetation factor, and P = is erosion control in practice factor.

The detail procedure and USLE parameter estimation can be seen in many researches e.g. Gray and Leiser (1982), Goldman and Bursztynsk (1986). However, on this paper the USLE Parameters will be applied according to Apiniti (2557).

As this paper focus mainly in the soil parameters, so the effect of soil type on measured erosion will be discuss extensively. The soil type is play important role on erodibility. The factors including gradation, plasticity indices, soil structure, and void ration can affect the soil erodibility value. A recommended hierarchy based on the Unified Soil classification system is presented as:

Most Erodible $\longrightarrow$ Least Erodible

ML > SM > SC > MH > OL >> CL > CH > GM > SW > GP > GW

when GW = is well graded gravel, GP = is poorly grade gravel, GM = is silty gravel, SW = is well graded sand, SC = is clayey sand, ML = is low plasticity silt, MH = is high plasticity silt, CL = is low plasticity clay, CH = is high plasticity clay, OL = is low plasticity organic soil.

2. Slope Stability with Vetiver Stabilization

The effect of vegetation on slope stability can be described as mechanical effects. Normally, soil has high compression but rather low tension. The roots of vetiver are strong tension with weak compression. Therefore, a combination of soil and vetiver roots can provide strength for the composite material (Thorne, 1990, Jotisankasa et al. 2015). Typically, the contribution of the Vetiver root on shear strength of soil can be described in term of soil cohesion due to root reinforcement, c_r . Many researchers proposed the equation to estimate the root cohesion. However, the root cohesion proposed by Wu et al. (1979) which describes the cohesion which considers the root tensile strength, area density and root distortion angle as:

$$c_r = T_r \left(\frac{A_r}{A}\right)(sin\theta + cos\theta tan\emptyset) \quad (2)$$

where c_r = is roots cohesion (kPa), T_r = is root tensile strength (kPa), Ar/A = is root-area ratio surface (consider at shear surface, θ is angle of distortion(degrees), and Ø is friction angle of soil (degrees).

Normally, slope or embankment in semi-tropical or tropical area may experience the unsaturated equation. The shear strength of soil which combined the effect of unsaturated soil and root reinforcement can be express as (3)

$$\tau = c_r + c' + \sigma_n tan\emptyset' - u_w tan\emptyset'' \quad (3)$$

where c' = effective cohesion, σ_n = normal stress, $\emptyset'$ = effective angle, u_w = pore water pressure, $\emptyset''$ = friction angle due to pore water pressure or matric suction which equal $\emptyset'$ when soil is saturated (u_w = 0).

The root cohesion and pore water pressure can be taken accounted in the slope stability equation for infinite slope proposed by Fredland and Raharjo (1993), which can be expressed as:

$$F = \frac{c_r + c' + (\gamma z cos^2\beta) tan\emptyset' - u_w tan\emptyset''}{\gamma z sin\beta cos\beta} \quad (4)$$

where F = factor of safety, β = slope angle, z = depth of failure plane, γ = soil unit weight. The mainly impacted of Vetiver root on factor of safety are to reinforce the soil mass and to reduce the pore water pressure u_w. The water table tend to decrease due to evaporation. If the pore water pressure decreases to negative, the tension in water will be generate. Then, shearing strength of soil will be increase significantly.

3. Site Investigation and Geotechnical Properties

To evaluate effect of Vetiver on erosion control and slope stability, the detention basin located in Kalasin Province the north eastern part of Thailand was be chosen as a study site. The detention basin is a large excavation project with total area 395 acres, and more than 10 km long for the boundary. The aerial photo of the detention basin was depicted as shown in the Fig. 1. The main objective of the project is to store the water from the flooding season and to store the water for the crops nearby the detention basin during the planting season 6.8 million cubic meter (At normal storage +132 Mean-sea average). A cross section for slope excavation is presented in Fig. 2. The total height of the slope is 8 m with slope 2:1 (horizontal: vertical, 26.6^o). The berm at 3 m was design for spawning fish, and counter weigh the toe slope.

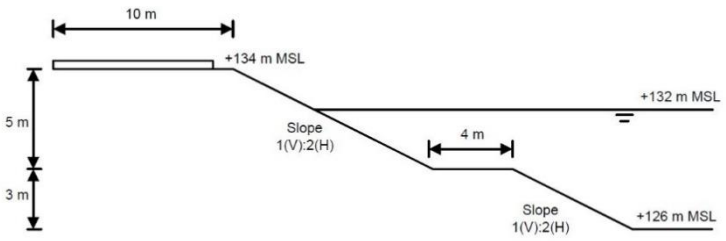

Fig. 1 Aerial photo of detention basin boundary **Fig. 2 Cross section for slope excavation**

3.1 Soil Profile and Geotechical Properties along the Detention Basin

The soil profile and geotechnical properties of soil was investigated by the borehole drilling with wash boring machine. The five boreholes including BH-1, BH-2 BH-3, BH-4, and BH-5 were drill along the slope of the detention basin and soil sample were collected for laboratory testing. The cross section of the soil profile is shown in Fig. 3. It is found that at the depth 0 m to10 m the soil layer for this area is non-uniform comprising with various fine soils such as low plasticity clay (CL), Low Plasticity Silt (ML), Low plasticity silt and low plasticity clay (CL). This maybe this area is located at the flooding plane. A highly weathered siltstone or mudstone which is a parent rock was found after 10 m at the BH-1 and BH-5. After 18 m, the dense to very dense sand (SM) was mostly found lay uniformly with depth. The relationship of standard penetration test (SPT) with depth for all boreholes were shown in the picture. At near surface (<5 m) the SPT is lower than 10, indicating of weak soil layer. The soil data from the borehole drilling will be used for slope stability analysis.

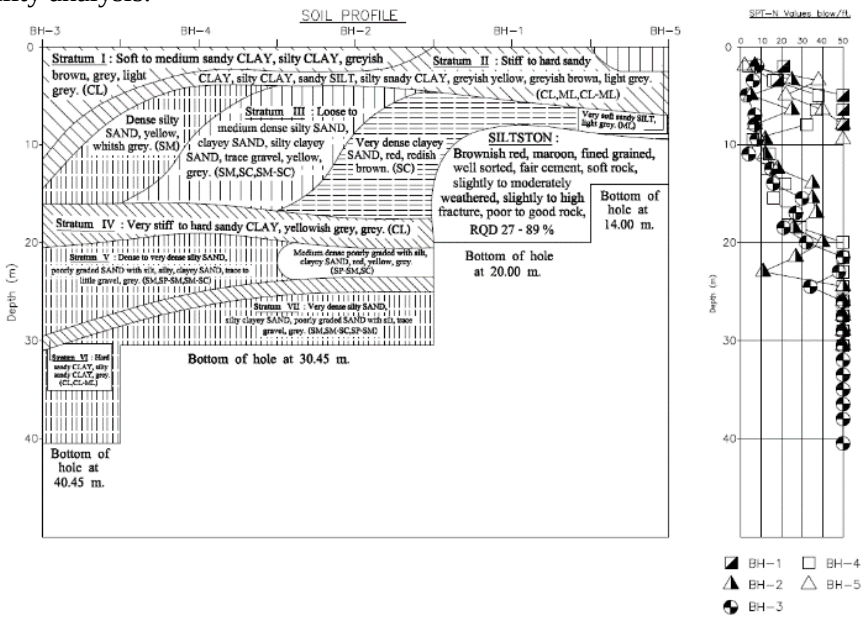

Fig. 3 Soil profile and the standard penetration value (SPT) from borehole BH-1, BH-2, BH-3 and BH-4

3.2 Soil Investigation and Sampling and at Near Surface along the Detention Basin

Since one of the objectives is to characterize the erosion of soil slope, the 15 soil samples which is used as representatives of soil along the detention basin were collected and test in the laboratory.

Fig. 4 Boundary of the detention basin and location for soil sampling

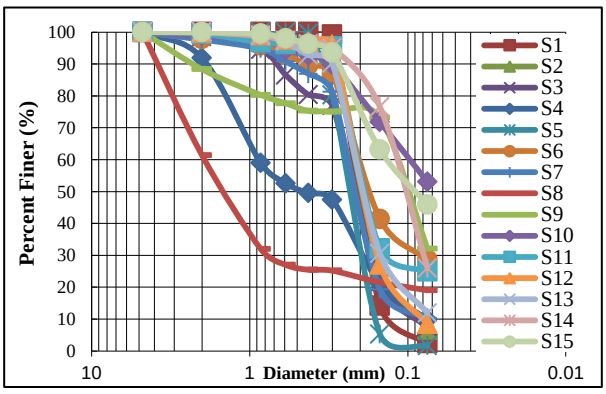

Fig. 5 Grain size distribution of tested specimens

Figure 4 presents the boundary of detention basin and location for soil sampling. The tests included grain size distribution, percent of and, percent of fines particle, plasticity indices, coefficient of uniformity (C_u), and coefficient of concavity (C_c) were determined for classifying soil type according to the Unified Soil Classification System (USCS). Fig. 5 present grain size distribution of all test samples. It is found that most samples comprising sand (particle between 0.075 mm to 4.75 mm) and tend to have uniform grade with size particles between 1mm to 3 mm. The percent of fines varies between 2.4% to 53.0%. For Atterbergs' limits, ten of fifteen samples are non-plasticity soil, and five samples present a low plasticity soil. Classified by soil the USCS most of soil are SP-SM while the rest are SM, SC, SP, and ML, respectively.

3.3 Soil Strength Investigation using Kunzelstab Penetration Test (KPT)

The Kunzelstab Penetration Test (KPT) is one of the in-situ strength test which popularly used because the test device is light weight, rapid to test, and economical to test when compare to other field test such as wash boring drilling or rotary drilling (Künzel, 1936; Krasaeteep and Thongchart, 2012). The Kunzelstab device comprises guild rod with diameter 25 mm, sounding rod with diameter 20 mm, hammer, anvil, base plate, penetration control, and cone with varying apex angle (60^o, 90^o, and 180^o) (Kererat, 2016). During the test, the 10 kgs hammer will be raised for 50 cm in height, and then drop freely, which equivalent 49 J (kg m^2 s^{-2})/blow. The test will continue until the advance distance of rod reach 20 cm. Then number of blows will be recorded (blows/20 cm). After that, the bow count will be converse to strength parameter such as cohesion or friction angle. Relationship between standard penetration test (SPT), Kunzelstab test (KPT), friction angle (Ø), and relative density for sand is shown in Table 1.

Table 1 Relationship between standard penetration test (SPT), Kunzelstab test (KPT), friction angle (Ø), and relative density for sand (EGAT 1980)

SPT (blows/30 cm)	KPT (blows/20 cm)	Ø (degree)	Relative density
0 – 4	0 – 6	25 – 30	very loose
4 – 10	6 – 18	27 – 32	loose
10 – 30	18 – 55	30 – 35	medium
30 – 50	55 – 92	35 – 40	dense
>50	> 92	38 - 45	very dense

RESULTS AND DISCUSSION

Erosion Prediction and Measurement

After the end of construction when the monsoon season pass, hundreds of erosions due to runoff water were observed along the slope. Many types of erosion including sheet erosion, rill erosion, gully erosion, until slope failure were observed along the slope of the project. The degree of severity for observed erosions can be ranked into four categories from level I low erosion, level II medium erosion, level III severe erosion, and level IV extremely severe erosion. The erosion level I represent non-erosion to rill erosion deep less than 5 cm. The level II erosion is rill erosion deep from 5cm to 10 cm. The level III erosion is the deep rill or gully deep more than 10 cm. The level IV erosion represents severe gully erosion with high volume soil mass. Fig. 6 presents erosion for each level observed from the detention basin project. As the slope is 10 km long with varying types of soil, the three zones were classified according by the soil type into zone A, zone B, and zone C as shown in Fig. 4. For Zone A, the typically soil is reddish silty sand which is highly decomposed from the weathered mudstone, a parent rock which lay underneath in this area. Zone B is the uniform loose sand (SM), and zone C is mainly low plasticity clay with sand (SC).

In this study, the erosion parameters required for the USLE were summarized based on Jotisankasa (2014). The Rainfall factor (R) was received from the rainfall station No 1110 Huasithon

reservoir Kasasin Province (about 40 kms from the project). The soil erodibility (K) is depending on the soil types. As the slope geometry is similar along the slope distance (10 m in length and 26.6^{o} for slope angle), the slope length factor (LS) is the same value for zone A, Zone B, and Zone C. Vegetation factor (C) is equal 1.0 for uncovered soil, and equal 0.1 for slope covering with Vetiver. Erosion control in practice factor (P). As a result, the soil loss predicted from the USLE was 2,517.3 ton/hectare, 2,591.2 ton/hectare, and 1,258.7 ton/ hectare. The detail of parameters is shown in Table 2.

a) level I: low erosion

b) level II: medium erosion

c) level III: severe erosion

d) level IV: extremely severe erosion

Fig 6. Erosion level observed from the detention basin project

a) level I low erosion (erosion deep less than 5 cm) , b) level II medium erosion, c) level III severe erosion (rill to gully erosion deep more than 10 cm, and d) level IV extremely severe erosion deep gully

Table 2 Summary erosion parameters for soil loss prediction in case of without vetiver convers

Erosion Factor	Zone A	Zone B	Zone C
Rainfall Factor (R, mm/yr)	583.53	583.53	583.53
Soil erodibility value (K)	0.34	0.35	0.17
Slope Length Factor (LS,m)	9.76	9.76	9.76
Vegetation Factor (C)	1.0	1.0	1.0
Erosion control in practice factor (P)	1.3	1.3	1.3
Soil Loss (tons/hectare/year)	2,517.3	2591.2	1,258.7

Slope Stability Analysis with Rotation Failure

For deep slope failure, the slope stability for studied point were analyzed based on rotation method using Simplified Janbu (1973), Simplified Bishop (1955), and Spencer (1973) Method. The shear strength parameters used for analysis were obtained from Kunzelstab test. The possible worse scenario which water table at -1 m from the surface while the water level in the detention basin was

set at 131 m mean-sea level. The KU Slope, a software developed by Kasetsart University, was used to calculate the factor of safety. The example of slope stability analysis at KPT-3 and compared to the slope failure which happen in the field the factor of safety for KPT-1, KPT-2, KPT-3, and KPT-4 calculated using various method were shown in Table 3. It is shown that the factor of safety ranges between 0.64 to1.60. The three analysis methods provide almost similar factor of safety. Typically, for permanent slope the Factor of safety should lower than 1.5, thus the four slopes at selected location have high risk to fail. The results from the analysis corresponds well with result in the field because after the end of rainy season all four selected locations failed with high soil mass movement.

Table 3 Factor of Safety calculated from Simplified Janbu, Simpliflied Bishop, and Spencer Method

Location	Factor of Safety		
	Simplified Janbu	Simplified Bishop	Spencer
KPT-1	1.23	1.24	1.25
KPT-2	0.64	0.69	0.72
KPT-3	1.56	1.53	1.60
KPT-4	0.81	0.88	0.94

Factor of Safety for Infinite Slope Reinforced with Vetiver Grass Root

In order to evaluate the effect of Vetiver grass root on infinite slope stability using equation (4), A scenario of soil slope and properties were set. In this analysis the root cohesion was calculated based on equation (2). The tensile strength is predicted from the pullout test with equation (5) when the root diameter equal was fixed at 1 mm. The unit weigh of soil is 1.8 t/m^2. The failure plane assumed to occur at 2 m. The pore water pressure (U_w) was assumed to be zero. Table 4 presents the factor of safety at varying percent of root area (A_r/A) which is calculated from equation (4). The factor of safety of bare soil (A_r/A = 0%) were 1.04, 1.02, 1.74, and 1.06 for Slope at KPT-1, KPT-2, KPT-3, and KPT-4, respectively, indicating high risk to fail (Factor of Safety <1.5). The factor of safety significantly increases with percent of root area ratio. With root area 0.2%, the factor of safety can increase more than 5 times due to root reinforcement. This result shows strong impact of Vetiver root on infinite slope, and it implies that slope will not fail in case of infinite slope if there is a Vetiver grass root ratio more than 0.2%.

Table 4 The factor of safety of infinite slope with varying percent root area (A_r/A)

Location	Factor of Safety at varying percent of root area (A_r/A)			
	0%	0.2%	0.4%	0.6%
KPT-1	1.04	5.20	9.36	13.51
KPT-2	1.02	5.18	9.33	13.49
KPT-3	1.74	5.90	10.05	14.21
KPT-4	1.06	5.21	9.37	13.53

CONCLUSION

This paper presents the ability of Vetiver grass for reducing erosions and stabilizing the soil slope with sandy soil. The detention basin project located at Kalasin Province, Thailand were selected because the project had plant Vetiver grass along the slope to relieve the erosions and slope failures in the project. The Vetiver roots were prepared and tested to obtain the tensile strength. It was found that the slope covering with Vetiver grass can reduce soil loss from erosion ten times than slope without Vetiver grass when computed with the Universal Soil Loss Equation (USLE).

The Kuzelstab is an effective tool for finding the strength parameters. The Factor of safety calculate from Simplified Janbu, Simplified Bishop, and Spencer were not significantly different. For pullout test, the vetiver roots provide high tensile strength ranging between 10 MPa to 50 Mpa. The tensile strength of Vetiver reduces with diameter as an exponential function. The Vetiver roots significantly contributes the soil slope stability for infinite slope. With roots area ratio 0.2% the factor of safety will increase five times.

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Research article

Comparative Study on 3 Rice Farming Systems: Conventional, Partially Organic, and Organic Farming, Case Study in Prey Kabbas District, Takeo, Cambodia

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Abstract Sustainable agriculture is an integrated farming system of plant and animal production practices with site-specific applications that can maintain over the long term. It is both environmentally sustainable and also can generate several impacts on rural society. Unfortunately, the development of sustainable farming in Cambodia is still limited, and in its early stages. Despite sustainably farming has the potential for targeting niche markets and ensure higher incomes, it is reported that the number of farmers choose to do or revert to produce conventional rice farming instead. The application of chemicals in conventional agriculture can generate high productivity; however, the intensive use of the chemical has led to the destruction of soil and water resources. By observing these matters, this study aims to examine the differences in characteristics and profitability between 3 farming systems: conventional, partially organic, and organic rice farming, and to identify impacts from sustainable farming to rice farmers. The present study is based on the survey conducted in Prey Kabbas District, Takeo province, in 2018. In this study, a random sampling method was applied, and 75 rice farmers were interviewed. Among the samples, 30 farmers practiced conventional rice farming, and others 45 farmers practiced sustainable rice farming (25 adopted partially organic, and 20 farmers adopted organic rice farming). The findings showed that despite the production costs of organic rice farming is higher, organic farmers still ensure higher yield and generate better profit. Both of sustainable rice farming systems also found to benefit farmers with both social and human impacts. Nevertheless, there are some constraints inhered these rice farming in this study area, such as labor shortage, lack of organic materials, and market instability. There are needs for farmers, supported institutes, consumers to work together to promote organic rice farming in the study area.

Keywords conventional rice, organic rice, partially organic rice, profitability, Cambodia

INTRODUCTION

Food is crucial to human life. The rapid growth of populations, which in turn entails increased demand for food, has led to changes in agricultural systems. With respect to Cambodian agriculture, more Cambodian farmers are in the midst of transition from traditional subsistent to modern commercial ones (Slayton et al., 2015). Modern agriculture systems have been practiced in many countries, including Cambodia, with the aim of poverty alleviation, food security, and increasing competitiveness. Although conventional agriculture has many large-scale positive effects, such as high yields in crops and increases food supply through the adoption of new technologies. The intensive use of chemical and mechanization has led to the destruction of the soil and water resources. It has damaged the critical supporting ecosystems (OECD, 2001).

Cambodia is one of the countries in Southeast Asia that is profoundly affected by the impacts of climate change, from the enormous floods in 2011 to the prolonged droughts in 2016. Cambodian farmers have been increasingly exposed to the adverse effects of climate-related risks, both in terms of crop growth and pest and disease outbreak. It is recommended by Slayton et al. (2015) to strengthen sustainable agriculture for future agriculture growth in Cambodia. However, there is still much work that needs to be done in promoting sustainable agricultural practices to Cambodian farmers. Improper and excessive use of fertilizer is still one of the major agricultural issues in the country. Farmers apply pesticides that are often not safe or counterfeit. Aside from being an unnecessary expense, this also results in an opposite outcome, which is the reinforcement of pest outbreaks by increasing pest resistance.

OBJECTIVES

The objective of this study is to grasp the differences in characteristics and economic performances of 3 farming systems in the study area: conventional, partially organic, and organic farming, and to identify the impacts of sustainable agriculture toward farmers in Prey Kabbas District, Takeo, Cambodia.

METHODOLOGY

The study was conducted in Prey Kabbas District, Takeo province. This province classified as one of the most significant rice-producing areas in Cambodia. Eighty-three percent of the population is engaged in this sector. However, this research site is regarded as low diversification in farming systems, and it is easy to prone to a natural disaster such as drought and flood every year. With such a poor farming condition, farmers in the research site have gradually shifted toward sustainable farming with the help from the government and Non-Profit Organization (Prey Kabbas district report, 2014).

This study is based mostly on primary data collected through direct interviewing with rice farmers in the district. Interviewed farmers were selected by random sampling method. The survey was conducted from August to September 2018 (20 days). Totally 75 rice farmers were interviewed and categorized into three groups: group A (conventional farmers- 30 respondents) and a group of farmers who practiced sustainably adopted rice farming: group B (partially organic farmers- 25 respondents) and group C (organic farmers- 20 respondents). The partially organic farmers refer to a group of farmers who used at least 50 percent of organic material in rice farming, and organic farmers refer to a group of farmers who applied only organic material in rice farming.

RESULTS AND DISCUSSION

Socio-Economic Characteristics of Studied Farmers

Table 1 Socio-economic characteristics of sustainable and conventional rice farmers

	Conventional (a)	Sustainable farming		T-test (t stat)		
		Partially Organic (b)	Organic (c)	(a) & (b)	(a) & (c)	(b) & (c)
Number of household (HH)	30	25	20			
Average of male head of HH	25(81.48%)	24 (96%)	20 (100%)			
Average family size (person)	4	4	4	-0.8	-1.4	-0.73
Average age (years old)	53.93	46.20	49.50	1.99*	1.07	-0.89
Year of education (years)	6.33	7.32	8.17	-1.08	-1.73	-0.85
Average owned land per HH (ha)	0.80	0.38	0.64	-1.46	-1.14	0.24
Average planted area per HH (ha)	1.02	0.87	0.64	0.37	1.03	1.10

Source: Field survey in 2018
**Indicates statistical significance at 0.05 level*

The basic features of interviewed farmers are presented in Table 1. Table 1 showed that farmers of groups B and C had more extended education compare to farmers in group A, although it is not significantly different. This indicated that education encourages farmers to adopt a new farming system while considering the environment and agricultural production in the long term. However, concerning family size and owned and planted areas, there was no significant difference among these 3 group farmers.

Total Production Cost of Rice Farming

Table 2 Total production cost of three farming systems

Item	Conventional (a)	Sustainable farming		T-test (t stat)		
		Partially organic (b)	Organic (c)	(a) and (b)	(a) and (c)	(b) and (c)
Number of HH (HH)	***30***	***25***	***20***			
Paid purchased seed	8.88	13.35	3.25	-0.65	1.16	1.57
Imputed cost of keeping seed	79.66	60.61	14.35	1.61	6.15 *	5.55 *
Chemical fertilizer	66.63	42.97	0.00	3.66 *	15.17 *	9.06 *
Paid organic fertilizer	0.00	3.72	119.99	-2.14 *	-6.68 *	-6.42 *
Imputed cost of organic fertilizer	0.00	20.20	23.89	-6.98 *	-3.65 *	-0.52
Insecticide	15.62	22.22	0.00	-1.08	4.92 *	4.32 *
Herbicide	20.78	22.42	0.00	-0.46	9.49 *	7.99 *
Fuel	13.71	20.17	30.72	-1.39	-3.97 *	-1.94 *
Water charge	3.13	5.00	0.00	-0.45	1.36	1.44
Material cost	***208.41***	***210.66***	***192.30***	***-0.17***	***0.89***	***0.99***
Paid land preparation service	65.19	47.30	30.40	2.58 *	3.64 *	1.74
Imputed cost of land preparation	28.70	32.00	18.06	-0.67	1.74	2.25 *
Paid harvesting service	***107.41***	93.00	40.97	2.36 *	5.68 *	4.23 *
Imputed cost of harvesting	0.00	0.00	0.00	-	-	-
Total service cost	***201.30***	***172.30***	***89.43***	***2.63*** *	***5.90*** *	***-4.08*** *
Hired labor	*23.85*	32.35	117.72	-1.43	-5.48 *	-4.90 *
Family labor	106.43	96.50	276.79	1.05	-6.45 *	-7.10 *
Total labor cost	***130.28***	***128.85***	***394.51***	***0.12***	***-8.37*** *	***-8.55*** *
Rented land	2.67	5.80	0.00	-0.65	1.00	1.44
Total variable cost	**325.20**	**302.50**	**343.05**	**1.30**	**-0.65**	**-1.37**
Total cost	***542.66***	**517.61**	***676.14***	**1.33**	**-3.92** *	**-4.56** *

Source: Field survey in 2018 *Unit: USD/ha*
**Indicates statistical significance at 0.05 level*

It found that in the study areas, there were three different types of rice farming existed and that the systems differed much in the input use among them. Thus, in the analysis of costs and returns of rice farming, diversified aspects among three farming systems should be full took into account.

Concerning the cost analysis, this study followed the method of Slayton et al. (2015). The study calculated the cost not only of cash payment, but also imputed costs such as cost of organic fertilizer, family labor costs, cost of owned land, and depreciation of farm assets. To check the significance of differences in cost items between farming systems, T-test with two-sampled assuming unequaled variances is applied in this study as well.

As shown in Table 2, the total production cost of organic farming per ha was higher than conventional and partially organic farming in the study area. Cost comprised both cash and non-cash costs, based on the result of the survey; cash costs were the ones that directly affected the farmers' financial conditions. High cash costs could disrupt farm production activities and put farmers in debt. Although the overall total costs of organic rice were higher, it is also clearly shown that organic rice farming initially entailed similar cash costs to the conventional and partially organic rice farming in the study area.

Economic Returns of Rice Farming

Regarding economic returns, several indicators, such as gross margin, total cash income, and net profit of each rice farming type, are examined in this study. Gross margin obtained by deducting gross revenue, intermediate inputs, and hired labor. Total cash income calculated by subtracting total cash expenses from gross revenue. Finally, net profit calculated by deducting costs of family

labor, costs of owned land, and depreciation cost from gross margin. In addition, T-test analysis with two-sampled assuming unequal variances was applied in this study as well.

Table 3 showed the comparison of cost and returns per hectare among conventional and sustainable rice farming in the study area. The production of organic rice was significantly more profitable than conventional rice farming in terms of gross margin and total cash income. However, when total net profit was analyzed, the result showed conventional, partially organic, and organic rice farming was not significantly different. This indicated that whatever model used that excluded non-cash cost, organic farming in the study area was the most profitable. It is understandable since organic farming in the study area obtained higher yield and premium price compare to conventional and partially organic rice. Although partially organic rice practiced in consideration of environment and health purposes, however, the average price of partially organic rice was not significantly different from conventional rice, which resulted in less profitable than organic rice farming.

As mentioned earlier, whenever non-cash expense considered in this study, organic rice was not significantly the most profitable one among groups. In general, most organic rice farmers used their on-farm resources to do organic farming; however, in this specific study area, farmers tended to purchase lots of animal manure from farmers from other villages. Higher organic fertilizer and family labor costs resulted in less total net profit in comparison to conventional and partially organic farming. This result also realized the reason behind the concerns of farmers to continue producing the organic products in the study area.

Table 3 Net profit of three farming systems

Item	Conventional (a)	Sustainable farming		T-test (t stat)		
		Partially organic (b)	Organic (c)	(a) and (b)	(a) and (c)	(b) and (c)
Number of HH (HH)	***30***	***25***	***20***			
Paddy yield (ton/ha)	3.27	3.37	3.57	-0.57	-1.26	-0.79
Paddy price per ton (USD)	287.96	289.50	329.17	-0.65	-3.20 *	-3.11 *
Paid Material Cost	128.75	129.85	153.96	-0.07	-1.40 *	-1.15
Total Material Cost	208.41	210.66	192.20	-0.17	0.89	0.99
Hired labor cost	23.85	32.35	117.72	-1.43	-5.48 *	-4.90 *
Family labor cost	106.43	96.50	276.79	1.05	-6.45 *	-7.10 *
Total labor cost	130.28	128.85	394.51	0.12	-8.37 *	-8.55 *
Total job commission	172.60	140.30	71.37	3.33 *	6.51 *	4.34 *
Cash land rent	2.67	5.79	0.00	-0.65	1.00	1.45
Owned land Rent	71.99	72.38	75.00	-	-	-
Depreciation	33.05	57.32	105.68	-1.06	-1.80	-1.10
Total cash expense	327.87	308.29	343.05	1.11	-0.56	-1.16
Total expenses	616.33	609.51	838.76	0.23	-3.91 *	-3.88 *
Gross revenue	**941.63**	**975.62**	**1175.14**	**-0.63**	**-3.02 ***	**-2.60 ***
Gross margin	**616.43**	**673.12**	**832.09**	**-0.95**	**-2.51 ***	**-1.81**
Total cash income	**613.76**	**667.33**	**832.09**	**-0.89**	**-2.54 ***	**-1.87**
Net profit	**402.29**	**441.13**	**374.62**	**-0.61**	**0.30**	**0.68**

Source: Field survey in 2018 *Unit: USD/ha*
**Indicates statistical significance at 0.05 level*

Impacts and Constraints of Sustainable Rice Farming

Understanding the considerable differences in costs and returns between conventional and sustainable rice farming in the study area, it is also necessary to examine the impacts and constraints from adopting these farming systems to farmers. The distribution of respondents' opinions and benefits they received is explained mainly in the descriptive analysis.

Social Impact

Farmer group participation: Based on the survey, it was seen that only 30 percent of conventional farmers were able to participate in farmer groups since most of them were seen to engage in some other off-farm works heavily. On the other hand, organic and partially organic farmers were instead more focus on on-farm work. They found to have some additional spare time to join and participate more enthusiastically in farmer group activities. Some of their hard works

were already recognized and able to generate profit, such as selling their own made livestock feeds, organic rice wine, seeds, and fertilizers to both inside and outside the village. Participation in farmer group activities is not only providing them financial benefits to farmers, but things such as labor sharing, farming information, idea sharing, updating marketing news, and possible sources of funds are provided while joining the group as well.

Relationship establishment: Two kinds of relationships were found: (i) direct relationship and (ii) indirect relationship. With respect to the direct relationship, the connection within the farmers' families is observed. From the survey, within conventional farmers, men mainly took care of most of all the farming work, while women took care of small activities such as seeding, weeding, and post-harvest tasks. Most children and women found to engage more in off-farm jobs. For farmers who practiced sustainable farming, on the other hand, spouses found to work mainly on farmland, and due to the additional labor required, children and wives also took a big part in farming activities as well. This suggesting that a closer family relationship of organic farmers is observed during their work, which also instills agricultural loyalty in the children.

The Indirect relationship between farmers who practice sustainable farming and consumer also existed. Farmers gather together once a month and share their monthly results, update marketing news from dealers, and sharing new sustainable farming knowledge and information. This type of relationship plays a crucial role in strengthening the promotion of organic agriculture in the study area, considering external factors, such as consumer demand, influence the development of agricultural systems.

Human Impact

Knowledge development on sustainable farming: Based on the survey, organic farmers obtained their knowledge of sustainable farming techniques and skills through joining agricultural cooperatives. Certain developments, however, have been adopted by organic farmers through a process of combing local culture and recent findings, to respond to the requirements of agricultural production and environmental conditions. Tables 4 and 5 showed the result estimation of multiple comparison tests between conventional and partially organic farmers regarding their awareness of sustainable farming knowledge. The result implied that partially organic farmers are significantly aware of organic farming and some local knowledge related to a safe way to use agrochemical products.

Table 4 Level of awareness of organic farming technique

Count of respondents			
	Conventional	Partially organic	Total
Aware	9	19	28
Unaware	21	6	27
Total	30	25	55
Chi square value		9.78*	

Source: Field survey, 2018 **Indicates statistical significance at 0.05 level*

Table 5 Level of awareness of safety use of agrochemical

Count of respondents			
	Conventional	Partially organic	Total
Aware	10	20	30
Unaware	20	5	25
Total	30	25	55
Chi square value		10.17*	

Source: Field survey, 2018 **Indicates statistical significance at 0.05 level*

Constraints on Organic Rice Farming

The constraints of organic farming in the study can classify into five categories: (i) lack of organic material, (ii) labor shortage, (iii) long growing period, (iv) low yield, and (v) market instability. As illustrated in Fig. 1, farmers believed that the labor shortage was the main reason that hinders them from adopting organic farming. This is understandable since organic farming spent more time on transplanting and weed management activity, which resulted in higher numbers of labors. In addition, due to off-farm work availability in the study area. This implied that the labor shortage

has already existed in the study area. Lack of organic material was also mentioned as the constraints since most of the farmers in the study are aging, and they found it hard to find or collect the organic materials around their village. As mentioned, farmers tended to purchase lots of animal manure from other farmers even though the price of the animal manure was much higher compared to the inorganic fertilizer.

The long growing period and market instability were concerned by studied farmers as well. They noted that organic farming had a more prolonged production stage, which hindered them from producing rice more than once in a year. Furthermore, most conventional farmers were not members of any organic farmer group, so it was hard for them to find a market for organic products with the premium price.

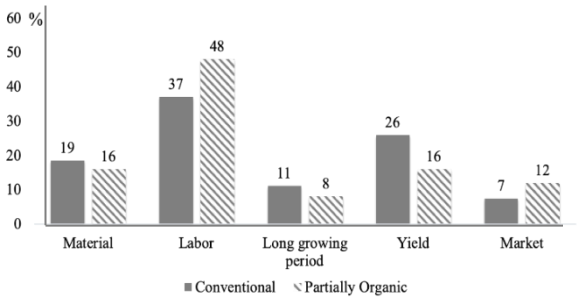

Fig. 1 Farmers' perception of constraints toward organic rice farming

Source: Field survey in 2018

CONCLUSION

The result of the analysis of production costs and returns revealed that cost indicators, such as gross margin and total cash income, reported that organic farming received higher income and more profitable from the economic viewpoint in comparison to conventional and partially organic farming. Moreover, sustainable farming systems such as partially organic and organic also benefited farmers in the study area to establish relationships within their family, among farmers and consumers, aware of the endangerment of agrochemical products to society and environment, and provide the opportunity to share and discuss knowledge and information. Unfortunately, constraints such as labor shortage and lack of organic material had hinder farmers from adopting sustainable farming in the study area. To respond to these matters, two significant issues are needed to address in order to improve the organic farming in the study area: (i) providing detailed training programs more widely especially to young farmers, and (ii) introducing farmers to the integrated farming system to help them minimize production cost, improve quality and quantity of soil and food produced, and increase cash income.

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Research article

Physical and Chemical Properties of Compost Made from Agricultural Wastes

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Abstract Compost is a decomposed organic material that can be used to help grow plants and keep soil healthy. The main objectives of this research are to prepare compost from agricultural wastes and study the physical and chemical properties of agricultural wastes and prepared compost. These agricultural wastes are cow dung, rice husk, saw dust, sesame husk and chaff. The physical and chemical properties of agricultural wastes and compost were characterized by pH, moisture, organic matter, calcium, magnesium, sulphur, nitrogen, phosphorus, and potassium. The EM (effective microorganism) solution was prepared by using organic kitchen wastes except onion and garlic peels for mixing in prepared compost. The microscopic morphology of microorganism was also studies for EM solution. The results showed that the prepared compost has pH value 7.29, moisture (20.39%), organic matter (22.89%), calcium (1.96%), magnesium (0.61%), sulphur (0.07%), nitrogen (1.25%), phosphorus (1.62%), potassium (1.56%), iron (1.30%), manganese (0.02%), copper (0.03%), zinc (0.01%) and chloride (1.07%). The yield percent of prepared compost was found to (58.45%) based upon the amount of agricultural wastes. The physical and chemical properties of agricultural wastes and prepared compost were used in soil management in a good way to improve and maintain soil quality, soil fertility, and conserve the environment.

Keywords agricultural wastes, physical and chemical properties, EM solution, compost

INTRODUCTION

Compost means to put together the correct amounts of compostable materials to make a great soil amendment. It is the biological reduction of organic material to humus; it is made from residues of plants and/or animals that are piled, moistened and allowed to decompose, and bacteria, insects and worms in the pile help this break down (Raabe, 2004). Quality control during compost production should ensure adequate chemical and physical properties (Inbar et al., 1993), as well as an adequate degree of stability and maturity (Benito et al., 2003). The beneficial effects on crop production and soil quality reported in literature (Hoitink et al., 1997; Atiyeh et al., 2001) are related to the physical, chemical, and biological properties of the composts (He et al., 1995). Agricultural wastes are defined as the residues from the growing and processing of raw agricultural products such as fruits, vegetables, meat, poultry, dairy products, and crops. They are the non-product outputs of production and processing of agricultural products that may contain material that can benefit man but whose economic values are less than the cost of collection, transportation, and processing for beneficial use. Their composition will depend on the system and type of agricultural activities and they can be in the form of liquids, slurries, or solids. Agricultural waste otherwise called agro-waste is comprised of animal waste (manure, animal carcasses), food processing waste (only 20% of maize is canned and 80% is waste), crop waste (corn stalks, sugarcane bagasse, drops and culls from fruits and vegetables, pruning) and hazardous and toxic agricultural waste (pesticides,

insecticides and herbicides, etc). Estimates of agricultural waste arising are rare, but they are generally thought of as contributing a significant proportion of the total waste matter in the developed world (Agamuthu, 2009). Effective Microorganisms (EM) are mixed cultures of beneficial naturally occurring organisms that can be applied as inoculants to increase the microbial diversity of soil ecosystem. They consist mainly of the photosynthesizing bacteria, lactic acid bacteria, yeasts, actinomycetes and fermenting fungi. These microorganisms are physiologically compatible with one another and can coexist in liquid culture. There is evidence that EM inoculation to the soil can improve the quality of soil, plant growth and yield (Kengo and Hui-lian, 2000).

Therefore, the present investigation was conducted to study produce a good quality compost from agricultural wastes. The physical and chemical properties of the agricultural wastes and compost were determined by the end of processing period. These properties include pH, moisture, organic matter, calcium, magnesium, sulphur, nitrogen, phosphorus, potassium, iron, manganese, copper, zinc and chloride.

METHODOLOGY

Sample collection: The agricultural waste materials such as cow dung, rice husk, saw dust, sesame husk and chaff were collected for the preparation of compost in June 2018. Cow dung was collected from Myitnge village and rice husk, saw dust, sesame husk and chaff were collected from production of Industrial Zone (I), Pyingyitagon Townships, Mandalay Region, Myanmar. Cow dung samples were dried under the sunlight for 3 months. The rice husk, saw dust, sesame husk and chaff were pounded and sieved with 60 sieve mesh size to get the size of powder.

Preparation of effective microorganism solution: The EM solution was prepared in container all the wastes of the fruits and vegetables from the kitchen except onion and garlic peels were placed in a 10 liters container to ferment for one month. The fermentation time took about one month to obtain effective microorganism (EM) solution.

Preparation of aerobic digester: The plastic container (50.8 cm) was taken. One hole (2.54 cm in diameter) was made at the centre of the base of the container to seep the liquid of the decomposing organic matter from container. Four holes were made around the top of the container, at 38.1 cm from each other. Another four holes were made around the bottom third of the container, at 38.1 cm from each other.

Preparation of compost by using aerobic method: Compost was prepared by mixing of cow dung (0.25 kg), rice husk (0.25 kg), saw dust (0.25 kg), sesame husk (0.25 kg), chaff (0.25 kg) and EM (10 L) solution in container (50.8 cm).

Turning over for compost under aerobic condition: During decomposition, the waste products were turned over regularly, in order that it remains well aerate and all the materials were converted into compost. The first turning over was done after two weeks. The second turning overtook that after one week. Then, each turning over was done after one week. During the process, water was sprinkled over the container, if necessary. After one month, decomposition was complete because the waste materials were changed into an unrecognizable crumbly dark mass. However, some stalks do not decomposed completely and can still be seen.

Analysis of physical and chemical composition of agricultural wastes and compost: The agricultural wastes and compost were air dried and physical and chemical properties were determined based upon the total weight of selected materials used (FAO, 2008).

Determination of pH of agricultural wastes and compost: Cow dung (5 g), rice husk (5 g), saw dust(5 g), sesame hush (5 g), chaff (5 g) and prepare compost (5 g) were weighed accurately and placed into a each beaker and 100 mL of distilled water was added into each beaker (the ratio of sample to water was 1:4). It was shaken and heated for 30 minutes. It was cooled and filtered. The filtered was determined by digital pH meter.

Determination of moisture contents of agricultural wastes and compost: With the oven-drying method, the loss of water on heating agricultural wastes and compost at 105°C in a silica crucible and heating it in a temperature control oven for 5 hours.

Determination of total sulphur contents of agricultural wastes and compost: 2-5 mL of aliquot was taken into 50 mL volumetric flask. 5 mL of 50% acetic acid, 2 mL of 0.25% Gum Acacia and 1 mL of ortho-phosphoric acid was added into the flask. It was shaken for 1 min. 0.2 g of $BaCl_2$ crystal was added and shaken for 1 min. Make the volume up to 50 mL with distilled water. Measure the turbidity intensity at 440 nm.

Determination of total nitrogen by using Kjeldahl method: 0.5 g of each sample was put into 600 mL digestion tube and 1 g of catalyst was added. It was heated gently unit frothing ceases. The flask was removed from the heater and cool, distilled water was added and transfer to the suitable volumetric flask. Accurately 20-25 mL of 2% Boric Acid was placed in the receiving conical flask. 2-3 drops of methyl red indicator was added. Water was add enough to cover the end of the condenser outlet tube. 5 mL of aliquot pipette into the distillation tube and 5 mL of 40% NaOH was added and the ammonia was distilled for about 4 minutes. The receiving flask was removed and rinsed the outlet tube into the receiving flask with a small amount of distilled water. Excess acid was titrated with 0.02 NH_2SO_4. Determine the blank a reagent in the same manner.

Determination of total phosphorus by using Molybivanado phosphoric acid method: Pipette 5-25 mL of aliquot depending on P content in a 50 mL volumetric flask and add 5 mL of Barton's Reagent and dilute to 50 mL with distilled water. After 1 hour, measure with spectrophotometer at 420 nm.

Determination of potassium, calcium and magnesium by using atomic absorption spectroscopic method: Potassium, calcium and magnesium content of agricultural wastes and compost were determined by Atomic Absorption Spectroscopic Method (AAS), at Department of Agriculture (Land Use), Ministry of Agriculture and Irrigation, Mandalay.

Determination of organic matter in agricultural wastes and compost: Loss of weight on ignition can be used as a direct measure of the Organic Matter (OM). The sample is ashed at 500-600°C by placing a suitable weight (0.5-1.0 g) of the sample in a silica crucible and heating it in a muffle furnace for 4-6 hours.

Determination of yield percent of compost: The compost was dried and the yield percent was determined based upon the total weight of selected materials used.

Isolation of microorganism from EM solution by using sub-micrometer: Isolation of microorganism from EM solution was done at Department of Biotechnology, Mandalay Technology University (MTU). The microscopic morphology of microorganism was also studied for EM solution (Krieg, 1984).

RESULTS AND DISCUSSION

Physical and Chemical Properties of Agricultural Wastes

Physical and chemical properties of agricultural wastes used for composting were measured. The results are shown in Table 1. According to these results the pH value of rice husk is greater than others. The pH value is directly affects plant growth. Calcium, potassium and moisture were highest values in cow dung. Sesame husk has highest phosphorus, sulphur, nitrogen amount and higher organic matter. Nitrogen, phosphorus and potassium are essential minerals for agriculture. The mixture of the richest sources, such as sesame husk, saw dust, chaff, cow dung and rice husk were combined and made the compost which used for agriculture. The agricultural wastes improve the overall health of soil and produce healthy various plants. The physical and chemical properties of prepared compost were rechecked in agricultural wastes and the results are described in Table 2.

Table 1 Physical and chemical properties of agricultural wastes used for composting

Parameter	Sesame husk	Saw dust	Chaff	Cow dung	Rice husk
pH	6.62	6.95	7.14	7.23	7.43
Moisture (%)	6.24	9.61	12.19	22.80	12.93
Organic matter (%)	89.97	91.18	23.49	51.03	79.36
Total Ca (%)	1.07	0.52	0.23	9.70	0.19
Total Mg (%)	0.15	0.07	0.11	0.57	0.12
Total S (%)	57.10	16.90	2.50	38.60	31.50
Total N (%)	3.36	0.19	0.09	2.18	0.41
Total P (%)	0.48	0.01	0.01	0.41	0.02
Total K (%)	0.51	0.06	1.01	1.15	0.93

Table 2 Physical and chemical properties of compost

Parameter	Results
pH	7.29
Moisture (%)	20.39
Organic matter (%)	22.89
Total Ca (%)	1.96
Total Mg (%)	0.62
Total S (%)	0.07
Total N (%)	1.25
Total P (%)	1.62
Total K (%)	1.56
Total Fe (%)	1.30
Total Mn (%)	0.02
Total Cu (%)	0.03
Total Zn (%)	0.01
Total Cl (%)	1.07

In accordance with the comparisons of physical and chemical properties of crude wastes and prepared compost, sulphur and nitrogen content are significantly decreased in compost which may be produced of gas in combination period. The organic matter is also reduced in prepared compost which is decomposed of agricultural wastes, cow dung and EM solution in moist aerobic conditions.

Yield Percent of Compost

Yield percent of compost was obtained 58.45% on based upon the total weight of material in aerobic condition.

Table 3 Cultural and Microscopic Morphology of Isolated Bacteria

Colony Morphology					Microscopic Morphology			Family
Sample name	Size (mm)	Color	Elevation	Shape	Size (µm)	Gram' reaction	Shape	
EM 1	2	White (Transparent)	Flat	Irregular	2-2.5× 5-6	+	Rod, spore	*Bacillaceae*
EM 2	3	White (Opaque)	Raised	Irregular	1.5-2× 3-4	+	Rod, spore	
EM 3	2	White (Transparent)	Raised	Irregular	1-1.5× 5-7	+	Rod, spore	

The Isolation of Microorganism from EM Solution

The microorganisms were isolated from prepare effective microorganisms solution. These microorganisms were used accelerator on composting process. EM cultures have been used effectively to inoculate both farm wastes as well as hasten the treatment process. EM enhances soil fertility and promotes grow ripening in crops. The isolated bacteria were shown in Table 3.

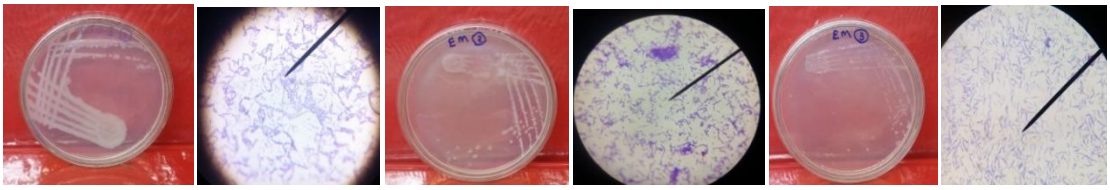

Fig. 1 Cultural and microscopic morphology of isolated bacteria

Three bacterial isolates (EM 1, EM 2, EM 3,) from sample EM were isolated on Nutrient media. According to the cultural and microscopic morphology, all three bacterial isolates on *Bacillaceae* shows in Fig. 1. *Bacillaceae* is mainly due to their ability to form resistant endospores. It is believed to be the key factor determining the ecology of these bacteria. They also perform fundamental roles in soil ecology and in plant health and growth stimulation.

CONCLUSION

According to physical and chemical properties of compost which should be used as organic fertilizer. As a result of analysis data of prepared compost showed that suitable for plant growth and health. In addition, waste products and compost were observed to be suitable for agricultural used. According to cultural and microscopic morphology, two aerobic bacterial strains were observed in liquid of EM solutions with different conditions. The compost should be used widely in agriculture because of their low cost, good fertility of the soil and supplying more trace elements. It provides many essential nutrients for plant growth and therefore is often used as fertilizer. Therefore, prepared compost has great potential for applications and as a source of plants nutrients.

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Research article

Effect of Long-Term Rubber Tree Plantation on Soil Properties Comparing to Sugarcane Plantation in Khon Kaen, Thailand

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Abstract Following extensive land conversion from other crops to rubber plantations, Southeast Asia has become the main natural rubber producer in the world. Within Southeast Asia, Thailand is a leader of rubber production. This research addresses the question of the long-term effect of land conversion to rubber tree plantations on selected soil properties. The study reported here aimed to evaluate change in soil properties after 5 and 23 years of rubber tree plantation (5 RB, 23 RB) compared to soil properties under annual cash crops such as sugarcane (SG), in Kranuan district, Khon Kaen province, Thailand. Randomized sampling was conducted at soil depth increments from 0-10 to 150-160 cm. Topsoil organic carbon, total N and total K were higher in 23 RB than in the 5 RB and in the SG system. Available phosphorus in 23 RB was also higher than in soil under the 5 RB system, but not significantly different from that in the SG system. Soil pH was identical throughout the soil profile in the three observed cropping systems. We found evidence of soil compaction under the SG system at the 30-40 cm depth. Finally, topsoil in 23 RB had higher moisture content than that under the 5 RB and SG systems. Overall, this study indicated that, relative to cash crops such as sugar cane, conversion to rubber tree plantation in Northeast Thailand did not lead to land degradation and even improved some of the soil property indicators.

Keywords rubber tree plantation, soil quality, cash crops, soil degradation

INTRODUCTION

Rubber tree (*Hevea brasiliensis*) is an important economic tree in tropical areas. In 2015, Thailand was the first world rubber producer with 4.5 million tons (Thailand Board of Investment, 2016). In the past, Northeast Thailand was considered as a marginal area for rubber trees due to climatic constraints. During the last 20 years, in relation with expected high benefits, farmers have converted many of their annual cropland (sugar cane, cassava) to rubber plantations. The environmental impact of this shift from annual to perennial crops remains unknown. Previous intensive and continuous annual cash cropping has degraded sandy soils of the Northeastern plateau. In particular, deep and repeated tillage and lack of organic restitutions resulted in

compaction of deeper layers (20-40 cm) and reduced soil organic matter levels to <1%. Such degradation is sometimes so severe that near-permanent erosion gullies occur even when the slope is <5%. In rubber plantations as in many other perennial tree plantations, the absence of tillage and the continuous accumulation of organic debris on the soil surface appears to facilitate a restoration of soil physical characteristics and an increase in soil organic matter. On the other hand, the absence of fertilization in rubber plantations may result in chemical degradation, acidification and a decrease in mineral nutrients.

OBJECTIVES

The objective of our study was to compare selected physical and chemical properties of soil under sugar cane, young and old rubber plantations and assess the impact of the rubber plantations on sandy soil already degraded by continuous annual cropping systems.

METHODOLOGY

Site Description

A study site representative of rubber tree plantations of Northeast Thailand was selected at Kham Hai village, Kranuan district, 50 km north of Khon Kaen city. Parent material was alluvial sand stone and current altitude is around 250 m asl. Soil is Chum Puang series (Cpg) with coarse-loamy, siliceous, isohyperthermic Typic Kandiustults; pH is ranging from 5.5 to 7 in the top soil and from 4.5 to 5 in subsoil and it is considered as a low fertility soil (LDD, 2015). The rubber tree plantation was converted from fields where cassava and sugarcane alternated for several decades. We compared 3 land uses: sugarcane (SG), 5 and 23 year old rubber tree plantation (5 RB and 23 RB, respectively). For each land use we sampled 3 replicates, i.e. blocks A, B, C. The blocks were located within a few hundred meters from each other (Fig. 1). As each plot was located at least 100 m from each other, we assumed that they were independent from each other, which allowed the use of ANOVA.

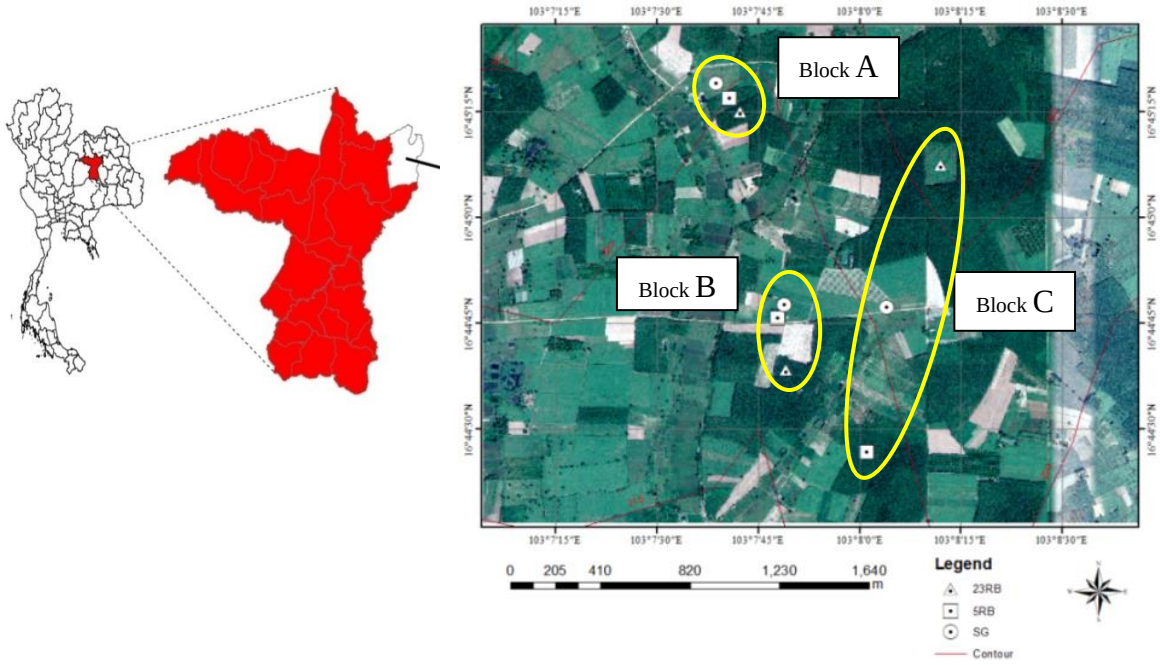

Fig. 1 The study plots in Khamhai village, Kranuan district, Khon Kaen, Thailand
○=sugarcane plantation (SG), □=5 years old rubber tree plantation (5RB),
△=23 years old rubber tree plantation (23RB) in Blocks A, B, C

Soil Sampling and Analysis

Rubber tree spacing was 2.5 x 7 m between trees and lines, respectively. Sugarcane spacing was 0.3 x 1.5 m between plant and lines. Samples were collected at 3 points per block, in which 3 points were randomized within the plot in the area of 50 x 50 m. At each point, samples were collected at 6 different depths between the plant rows: 0-10, 10-20, 30-40, 60-70, 100-110 and 150-160 cm (Haile et al., 2008, Gama-Rodrigues et al., 2010, and Monroe et al., 2016). The samples were oven dried at 105°C for 48 hours to determine the water content; after that, samples were sieved with 2 mm mesh size and stored in sealed plastic bags for laboratory analysis. Soil pH was measured in 1:2.5 soil: water suspensions with glass electrode pH meter. Organic Carbon (OC) was determined using the Walkley and Black's method, the total N was determined by Kjeldahl's method, while available phosphorus (P) was extracted by BrayII method. Exchangeable K was determined by extraction with neutral 1M NH_4OAC. Percentage of coarse sand, find sand was determined by sieving.

Statistical Analysis

Data were tested for normality; standard deviations were computed and outliers identified. Data were analysed by analysis of variance (ANOVA) as randomized complete block design (RCBD). All computations were done with the R software, and the Tukey's test was applied to identify differences between means at 5% probability level. Microsoft Office Excel was used to plot figures.

RESULTS

Soil Physical Properties

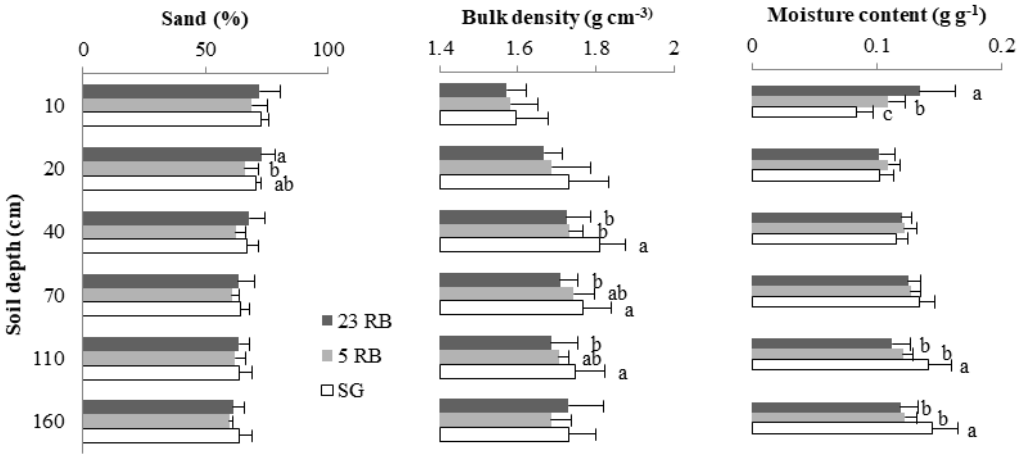

Fig. 2 Soil physical properties of three studied plantations 23RB, 5RB and SG in Khamhai village, Kranuan district, Khon Kaen, Thailand

Throughout the soil profile 0-160 cm depth, bars followed by different letters are significantly different according to Tukey HSD test n= 24, α=0.05. Horizontal solid lines correspond to the standard deviation

Sand content in this area was > 60% on the average. The analysis revealed that three study plots were not significantly different throughout the soil profile. The high amount of sand content was consistent with low fertility and low content of plant nutrients. Soil moisture content of the three 23 RB plantations was higher ($p<0.001$) at 0-10 cm (0.13 g g^{-1}), than that of 5 RB (0.11 g g^{-1}) and SG (0.08 g g^{-1}) samples. In the 10-70 cm depth layers, there were no differences in soil moisture content between the three cropping systems (Fig. 2). Between 70 and 160 cm depths, however, soil moisture content was higher in the SG than in either the 23 RB and 5 RB systems ($p<0.001$). The bulk density of the 0-20 cm depths was not significantly different among systems.

However, at soil depths of 30 to110 cm depth, bulk density was higher in the SG than 23 RB or 5 RB systems (Fig. 2). In the SG system, the highest compaction was found at 30-40 cm depth (1.81 g cm^{-3}).

Soil Chemical Properties

The soil pH of the entire area was very low which is the case for sandy soils of this region of Thailand and for soils of this particular classification (Ultisols). We found that long term rubber tree plantation did not appear to change the soil pH in the top 10 cm of soil depth compared to 5RB and SG systems ($p>0.29$). However, the 10-20 cm layers of the SG system revealed a lower mean pH (5.3) compared to that in 5 RB system (5.6) ($p<0.01$). The pH at depths between 30 and 110 cm were not different for the 3 situations whereas a pattern similar to that observed at 10-20 cm, i.e. 5 RB > SG but 23 RB not different from either 5 RB or SG, was found at 110 and 160 cm depths (Fig. 2).

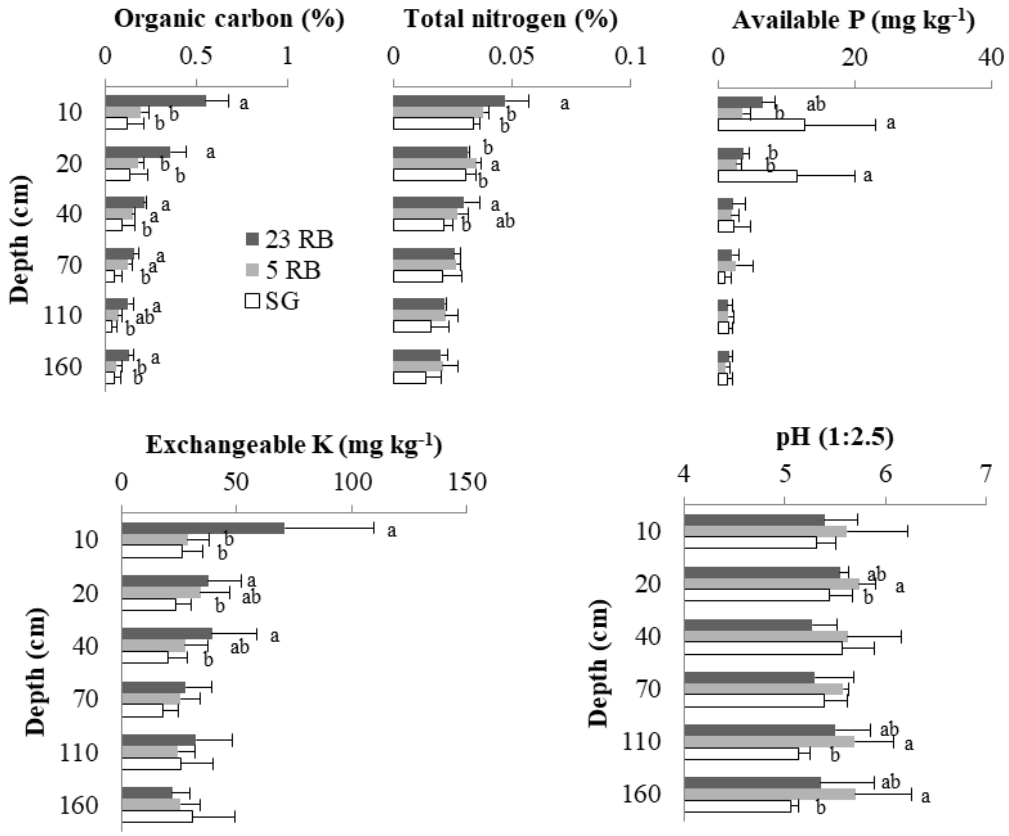

Fig. 3 Nutrient, Carbon content and pH of the three plantation systems 23 RB (23 years under rubber), 5RB (5 years under rubber) and SG (sugar cane system) in Khamhai village, Kranuan district, Khon Kaen, Thailand

Throughout the soil profile 0-160 cm depth, bars followed by different letters are significantly different according to Tukey's HSD test n= 24, α=0.05. Horizontal solid linescorrespond to the standard deviation

Organic carbon was higher in the 23 RB system than in SG throughout the soil profile and also different from 5 RB from the surface to 30 cm (Fig.2). OC of the 23 RB system was 2.75 and 4.58 times higher compared to 5 RB and SG systems, respectively. Total N in the studied area was also very low, less than 0.05%on the average, even in the top soil of the 23 RB system (Fig. 3). The 23 RB was characterized by the highest total N at 10 cm, while 5 RB was highest at 20 cm depth. There were no major differences between the 3 systems deeper in the profile. Levels of available

phosphorus of 23 RB, 5 RB and SG were also very low throughout the soil profile, again consistent with the soil classification of (Ultisol). There were, however, significantly higher amounts of P in the top10-20cm of SG. Finally, exchangeable K was higher in 23 RB than in the SG system from the surface down to 40 cm depth.

DISCUSSION

This study revealed that organic carbon levels increased slightly, but not significantly in the top soil of the 23-year-old rubber tree plantation compared to that in the 5-year-old rubber tree plantations and sugar cane plantations. This low increase in OC might be due to the low input of litter in rubber tree plantations compared to that occurring in natural forests. Naturally occurring tropical forest structure typically comprises 4 layers; namely the emergent layer, the canopy, the understory and the forest floor. Rubber tree plantations, however, only have the canopy layer with hardly any growth on either the understory or the plantation floor (Spies, 1998). The four layers of rain forest structures play an important role for ecosystem, especially soil protection and in improving soil fertility. Soil fertility accumulation also depends on tree species (Ramesh et al., 2013), with some species producing more biomass than others and/or biomass that is more readily degradable often caused by differences in lignin/nitrogen ratio, C/N, and cellulose etc) . Sang et al. (2013) reported that *A. mangium* plantations decreased soil bulk density and increased OC, total N and available P compared to secondary forest and pasture. It has been reported that the litter fall of rubber tree plantation is less than that of oil palm, jungle rubber and natural forest, amounting to an average of only 3.84 Mg ha^{-1} while that of natural forest was 9.04 Mg ha^{-1}. This clearly results in a lower nutrient return to the soil (Kotowska et al., 2016). The total nitrogen in the top soil of 23 RB was significantly higher compared to that of either the 5 RB or the SG systems, probably because of higher biomass accumulation. However, this increase in total N in 23 RB was, as in the case of OC, very small, probably due the large amounts of N needed for rubber tree growth or exported in latex production. Indeed, Iewkittayakorn et al. (2018) reported that the N content of latex is of the order of 40%. Finally, available P in the SG system was significantly higher than that in either the 23 RB or 5RB system, most likely as the result of previous chemical fertilization.

The main result of the work presented here was that OC, total N and exchangeable K in old rubber tree plantation were higher at some soil depths than in 5RB and SG systems. This is in line with results of Lakshmi et al. (2016) who reported reductions of N and K in sugarcane mono-cropping. Long term sugarcane cultivation in semi-arid regions and soils can, reportedly, increase OC and total N in 0-10 cm soil depth (Beza and Assen, 2016) which is not consistent with our results. This outlines the need for further studies to clarify the respective effects of sugar cane and rubber tree on soil fertility depending on soil type and climate. In this study, we also report that the BD of sugarcane plantation was very high, reaching 1.81 g cm^{-3} at the 40-70 cm depth, which constitutes a compacted layer. This reveals the negative impact of the use of heavy machinery to manage crops on such sandy. weathered soils (Usaborisut, 2011; Barzegar et al., 2005). Soil preparation is also a known a factor influencing SOC loss and soil degradation (Bilandžija et al., 2016). Together with improved OC levels at the surface in the 23 RB system, the higher soil moisture content illustrates the widely reported positive effect of organic matter on water retention (Brady, 1990; Robin et al., 2018; Minasny and McBratney, 2018; Ankenbauer and Loheide, 2017). Deeper in the soil however, our study indicates that soil moisture content was higher under the sugar cane system, which may reflect a lower water uptake than that of 23 and 5 year old rubber tree plantations.

CONCLUSION

In the studied plots of Khon Kaen province, Northeastern Thailand, rubber tree plantations were found to improve soil fertility, especially soil organic carbon as well as total N, and exchangeable K in comparison with a sugar cane system. Available P in sugarcane plantation was higher than in rubber tree plantation most likely because of the effect of fertilization. In this specific agro-

ecosystem, rubber tree plantations did not appear to have a negative impact on soil fertility relative to previously established sugarcane crops. However, more extensive long-term studies should be carried out to clarify the relevance of the results of this study.

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Research article

A Comparative Study of Economic Efficiency Between Small and Medium Size Rubber Plantation in Thbong Khmom Province

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Abstract The strong fluctuation of price makes investment decision difficult, especially smallholder rubber plantation that depend solely on rubber production to support their livelihood. An investment analysis of the rubber production was needed to complete the study, so a discounted cash flow (DCF) was introduced to account for this study. The findings of the study illustrate that the investment of rubber seemingly economically feasible. However, the result from the Discounted Cash Flow Analysis showed that the time to recover the initial investment on the rubber plantation is getting longer at the current price of rubber. The payback period will be 11.9 years for small size producers. For medium size plantations, the payback period was estimated to be 12.2, 10.5 and 9.8 years in MI, MII and MIII, respectively. The further findings also suggest that small size producers have less choice in term of output produce that they want to put out in the market.

Keywords discounted cash flow analysis, natural rubber, payback period, profitability, productivity, smallholder rubber plantation

INTRODUCTION

Rubber has long been a major commercial crop and export earner for Cambodia and, as a labor-intensive crop, has the potential to contribute to poverty alleviation through rural employment. The gross value added of rubber in 2006 was estimated at USD103.61 million, or about 5 percent of agricultural sector production (MAFF, 2008).

The growing surplus of rubber worldwide, which is steadily decreasing the demand for Cambodian rubber (Hor and Renzenbrink, 2013). According to a representative of Chop Rubber Plantation, a major rubber exporter, the global oversupply of natural rubber reduced their prices significantly from $3,100/ton to $2,100/ton in 2013 (Ross, 2016). Domestic demand for rubber is also very low and studies have revealed that "there is currently very little domestic use in secondary or tertiary industries for Cambodia's natural rubber products" (Ministry of Commerce, 2013).

In 2014, 70% of the total rubber production was contributed by household-owned rubber plantation. According to General Directorate of Rubber, the price of rubber has been decreased by 3/4 compared to a decade ago. However, little attention is given to their profit efficiency and its determinants. Farmers' income who live in the rural areas depends heavily on rubber production. The instability of rubber price, and low productivity due to the lack of technology and information, it affects greatly on their income.

OBJECTIVE

General objective of this study is to analyze economic efficiency of the rubber farmers. The specific objectives are: 1) Identify the socio-economic characteristic of rubber producers, 2) Access to farmer's profitability, 3) Analyze the financial feasibility of rubber producers, and 4) Formulate suggestions and recommendations.

METHODOLOGY

DCF analysis was used as the framework for assessing the returns from the investment of household-owned rubber production, with the usual investment criteria of net present value (NPV), internal rate of return (IRR), and benefit-cost ratio (BCR) (Campbell and Brown, 2003). A positive value of NPV for a given project shows that the project's benefits are greater than its costs. When IRR is equal to or greater than the interest rate, the investment is worthwhile. If the value of BCR is equal to or greater than 1, it is a sign that investment is of worth, but if it is less than 1, the investment project is not profitable. In order to apply DCF, the costs and benefits of rubber production first had to be identified, where the costs include establishment costs (before yielding stage) and maintenance costs (after yielding stage). Then the issue of the discount rate had to be addressed. Therefore, an allowance was made for risk and uncertainty through a sensitivity analysis.

RESULTS AND DISCUSSION

Farm Characteristics of the Small and Medium Size Rubber Producers

Table 1 Farm characteristics of the studied area

Items	S Under 2 (n=20)	MI 2 to 10 (n=18)	MII 10.1 to 20 (n=14)	MIII 20.1 up (n=11)
Average Rubber Owned Area (ha)	1.3	4.4	16.6	41.2
Average Planted Tree (tree / ha)	557	559	566	563
Average Mature Tree (tree / ha)	456	472	511	524
Average Immature/Damaged Tree (% / ha)	17.3	15.7	7.9	7.5
Average Rubber Tree Age (Year)	8	9	12.6	13
Tapping Frequency (days / week)	2	6.6	6.8	7
Output Produces	Coagulum [1)]	Coagulum [1)]	Latex [2)]	Latex [2)]
Labor Type	Family labor	Family labor	Family labor + Seasonal hiring labor	Non-family management [3)] + Fixed hiring labor

Source: Field Survey, 2018

Notes:

1) Coagulum: Coagulated latex. There are two ways to coagulate latex, by additional acid to latex or let it coagulate naturally. Due to high cost of acid S and MI producers in the studied area use the later method to coagulate their latex and sell it as coagulum.

2) Latex: MII and MIII producers sell their produces in the liquid latex form. The price will be determined by the DRC (Dry Rubber Content) % that has in the latex and Dry Rubber Price at the farm gate.

3) Non-family management: No family labor is engaged to manage the plantation. 1 to 2 managers are hired to manage the whole plantation in addition to the working labor (eg: tapping labor).

The farm characteristics is presented in Table1. Rubber producers were categorized into two main types, small (S) and medium (M) scale producers. For further investigation, this study divides medium scale producers into three categories, accordingly. MI refers to medium scale producers that use family labor only to manage the plantation, while M II are producers that manage the plantation themselves and use hired labor occasionally. Lastly, M III are producers that use hired labor only to manage the plantation.

For S producers refer to those who own less than 2 ha and use family labor only. As presented in the Table 1, the average owned area is 1.3 ha, 4.4 ha, 16.6 ha, and 41.2 ha, respectively. There is no transition of land or rental land system found in the studied area. Most of the producers acquired the land from the government, inheritance, and purchased land. The planting density is not so different between the 4 groups of producers, as they planted an average of 550 to 560 per ha. However, the ratio of immature/damaged tree is different across the groups, the producers that has the most immature/damaged tree is S producers that accounted for 17.3% following by MI 15.7%, MII 7.9%, and MIII 7.5%, respectively. This is the crucial point since only the mature area of plantation is calculated and compared and number of tree per ha is statically significant related to the productivity of the plantation itself.

Another distinguish differences that can be spotted in Table 1 is the age of rubber and tapping frequency. Compare to the M producer's groups S producers have smaller plantation area. Since the rubber tree can be tapped every four days, producers with bigger plantation areas tapper can rotate the tree in circle and able to tap every day (Usually 400 trees can be tapped per day per tapper).

Profitability Analysis of Small and Medium Size Rubber Plantation in the Study Area

Total production cost:

The total production cost includes both variable and fixed cost. The variable costs include the expenditure of fertilizers, herbicide control, latex stimulants and labor costs (tapping labor, fertilizing labor, herbicide labor, and latex stimulant labor).

Table 2 Total production cost of rubber production

Items	S Under 2 ha	%	MI 2 to 10 ha	%	MII 10.1 to 20 ha	%	MIII 20.1 ha up	%	t-statistic		
	(n=20)		(n=18)		(n=14)		(n=11)		S vs MI	S vs MII	S vs MIII
Fertilizer	513	11	544	12	642	15	677	15	2.03	**2.03***	**2.07***
Herbicide Control	170	4	178	4	195	4	213	5	2.12	2.06	**2.09****
Latex Stimulation	187	4	193	4	214	5	223	5	2.05	2.08	2.07
Family Labor (2)	3,321	74	3,220	72	929	21	0	0	2.03	**2.04*****	N/A
Hiring Labor (3)	0		0		2,139	48	2,988	68	N/A	N/A	N/A
a. Total Variable Cost	**4,191**	93	**4,135**	93	**4,119**	93	**4,102**	93	2.08	2.03	2.04
b. Total Fixed Cost	**378**	7	**371**	7	**355**	7	**330**	7	2.04	2.03	2.05
c. Total Production Cost (a+b = c)	**4,514**	100	**4,450**	100	**4,425**	100	**4,405**	100	2.04	2.05	2.04

Source: Field Survey, 2018

Notes: N/A = no data

1) The production cost does not include the cost that applied on the immature area of the plantation.

2) Current wages are applied to calculated family labor cost. (25,000 riel/day)

3) There is no hiring labor cost in S and MI producers, only family labor is engaged in the plantation.

4) Establishment cost refers to all the expenses incurred during the first six years till the plantation come to commercial yielding stage. Depreciation straight line method was used to calculate the annual share of establishment cost.

*Significant codes: *** 0.001 **0.01 * 0.05*

Fixed costs consist of establishment costs only, since there are no agricultural taxes in Cambodia and all the interviewed producers owned the land they are farming. Moreover, unlike other countries the interviewed producers only produce and sell raw material (coagulum, and latex), with no machines or heavy machinery involved in the rubber production. Establishment cost includes all the expenses incurred during the first six years till the rubber tree comes to yielding stage. The total cost of establishment comprised land preparation, lining and holding, planting, clone replacement, weeding, pruning/branch induction, fertilizer, and disease control.

To avoid being biased in this study, the total cost per tree has been computed. More than 70% of the total cost goes into labor for S producers. Producers in the studies area applied at least 1 bag (50 kg) of fertilizers (chemical) per ha to the rubber plantation and apply twice per year. One bag of fertilizer can cost up to 120,000 riel/bag (30 USD). The average quantity of fertilizer applied

was roughly 151 kg/ha, the cost of fertilizers wraps up 15% of the total variable costs, annually. Usually, latex stimulant is applied once a month, with roughly about 1 liter/ha costing around 10,000 riel/liter.

Rubber productivity and profitability:

Two types of produce were in the market, coagulum and latex. Coagulum is coagulated latex and consists of two ways to coagulate the latex. It can be developed by introducing additional acid to latex or by simply allowing it coagulate naturally. Due to the high cost of acid, S and MI producers in the studied areas use the latter method to coagulate their latex and sell them as coagulum.

Table 3 Average rubber productivity and profitability

Items	S Under 2 ha	MI 2 to 10 ha	MII 10.1 to 20 ha	MIII 20.1 ha up
	(n=20)	(n=18)	(n=14)	(n=11)
Yield (kg / tree) (a)	4.97	5.41	2.79	2.87
Price (riel / kg) (b)	1,890(1)	1,877(1)	4,307(2)	4,345(2)
A. Revenue (A = a*b)	**9,395**	**10,161**	**12,001**	**12,477**
Total Variable Cost (riel / tree) (c)	4,191	4,135	4,119	4,102
Total Fixed Cost (riel / tree) (d)	378	371	355	330
B. Total Production Cost (B = c+d)	**4,514**	**4,450**	**4,425**	**4,405**
C. Net Farm Income (A+B = C)	**4,881**	**5,711**	**7,576**	**8,072**

Source: Field Survey, 2018

Notes:

1) Coagulum rubber price riel/kg

2) Dry rubber price riel/kg

3) The production cost does not include the cost that applied on the immature area of the plantation.

Table 3 shows the average yield per tree for S and MI coagulum production, the producers' yields equated to 4.97kg and 5.41kg, and the net farm income was computed at an average price of 1,890 riel/kg and 1,877 riel/kg. Net farm income per tree/year came in at a total of 4,881 riels and 5,711 riel for S and MI producers. The average yield per tree was 2.79 kg and 2.87 kg for latex production, with the net farm income standing at 7,576 riel and 8,072 riel.

MII and MIII producers can generate more profit than S and MI producers, as latex is a higher-grade rubber that is used to make elastic bands, teats for babies' bottles, and athletic shoes, while coagulum is a low-grade (quality) rubber that is used for tires (ADI, 2007). Most of the large processors prefer to buy latex rather than coagulum and offer a premium for it. In contrast, smallholders prefer to sell coagulum, as farmers can receive cash in hand (Hing and Thun, 2009), where the smallholders producing the coagulum are selling them to collectors at either the farm gate or at various collection points in the districts' towns. Smallholders are also known to adulterate their latex with all kinds of additives, rendering it unusable for higher grades of rubber (ADI, 2007). Due to this, the factory prefers to make a deal with large-plantations so that they can secure the quality as well as the quantity.

Rubber smallholders have little choice but to sell their collected latex to private companies for processing and export, given that only semi-processed (dry) rubber, not latex, can be exported (Hing and Thun, 2009). Competition among collectors is limited and localized, resulting in price collusions against the farmers (so farmers are quoted the same prices by the collector) (Rubber Sector Profile, 2012).

Discounted Cash Flow Analysis

The financial feasibility analysis for rubber production was carried out by employing important tools such as the Net Present Value, Benefit Cost Ratio, Internal Rate of Return, and Payback Period as seen in Table 4.

The BCR for the rubber plantation presented more than unity in every category, but also implied that rubber cultivation was a profitable venture. The Net Present Value of the stream of

returns from one hectare of rubber plantations worked out to 38,231,362 riel for S producers, 40,820,918 riel for MI, 43,311,209 riel for M II and 46,030,839 riel for MIII at a non-discounted rate. The high positive Net Present Value indicates the soundness of the investment.

The internal rate of returns equated to 21% for S producers, however the ratio was 23%, 32%, and 33% in MI, MII, and MIII respectively. Since the values of the internal rate of returns are considerably higher than the market rate, more than 14.50% would be financially feasible (Shunmugiah, 2000).

Table 4 Benefit cost ratio and internal return rate

	S	M1	M2	M3
IRR	21%	23%	32%	33%
NPV	38,231,362	40,820,918	43,311,209	46,030,839
PB (Year)	11.9	12.2	10.5	9.8
BC	1.8	1.8	1.7	1.8

Source: Field Survey, 2018

The payback period refers to the time required to recover the initial investment in the rubber production. While the payback period worked out to be 11.9 years for S producers, the payback period for medium-size plantations was estimated to be 12.2, 10.5 and 9.8 years for MI, MII, and MIII, respectively. Thus, all the criteria of financial feasibility of the project indicated that investment in rubber production was economically feasible and financially sound in the study areas.

Table 5 Results of DCF analysis for rubber producers

Scenario		5%				8%			
		S	MI	MII	MIII	S	MI	MII	MIII
A	NPV (riel/ha)	-1,244,873	-462,624	-124,128	1,234,496	-1,868,824	-1,015,001	-130,399	-678,883
	B.C ratio	0.97	0.99	1.00	1.03	0.94	0.97	1.00	1.02
	IRR%	3.90%	4.60%	5.30%	7.40%	3.90%	4.60%	5.30%	7.40%
B	NPV (riel/ha)	10,327,710	12,006,326	13,960,084	15,506,547	5,352,964	6,757,139	9,051,105	10,153,484
	B.C ratio	1.26	1.29	1.30	1.33	1.17	1.20	1.24	1.27
	IRR%	13.60%	15.10%	21.00%	22.00%	13.60%	15.10%	21.00%	22.00%
C	NPV (riel/ha)	25,372,068	28,215,962	32,269,560	34,060,215	16,620,349	18,952,529	23,115,069	24,376,616
	B.C ratio	1.64	1.67	1.69	1.74	1.52	1.56	1.61	1.65
	IRR%	23.00%	24.80%	35.80%	36.50%	23.00%	24.80%	35.80%	36.50%

Source: Field Survey, 2018
Notes: A scenario: Rubber price decrease by 30% (of projected price); B scenarios: World Bank projected price; C scenarios: Rubber price increase by 30% (of projected price).

Table 5 shows the DCF applied the sensitivity analysis of small and medium-sized rubber plantations at the discount rate of 5% and 8%. Table 5 is using the wage of 34,000 riel/day to compute.

The results show that for 30% less than the projected price (scenario A), the investment for rubber production is unprofitable in all categories. With the world bank projected price (scenario B), the investment shows positive signs in all categories, indicating that the investment project is viable. At 30% more than the projected price (scenario C), the investment was worthwhile for all discounted rates.

The findings from the sensitivity analysis shows that if the input material costs were to increase by 30% from the current price, the investment in rubber production would no longer be worthwhile, indicating that the expansion of rubber may stop if there is a decline in the price of rubber in the future. In fact, at the wage rate of 34,000 riels/person per day and a discount rate of 5%, the investment in rubber production becomes unprofitable when the price of rubber decreases more than 30% from the current market price. This could perhaps be countered by increasing yields (e.g., through the use of fertilizer) or obtaining a higher farm-gate price by improving the quality of rubber. Nevertheless, the current expansion is clearly vulnerable to a price downturn.

CONCLUSION

The findings suggest that the bigger plantations can generate more income than the smaller plantations due to a difference in output production. Medium-size producers tend to produce latex that are more likely to be in demand by the factory. This type of produce is identified as a high-grade rubber that is commonly used for high-end products. In contrast, small-size producers sell their produce as coagulum used in the tire industry, and they are usually purchased by middlemen. In the current market, the price of latex is twice as profitable than coagulum rubber. However, the small-size producers prefer to sell their produce as coagulum in order to receive cash-in-hand, while the big factories prefer to purchase the latex only from the medium to large-size plantations to secure the quality as well as the quantity.

Further findings also show that despite the continuously decreasing price of rubber, rubber production is still seemingly economically feasible. However, if the price continues to decrease, rubber producers will struggle to recover the initial investment from the rubber plantation as the payback period is getting longer. From the results, it can be concluded that the investment for rubber plantations is getting riskier, and small-size producers are likely to be at the most disadvantaged. Upon weak market channels, rubber producers are not proactively addressing any potential risks, with even the slightest changes to input costs (labor, fertilizer, herbicide, and latex stimulant) having the potential of posing a major threat for rubber producers.

Smallholder rubber plantations usually have no control to dictate the price of their produce, as farm gate prices are usually set by collectors and traders. Therefore, the development of proper fair market channels and support from the government should be established to sustain the rubber producers' livelihoods and to mitigate any potential future risks. Support such as subsidies and quality material inputs should be accessible and available to rubber producers, especially during the establishment period when producers cannot generate any income.

Relevant and timely information on local and international rubber markets and rubber feasibility investment reports should be provided to rubber producers. Moreover, information such as potential markets and required standards should be informed to all rubber producers. Using the latest information and techniques can help rubber producers during the investment making processes and increase their productivity and income, potentially protecting the producer's livelihoods in the long run.

To further address this study, a study on the biophysical components (weather, soil, intercrop system, and clone) should be conducted in order to determine the factors that may affected farmer decision on output produce.

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Research article

Factors Affecting Farmers` Decision on Crops Selection with Special Reference to New Technology: Case of Sunflower Seed and Sweet Potato in Ikungi District, Tanzania

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Abstract The main objective of this paper is to investigate why the sharp decline of sunflower seed production had occurred just after the starting of modern varieties promotion policy in Tanzania. Specifically, the study aims to (1) examine the changes in production of sunflower seed crop and that of its substitutable crop (sweet potato) for ten years, (2) determine the differences in profitability between sunflower production with modern varieties and production of related crops (sunflower seed with traditional varieties, and sweet potato), (3) examine the effect of relative price changes, (4) clarify other related factors such as famers' characteristics in the adoption of new technologies, contract farming, and limited capacities of oil processing sectors. The field study was conducted in March and September 2018, selecting 270 farmers from three villages in Ikungi District. Based on the data obtained in the 2018 field study, profitability of the three types of cultivation was calculated. The result shows that sweet potato farmers received the highest economic return in terms of gross profit (545.7 TZS/ha) than sunflower farmers with modern seed varieties (397.0 TZS/ha). Sunflower farmers using traditional varieties received the lowest (273.7 TZS/ha). Furthermore, it was confirmed that changes in the farm gate prices over time had influenced profitability of three types of farming. At the starting time sunflower production with modern technologies had its advantage against sweet potato production. Farmers' crop selection is mostly rational but institutional factors like contract farming and limited capacity of processing sector were the barrier for the change. Also, it was suggested that farmers need more education and training for more rational crop selection. Finally, from this case policy makers have to know that if the conditions are not well fulfilled the promotion of new technology may not have the desired result.

Keywords crop selection, new technology, sunflower seed, sweet potato, contract farming, Tanzania

INTRODUCTION

Adoption of modern technologies such as chemical fertilizers, pesticides, and improved seeds is an effective pathway to enhance the welfare of farmers through attaining higher productivity (World Bank, 2008). Following this idea, the government of Tanzania set up new agricultural policy of promoting modern seeds for sunflower producers in 2009. Due to its low level of cholesterol, sunflower oil is highly preferred as edible and safe cooking oil for many households in the country. The crop accounts 40% of the total national cooking oil requirements (URT, 2014). The country attempted to reduce the burden of importing edible cooking oil from foreign countries by offering opportunities of high yield varieties together with aim of income generation to farmers. The government promoted the adoptions of modern varieties through extension services and contract farming (URT, 2014). Despite the efforts done by the government of Tanzania to set up new

agricultural policy of promoting modern seeds for sunflower producers, the production has been decreasing.

OBJECTIVES

The main objective of this paper is to investigate why the sharp decline of sunflower seed production had occurred just after the starting of modern varieties promotion policy in Tanzania. Specifically, the study aims to (1) examine the changes in production of sunflower seed crop and that of its substitutable crop (sweet potato) for ten years, (2) determine the differences in profitability between sunflower production with modern varieties and production of related crops (sunflower seed with traditional varieties, and sweet potato), (3) examine the effect of relative price changes, (4) clarify other related factors such as famers' characteristics in the adoption of new technologies, contract farming, and limited capacities of oil processing sectors.

METHODOLOGY

The field study was conducted in Ikungi District, one of the three districts of Singida region in March and September 2018. This region is selected because new technology has been promoted through extension services and contract farming to sunflower farmers since 2018. Based on the observation, it was found that there were three types of sunflower seed related farmers; i) sunflower farmers still using new technology; ii) sunflower farmers with traditional varieties iii) and farmers who changed from sunflower production using new varieties into sweet potato. Considering this observation, a total of 270 farmers from three types of groups were selected randomly from a list of farmers in the respective three villages: Damankia; Nkwiree; and Ikulume. Among them, 90 farmers from each village were selected from each category of farmers (30 sunflower farmers with new technology; 30 sunflower farmers with traditional varieties; and 30 farmers who changed from growing sunflower with new varieties to grow sweet potato)

In the field survey in March 2018, production data were collected through interviews with farmers. Additional information was obtained from the discussion with key informants such as traders, processors, and extension workers. The major information collected included: farmers' characteristics, cost and sales conditions of producers, and current problems and future prospects. The second interview were carried out in September 2018 in order to probe more information on the processing industries and area of contract farming that promote new technology among sunflower farmers.

RESULTS AND DISCUSSION

1) Changes in Production of Sunflower Seed Crop and Sweet Potato

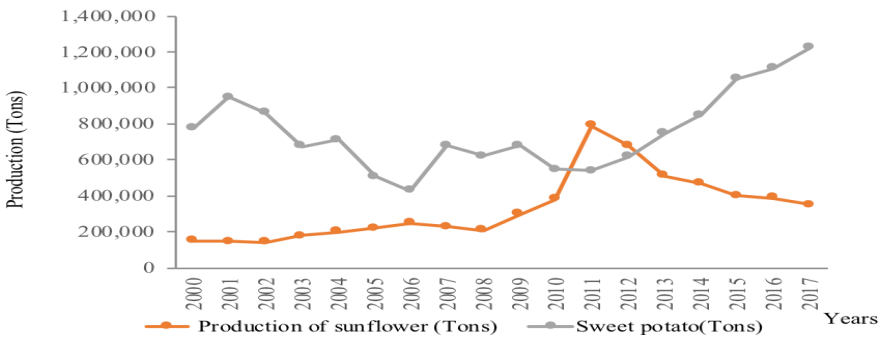

Fig. 1 Changes in production of sunflower seed and sweet potato in Tanzania (2000-2017)
Source: Country FAO-Statistics, 2018

In 2011, sunflower seed production increased significantly to more than 790,000 tons from 380,100 tons in 2010. But, from next year sunflower seed production had sharply declined continuously to less than half in 2017, comparing its peak in 2011 as shown in Fig. 1.

2) Features of the Farmer-Respondents

From the field study it was found that sunflower farmers with traditional varieties was older (45.2 years) compared to sunflower farmers with modern varieties (39.4 years) and sweet potato producers who transformed production from sunflower producing (37.3 years). Furthermore, with respect to the farm size, traditional sunflower producers were relatively small (0.83 ha), sunflower farmers with modern varieties was (1.21 ha) and farmers who changed production into substitutable crop (sweet potato producers) was higher (1.52 ha) as shown in Table 1.

The study went further to observe farmers' educational background because this is one of the most important factors for farmers to manage their farms in smartly move. Educational background of heads of household was grouped based on the education system of the country. There was high improvement in education for heads of household producing sweet potato whereas more than (80%) have reached to high school level and university level. Also, more than (8%) of sunflower farmers with modern varieties have reached to high school level and university level. But, majority of heads of household (98%) producing sunflower using tradition varieties have reached to primary level and secondary level only (Table 1).

Table 1 Features of the farmer-respondents

	Tradition sunflower varieties producers (n=90)		**Modern sunflower varieties producers (n=90)**		**Sweet potato producers (n=90)**	
Characteristics	Mean	SD	Mean	SD	Mean	SD
Age of heads of household (years)	45.20	8.09	39.40	7.81	37.30	6.53
Average cultivated area (ha)	0.83	0.42	1.21	0.64	1.52	0.71
Gender of farmers	Number of farmers	Percentage of farmers	Number of farmers	Percentage of farmers	Number of farmers	Percentage of farmers
Male	74	82.2	58	64.4	67	74.4
Female	16	17.8	32	35.6	23	25.6
Farmers' education						
Primary level	87	96.7	40	44.4	13	14.5
Secondary level	2	2.2	42	46.8	60	66.7
High school level	1	1.1	3	3.3	8	8.9
College level	0	0.0	4	4.4	6	6.7
University level	0	0.0	1	1.1	3	3.3

Source: Field survey, 2018

Note: (1) SD refers standard deviation (2) Primary level is seven years of schooling (3) Secondary level is four years of schooling (4) High school level is two years of schooling (5) College level is two years of schooling (6) University level is three to four years of schooling.

Concerning the gender of the household head, the study shows that heads of household producing sunflower seed with tradition varieties (82.2%) were male and (17.8%) were female. In the cases of other two types, more participation of female in new sunflower varieties (35.6%) is bigger than in sweet potato production (25.6%). This suggest that more participation of female tend to move to new technology adoption; that may be because farmers` education was higher than other types of farmers.

3) Differences in Profitability

In order to understand the profitability of two crops, the gross income and gross profit were calculated based on the data obtained in the field survey 2018. Gross income is calculated as a gross revenue minus total production cost excluding family labor cost. Gross profit is calculated as gross income deducting family labor cost. With respect to the estimation of family labor cost, opportunity cost was applied. In the cost calculation depreciation were not considered since farmers in the studied area did not use modern machinery in agricultural activities. The result revealed that, there were significant differences in income and profit among the three types of farmers. The sweet potato farmers receive the highest economic return in terms of gross profit (545.7 TZS/ha) than sunflower farmers with modern sunflower seed varieties (397.0 TZS/ha). Sunflower production using traditional varieties received the lowest (273.7 TZS/ha) (Table 2).

Table 2 Profitability comparison of sunflower seed and sweet potato in 2017

Item	Tradition sunflower varieties users (a)	Modern sunflower varieties users (b)	Sweet Potato Producers (c)	Comparison		
				(b-a)	(c-b)	(c-a)
Head of household	(n=90)	(n=90)	(n=90)			
Yield (tons/ha)	1.2	1.8	2.0	0.6	0.2	0.8
Seeds cost	10.6	18.2	10.3	7.6	-7.9	-0.3
Chemical fertilizer cost	22.7	37.9	0.0	15.2	-37.9	-22.7
Pesticide cost	0.0	10.8	9.3	10.8	-1.5	9.3
Hired labor cost	23.4	27.9	23.7	4.5	-4.2	0.3
Total variable cost	56.7	94.9	43.3	38.2	-51.6	-13.4
Family labor cost	41.6	50.1	45.8	8.5	-4.3	4.2
Total labor cost	65.0	78.0	69.3	13.0	-8.7	4.3
Total production cost	98.3	145.0	89.1	46.7	-55.9	-9.2
Gross Revenues (GR)	372.0	542.0	634.5	170.0	92.5	262.5
Gross Income (GI)	315.0	447.1	591.4	132.1	144.3	276.4
Gross Profit (GP)	273.7	397.0	545.7	123.3	148.7	272.0

Source: Survey, 2018 Unit of cost: `000TZS/ha

Table 3 Farmgate price changes of sunflower seed and sweet potato (100 =2007)

Year	Price index of sunflower seed	Price index of sweet potato	Relative price index of sunflower seed
2007	100.0	100.0	100.0
2008	99.4	106.7	93.2
2009	102.9	100.0	102.9
2010	113.2	103.3	109.6
2011	102.9	120.0	85.8
2012	102.6	121.7	84.4
2013	102.1	123.3	82.8
2014	97.1	124.0	78.3
2015	91.2	124.0	73.5
2016	88.2	125.0	70.6
2017	87.6	127.3	68.8

Source: SDC, 2018

Of course, the significant differences in profitability among three types in Table 2 were based on the data in 2017. Prices of sunflower seed and sweet potato had changed as shown in Table 3. Relative price of sunflower seed comparing with sweet potato has been declining as indicated in Table 3. At the starting year 2010, the profitability of sunflower seed might be better than sweet potato. In order to check this, the study simulated the comparative profitability of sunflower seed to sweet potato in various years with the following assumption: Farmers cultivated sunflower seed and sweet potato by using same technologies as in 2017 (then the cost and yield same as that in 2017), but the selling prices differ. The economic return in each year were calculated by replacing the farmgate price of 2017 by the price of corresponding year. The result shows that if the output price level was the same as that in 2010, the sunflower production with modern varieties ranks first in profitability (gross income and gross profit) and sweet potato production ranks in the second place. Profitability of sunflower production with traditional varieties was the lowest. In 2011, the price of sunflower seed sharply declined as in Table 3 and the sunflower production with modern technologies lost its advantage against sweet potato production.

4) Other Related Factors

i) Limited absorption capacity of processing sector:

Capacity building of various institutions especially in agriculture is important factor to ensure efficiency and effectiveness in service delivery. In Tanzania sunflower oil processing sector is facing a big challenge of limited capacity to absorb farmers' produce. Direct interviews with sunflower processors revealed that the three processing companies in the studied area only had total annual absorption capacity of 12,420 tons. However, this capacity could not absorb sunflower farmers' produce of 35,700 tons in (2017) in the studied area. This evidence is supported by other scholars that in Tanzania, absorption capacity of processing sector is limited and most of the local investors are not moving fast enough to invest in agricultural processing. Meanwhile foreign investment is not attracted sufficiently (Mpagalile, 2012).

ii) Contract farming:

As noted earlier in 2017, though differences in profitability was apparent among three types of farming, it observed that still some sunflower producers did not change the crop selection. Sunflower production with new technology is dominated by the production contract that established in 2010 with specific goal of promoting new technology to sunflower farmers. In this contract, the company provides agricultural inputs, agricultural extension services and sometimes credit to sunflower farmers together with new technology. Likewise, the period of contract is eight years. Major actors in the governance of sunflower contract farming are sunflower farmers with new technology, company providing contract, and the government of Tanzania. Based on the findings through direct interviews with sunflower farmers it observed that on the regularity of contract farming, farmers who want to terminate the contract before time must be punished through the contract law. This clearly show that sunflower farmers with new technology still continue the production because of the existence of contract farming.

iii) Characteristics of sunflower farmers with traditional varieties:

It has been pointed out that, although sunflower farmers with traditional varieties received the lowest profit but still continue the production. Table1 indicated that the sampled sunflower farmers using local varieties was more aged (45.2 years), relatively small in size, and less educated. Due to these features, they may be more reluctant to changes in adoption of new technologies. This is supported by other scholars that young farmers are more knowledgeable on better practices and may be more ready to adapt to better farming techniques because of their willing to achieve more production in their fields (Abunga, et al., 2012).

CONCLUSION

The main objective of this paper was to investigate why the sharp decline of sunflower seed production had occurred just after the starting of modern variety promotion policy in Tanzania. It was found that changes in the farm gate prices over time had influenced the sunflower production with modern technologies lost its advantage against sweet potato production. In other words, farmers' crop selection is mostly rational but institutional factors such processing sector and contract farming were the barrier for the change.

In relation to the finding and conclusion the following were recommended so as alleviate the existing challenges by all stakeholders of this sector. First, there is a definite need for the government of Tanzania to consider the area that absorb farmers' produce after production. Therefore, policy makers have to know that if the conditions are not well fulfilled the promotion of new technology may not have the desired result. Also, farmers need more education and training for more rational crop selection. Lastly, the area of sunflower contract farming should be revised to enhance its efficiency in new technology provision among sunflower farmers.

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Research article

Content of Online Marketing that Influence Customers` Decision: A Case on Buying Indigo-Dyed Clothing

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Abstract Nowadays, technology plays a significant role in business success. Technologies, including the Internet, web application, and social media can help to grow business by expanding distribution channels to reach customers, even in rural areas. In addition to technology, an online place to promote trade and the content of the products should be considered to help customers in buying decision processes. This research is conducted to understand how to create a proper content to promote online marketing. Consequently, good content can help to decrease the burden of web administrators who have to answer all frequently asked questions from customers. This paper begins with a literature review. Then, by using the focus group method, the customers' factors were identified on buying experiences of indigo-dyed clothing, which is a popular product in the Northeastern region of Thailand. Moreover, the interview of an administrator of an indigo-dyed clothing's web page as a purposive sample was summarized. By using content analysis, the results suggest some broad guidelines to present the content to promote products to gain the customers' response and interest. The conclusion and future work will be mentioned to contribute to the academics and the sellers to sustain online businesses.

Keywords impact, content marketing, buying decision, e-commerce, indigo-dyed clothing

INTRODUCTION

E-commerce or online marketing could reduce economic inequality for people in a rural area to set up their businesses with limited marketing resources. However, e-commerce itself could not be a reason that a product could be sold. One factor that has an impact on the buying decision-making process is product content. It affects customer satisfaction (Saetang, 2017). In turn, it will influence the consumer buying decision, especially the process of information search (Stankevich, 2017). This paper aims to study on what content that customers' interests for helping them to make such a buying decision. The paper will begin by reviewing previous studies as follows.

Consumer Decision Making Process

From a critical literature review of Stankevich (2017), consumer decision making processes compose of 5 main processes, including need recognition, information search, evaluation of alternatives, purchase, and post-purchase. The information search process is a crucial process for gathering information about the description of products, promotion, recommendations, and reviews from other customers and the experience of using the products. All these pieces of information have an impact on the buying decision-making process.

Indigo Dyed Clothing

Indigo dyed clothing was chosen to be a case study as this local product is very famous in Northeast Thailand mainly, in Sakon Nakhon province. Indigo dyed clothing helps agriculturists generate more income apart from farming. In 2001, the Thai government encouraged local communities to apply their local knowledge and create a product that represents their local

communities through the campaign called “One Tambon (sub-district), One product.” This campaign is to boost local economies for each community (Chanjittra Chanorn, 2016). Indigo dyed clothing was selected as one product for the Sakon Nakhon province since it uses local wisdom inherited from generation to generation to produce cloth and can increase household income. Its fabric has its unique indigo color, odor, and properties, which make it unique and famous. It was dyed with an indigo tree and can help prevent Ultra Violet rays (Phuphat, 2012).

Indigo dyed clothing is one of the experience goods that customers should have experience with the products before buying. Otherwise, they will not recognize the quality and will not be interested in buying. However, there are many online stores and communities that sell indigo dyed products such as scarves, shirts, skirts, and bags. The example could be seen as the following Fig. 1.

Fig. 1 An example of online stores (Ban Non Ruea, Sakon Nakhon) for indigo dyed products

Even though village product promotion has many advantages and brings more income to communities, one major problem that arises for this campaign is that village producer groups have no experience with product development and marketing (Chanorn, 2016). Therefore, some communities failed to sell their products in spite of the support from governments.

Marketing is the key to success, which villagers, including indigo-dyed clothing sellers, have to deal with. One problem is they are naïve to business and do not know how to sell their products or how to communicate with customers. Content marketing could be an inexpensive way to sell products online. Creating the right content could reduce the workload upon answering their customers ’ frequently asked questions and can have more time to develop products.

This study focuses on this indigo-dyed clothing to assist naïve sellers who want to start their online businesses, but still not know what content or information that customers needed the most in particular, for experience goods such as indigo fabric. Some results of this study could give some guidelines for creating interesting online content for customers.

Content Marketing

Content marketing could be defined as the pull strategy that provides consumers about the marketing information that is relevant, educational, helpful, engaging, needed, and sometimes entertaining without hard-sell advertising (Lieb, 2011). Nowadays, hard-sell advertising is not selling. The companies should give only a piece of content or information that serve their customers’ need. In turn, it will make a customer return to the companies for that helpful information and have more intention to buy their products. Then, some questions were raised in mind; for example, what is the information that customers need or what kind of information we should provide for customers.

The work of Resnik and Stern (1997) has defined what is considered to be useful information for advertising in general. They identified 14 criteria for evaluating advertising content as 1. Price or value 2. Quality 3. Performance 4. Components or contents 5. Availability 6. Special offers 7. Taste 8. Packaging or Shape 9. Guarantees or warranties 10. Safety 11. Nutrition 12. Independent research, 13. Company-sponsored research, and 14. New ideas.

Additionally, the work of Gupta et al. (2004) shows that the factors that influence consumer switching from offline to an electronic channel are the ease of online price and information search

to evaluate the products. Moreover, delivery time and free express delivery are considered for online consumers. Furthermore, the study suggests that trust has an impact on purchase intention, especially for the experience goods (i.e., Ones that consumers would rather physically examine before making a buying decision).

Moreover, the global online consumer report (KPMG International cooperative, 2017) shows that reasons that consumers buy things online instead of in stores are the convenience and the ability to compare and gain a better price. Moreover, it suggests that the information that consumers are looking up for information about products are price comparison, product information or specification, reviews, product options (e.g., color, size, style, etc.) and store inventory/ availability. The report also shows that when consumers decide where to buy products depends on the best price, preferred website, best delivery options or price, stock availability, peer advice, and returns policy.

From the previous work above, it can be identified the essential and relevant content that should be included to promote experience products like indigo-dyed clothing to facilitate the buying decision making are: 1. Prices 2. Quality and product information 3. Availability 4. Special offers 5. Reviews 6. Packaging or Shape 7. Guarantees or warranties / Return policy, and 8. Delivery time and fee.

OBJECTIVE

This research is conducted to study how to create content to respond to customer's needs and could help customers on buying decision processes by using indigo-dyed clothing as a case study. The good content, in turn, could help to reduce the workload of the online products' owner to answer all frequently asked questions. This study tried to identify the ways to create content that supports customers in their buying decision making. The methodology will be presented in the next section.

METHODOLOGY

This study referred to previous work, applied focus group, and interview as research methods. A focus group was used to identify the customers' factors on the experiences of indigo-dyed clothing's buying decision. Indigo dyed clothing is an experience good which people have been buying experience before. A focus group is a useful tool used in marketing to collect peoples' opinions, attitudes, and feelings on a given topic (Dilshad and Latif, 2013). A group of 10 persons who used to buy indigo-dyed clothing was asked questions about what information they used to make a buying decision on indigo dyed clothing and what channels (online/ offline shops) that they used to buy.

Moreover, the interview of an administrator, who is experiencing online selling of indigo-dyed clothing, on what information she used to be asked the most from customers was summarized in Table 1.

Sample groups in this research were selected using purposive sampling because of the limited numbers of customers and web administrators (sellers) and a group of people who experience and want to give information for the research. Thus, this research has a sample limitation and could be further expanded to collect more samples.

The results using content analysis suggest some ways to present the content to promote products in order to gain the customers' response and interest.

RESULTS AND DISCUSSION

The content that was considered when buying indigo-dyed clothing from previous work was analyzed and presented as in Table 1. Which is (unordered data): 1. Prices 2. Quality and product information 3. Availability 4. Special offers 5. Reviews 6. Packaging or Shape 7. Guarantees or warranties/Return policy, and 8. Delivery time and fee.

Table 1 The information that was considered when buying indigo-dyed clothing from the literature review

	Literature review
1	Prices
2	Quality and product information
3	Availability
4	Special offers
5	Reviews
6	Packaging or Shape
7	Guarantees or warrantees / Return policy
8	Delivery time and fee

Additionally, the results from the focus group summarized by content analysis are presented in Table 2. The group of purposive samples indicates that the styles (e.g., patterns, appearance), texture and smell of indigo plants, shop name or brand, and price are important information that focus group members considered when they make an indigo-dyed clothing buying decision, respectively. One of the samples said, "styles of the cloths" is the most crucial factor in buying them.

Table 2 The information that was considered when buying indigo-dyed clothing

Importance	Focus group	Interview an administrator of online indigo clothing seller
1	"Styles" (e.g. Patterns, appearance)	Products' information (i.e. Dimensions)
2	"Texture and smell of indigo plants."	Patterns and Styles
3	"Shop name/ Brand."	Buying channels/methods
4	"Price"	Fabric care methods
5	"Friends' recommendations."	Price
6		Address and Map of shops

From interviewing an administrator of a web site that sell indigo-dyed clothing, the information that was asked most frequently about indigo-dyed products are products' information such as dimensions and color, patterns and styles, buying channel or methods to buy, fabric care or how to take care the indigo-dyed clothing, price, address and map of the shop, respectively.

The results from the focus group and the interviews indicate that styles and patterns are the most important information (more than price) that customers will use to make their buying decisions since it will make customers happy and confident when wearing it. They will pay for cloth if it makes them good looking. Therefore, as an online shop, photos of the products and information needed to be prepared carefully. They have to be a clear picture with natural light and make people appreciated with.

Moreover, it can be seen that as an online shop where we cannot see each other face to face, some factors that increase trusts such as shop name or brand, address and map of shops, and friends' recommendations are also important. All in all, from the above literature review on the section of content marketing (summarized in Table 1.), focus group and interview (summarized in Table 2.), information that should be provided for customers is all information as follows: 1. Prices, 2. Styles, patterns, texture, and product information, 3. Availability, 4. Special offers, 5. Reviews, 6. Packaging or Shape, 7. Guarantees or warranties / Return policy, 8. Delivery time and fee; 9. Shop name/ Brand, 10. Address and map of shops, 11. Buying channels/ methods, and 12. Fabric care methods.

All information (altogether from table 1 and 2) that should be provided for customers to help them make a buying decision for indigo-dyed clothing could be separated into 2 groups: 1. Information that is related to products including prices, styles, patterns, texture and product information, availability, special offers, packaging or shape, guarantees or warranties/return policy, delivery time and fee, buying channels/ methods, and fabric care methods, and 2. Information that increase trust including reviews, shop name/ brand, and address and map of shops. These kinds of

information could help customers accelerating a decision on buying processes and reducing workload to answer all frequency asked questions from customers.

LIMITATIONS

The samples of the interview were selected using purposive sampling since there was little time to conduct this study. However, some lesson was learned and gained some guidelines for an administrator of any website to create content and provide some helpful content and information for their customers.

CONCLUSION

Online marketing could help people in rural areas sell their products with limited resources and investment. However, nowadays, hard-sell advertising could not gain a high purchasing demand anymore; some marketing techniques have to be adopted. This study focuses on how to provide practical content that is useful and helpful for customers to make a quicker buying decision on indigo-dyed clothing. From previous work, focus group, and interviewing an administrator who sells indigo dyed fabric online, there are 2 kinds of information that should be provided for customers to facilitate indigo-dyed clothing's buying processes online, which are 1. Information that is related to products ,including prices, styles, patterns, texture and product information, availability, special offers, packaging or shape, guarantees or warranties / return policy, delivery time and fee, buying channels/ methods, and fabric care methods and 2. Information that increase trust, including reviews, shop name/ brand, and address and map of shops.

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Research article

The Impact of Agricultural Export Product on Income and Employment in the Thai Economy

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Abstract From past to present, the Thai economy has been heavily export-dependent, with exports accounting for more than two-thirds of its gross domestic product (GDP). Agricultural export product is one of the main export products but its tendency is declining. The research objectives were to study the impact of agricultural export products on the income and employment of the Thai economy. In this research, the data applied were collected as the yearly time series for a period of 27 years from 1990 to 2016 by the Bank of Thailand. The primary data were collected from the stakeholders of the agricultural product export policy of Thailand. Data analysis was based on descriptive statistics by the arithmetic mean and standard deviation. The Monte Carlo Simulation technique and time trend analysis was applied to the forecasting of agricultural product export value. In addition, the impact of agricultural export product on income and employment measured by the econometric model and the estimated parameters were calculated by the ordinary least square technique. The research results revealed that: agricultural export product value of Thailand from 1990 to 2016 was $10.270 billion with its yearly growth rate of 4.984 percent, in addition, the forecasting of agricultural product export value of Thailand has increased but its growth rate has declined. The impact of agricultural export products has a positive impact on income in the Thai economy; agricultural product export value of Thailand increased 1 percent which, in turn, led to the income increase by 0.0051 percent. In addition, the impact of agricultural export product value has a positive impact on employment in the Thai economy; agricultural export product value of Thailand increased 1 percent which, in turn, led to the employment increase by 0.079 percent. The Thai agricultural export product policy should be focused on finished or semi-finished agricultural products instead of raw materials by applying technology and innovation to make value-added agricultural product export.

Keywords agricultural export product, income, employment, Thai economy

INTRODUCTION

Thailand is a newly industrialized country. Its economy is heavily export-dependent, with exports accounting for more than two-thirds of its gross domestic product (GDP). In 2014, according to the Office of the National Economic and Social Development Board, Thailand had a GDP of 92.11 trillion baht (US$366 billion). The Thai economy grew by 8.5 percent, (the Office of National Economic and Social Development Board, 2016) with a headline inflation rate of 3.02 percent and an account surplus of 0.7 percent of the country's GDP. In 2016, the Thai economy is expected to grow in the range of 3.8 to 4.3 percent (Bank of Thailand, 2016).

The industrial and service sectors are the main sectors in the Thai gross domestic product, with the former accounting for 39.2 percent of GDP. Thailand's agricultural sector produces 8.4 percent of GDP—lower than the trade and logistics and communication sectors, which account for 13.4 percent and 9.8 percent of GDP, respectively. The construction and mining sector adds 4.3 percent to the country’s gross domestic product. Other service sectors, including the financial, education and hotel and restaurant sectors, account for 24.9 percent of the country's GDP. (Bank of Thailand, 2016).

In addition, telecommunications and trade in services are emerging as centers of industrial expansion and economic competitiveness (World Bank, 2016). Thailand is the second-largest economy in Southeast Asia with a GDP per Capita of $ 5,490 (The Office of National Economic and Social Development, 2016). Thailand ranks second in Southeast Asia in external trade volume, after Singapore (World Trade Organization, 2016). Thailand has been the largest rice exporter in the world. Forty-nine percent of Thailand's labor force is employed in agriculture (Henri et al., 2010). Developments in agriculture since the 1960s have supported Thailand's transition to an industrialized economy (Henri et al., 2010).

As recently as 1980, agriculture supplied 70 percent of employment (Henri et al., 2010). In 2008, agriculture, forestry, and fishing contributed 8.4 percent to GDP; in rural areas, farm jobs supply half of employment (Henri et al., 2010). Rice is the most important crop in the country and Thailand had long been the world's number one exporter of rice, until recently falling behind both India and Vietnam (International Grain Council, 2014). It is a major exporter of shrimp. Other crops include coconuts, corn, rubber, soybeans, sugarcane, and tapioca (New York Times, 2010).

Thailand is the world's third-largest seafood exporter. Overall, fish exports were worth around US$3 billion in 2014, according to the Thai Frozen Foods Association. Thailand's fishing industry employs more than 300,000 people (Lefevre et al., 2015). In 1985, Thailand designated 25 percent of its land area for forest protection and 15 percent for timber production. Forests have been set aside for conservation and recreation, and timber forests are available for the forestry industry. Between 1992 and 2001, exports of logs and sawn timber increased from 50,000 to 2,000,000 cubic meters per year. In 2014, industry contributed 50.3 percent of GDP, employing 16 percent of the workforce. The industry expanded at an average annual rate of 4.4 percent. The most important sub-sector of the industry is manufacturing, which accounted for 38.5 percent of GDP in 2014 (Bank of Thailand, 2016).

Thailand’s strategic location makes it an investors’ gateway to Asia. It is at the center of most ASEAN countries, including Myanmar to the west, Cambodia and Lao PDR to the east, and Malaysia, Indonesia, and Singapore to the south. Being at the crossroads of ASEAN and other dynamic markets in Asia, such as China and India, allows Thailand access to a burgeoning consumer population overseas aside from its equally huge population of almost 68 million people. Thailand offers investors a world-class infrastructure. Trade and business transactions are made easier through Thailand’s extensive highway system, modern city-wide mass transit, international airports, deep seaports, and international river ports. As the hub of ASEAN, Thailand advocates for free and fair trade. It is instrumental in the formulation of the ASEAN Free Trade Area and a signatory to a number of other free trade agreements. Business opportunities in Thailand are abundant across several industries which include automotive, alternative energy, food, electrical & electronics, logistics, printing, yacht building, rubber industry, etc. (Thailand Board of Investment, 2016).

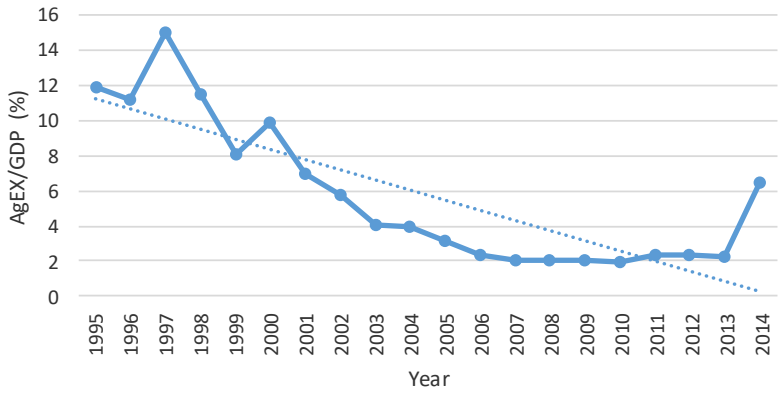

Fig. 1 The value of agricultural export per gross domestic product (GDP)
Source: Calculation

From past to present, the basis of the Thai economy has been heavily dependent on the agricultural sector. The agricultural sector is still part of food production, clothes, raw materials, and labor to serve other sectors in the economy. Obviously, the Thai economy mainly relies upon the export sector. About 80 percent of Gross Domestic Product (GDP) stems from the export sector. This means that the Thai economy has been and still depends on the export sector which generated the National Income and GDP growth rate. According to the Thai economy, there were 2-main sectors which are Agricultural and Non-agricultural sectors Industrial sub-sector, financial sub-sector, and service sub-sector. The non-agricultural sector generated about 95 percent of GDP while the agricultural sector generated about 5 percent of GDP. Statistically, from the last 20 years, the agricultural sector has been smaller than it was. The ratio of Agricultural export per GDP has been declined (Fig. 1).

In this research, the researcher tries to examine the impact of agricultural product export on income and employment in order to determine the future shape of the agricultural sector as a part of the Thai economy.

OBJECTIVE

The research objectives are as follows:

1) to find out the impact of agricultural export product on the income of the Thai economy
2) to find out the impact of agricultural export product on the employment of the Thai economy

METHODOLOGY

Data Collection

The secondary data time-series data from 1998 to 2017 accounted for 20 years were collected from the database of Bank of Thailand, the Office of National Economic and Social Development and the Office of Agricultural Economics (OAE), the Ministry of Agriculture and Cooperatives, the Royal Thai Government.

Data Analysis

The impact of agricultural export products on income and employment was calculated by the econometric model applied T-test, F-test, Determinant of Coefficient (R^2) and Durbin-Watson (DW).

RESULTS AND DISCUSSION

The impact of Thai agricultural export on the income of the Thai economy can be expressed as equation (1) below:

$$\ln (GDP)_t = \hat{\alpha}_0 + \hat{\alpha}_1 \ln (AgExport)_t + \hat{\alpha}_2 \ln (GDP)_{t-1} + \varepsilon \quad (1)$$

Where $(GDP)_t$ = Gross Domestic Product at time t, $(AgExport)_t$ = Agricultural Export Product at time t, $(GDP)_{t-1}$ = Gross Domestic Product at time t-1, and ε = the error term.

The statistical results calculated from equation (1) could be expressed in Table 1. According to Table 1, the impact of Thai agricultural export products on income expressed that increasing in agricultural export by 1 percent led to an increase in income by 0.03 percent while increasing in last year's income by 1 percent led to an increase in income by 0.826 percent.

Table 1 The impact of the agricultural export product on income

Dependent Variable: Gross Domestic Product $ln(GDP_t)$

Independent variables	Estimated coefficient	T-value
Constant	2.294	21.32**
ln $(AgExport)_t$	0.030	9.53**
ln $(GDP)_{t-1}$	0.826	9.01**
F-statistic = 228.53**		
D.W 1.86**		
$\widehat{R}^2$ 0.974		

***Statistical significance at 99 percent*
Source: Calculation

The impact of Thai agricultural export product on employment of Thai economy can be expressed as eaquation (2) below:

$$\ln (Employment)_t = \hat{\alpha}_0 + \hat{\alpha}_1 \ln (AgExport)_t + \hat{\alpha}_2 \ln (AgExport)_{t-1} + \hat{\alpha}_3 \ln (GDP)_{t-1} + \varepsilon \quad (2)$$

Where $(Employment)_t$ = Employment at time t, $(AgExport)_t$ = Agricultural Product Export at time t, $(AgExport)_{t-1}$ = Agricultural Product Export at time t-1, $(GDP)_{t-1}$ = Gross Domestic Product at time t-1, and ε = the error term.

The statistical results calculated from equation (1) could be expressed as Table 2 below:

Table 2 The impact of agricultural export product on employment

Dependent variable: $ln(Employment_t)$

Independent variables	Estimated coefficient	T-value
Constant	20.68	26.65**
ln $(AgExport)_t$	0.36	18.68**
ln (AgExport)t-1	0.04	13.69**
ln $(GDP)_{t-1}$	0.14	21.80**
F-statistic = 229.10**		
D.W 1.82**		
$\widehat{R}^2$ 0.824		

***Statistical significance at 99 percent*
Source: Calculation

According to Table 2, the impact of Thai agricultural export product on employment expressed that increasing in agricultural export product at time t by 1 percent led to an increase in employment at time t by 0.36 percent, the increasing in agricultural export product at time t-1 by 1 percent led to an increasing in employment at time t by 0.04 percent while increasing in Gross Domestic Product at time t-1 led to an increase in employment at time t by 0.14 percent.

CONCLUSION

Agricultural export products of Thailand have been an important sector for the Thai economy as one of the economic drivers. From 1998 to 2017, the value of Thai agricultural export products has significantly increased with an average of $23,819 Million and an average growth rate of 6.08 percent a year. For Thai Agricultural export product value forecasting, it is found that the average growth rate is 9.16 percent a year. The agricultural export product also has an impact on income and employment for the Thai economy, increasing in 1 percent of agricultural export-led to an increase in income and employment by 0.03 and 0.36 percent, respectively.

Due to the research results, the agricultural sector has been and still is an important economic sector of the Thai economy. Agricultural product export is one of the economic sectors that functioned as an economic driver in the Thai economy, not only being the source of income but also the source of employment for the Thai economy. In addition, the agricultural sector is still the

source of food, clothes, raw materials, and labor to serve other sectors such as industrial, service, and other sectors in the Thai economy

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Research article

Comparative Study on Pulse Production with Different Practices: A Case Study of Mungbean and Black Gram

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Abstract Pulses play a vital role in contributing to food security and enhancing soil fertility. In Myanmar, pulses are the second most important crop after rice, and have a high potential for export. Mungbean (*Vigna radiata* L.) and black gram (*Vigna mungo* L.) are the major species of pulses that are widely grown throughout the country. The actual yield obtained at the farm level is still lower than the potential yield and pulse farmers are facing various problems and constraints. Considerable improvements of crop management practices are needed in pulse cultivation. Field experiments were conducted at Thongwa Township (lower Myanmar) and Pyinmana Township (middle Myanmar) from November 2017 to March 2018 to investigate the effect of crop management practices on yield and suitability of mungbean and black gram varieties grown in the study areas. Each experimental area was laid out in a split-plot design with four replications. Two crop management practices (Recommended practice and Farmers' actual practice) were assigned to each main plot and four varieties of mungbean (Yezin-1, Yezin-9, Yezin-11 and Yezin-14) were planted at the Thongwa Township sites and black gram (Yezin-2, Yezin-5, Yezin-6 and Yezin-7) at the Pyinmana Township site, being assigned to sub plots. The results reveal that more yield and yield components were obtained in mungbean varieties grown following recommended practices than by farmers' practices. However, the yield and yield components of black gram varieties are not significantly different between the two crop management practices. All mungbean varieties tested, except Yezin-11, are suitable for cultivation in Thongwa Township. Of the black gram varieties tested in Pyinmana Township, only Yezin-7 is unsuitable. Therefore, it is necessary to further investigate and possibly amend the recommended practices for these particular areas to improve the production of mungbean and black gram in these areas. In addition, demonstration plots that make use of these recommended practices should be organized to improve the awareness of farmers of the advantages of these techniques.

Keywords recommended practices, farmers' practices, mungbean, black gram, yield

INTRODUCTION

Pulses play a vital role in their contribution to food security and enhancement of soil fertility. Their inclusion as part of cereal-based cropping systems improves soil health by enriching organic nitrogen, reducing the demand for the application of chemical fertilizers, and increasing soil micro flora (Dasgupta and Roy, 2016). In Myanmar, pulses are the second most important crop and have a high export potential. Currently, about 4.2 million ha is planted to pulses, with yields in 2016-

2017 ranging from 0.7 to 1.3 metric tons per hectare (GAIN, 2017). In Myanmar, black gram, mungbean, pigeon pea, chickpea, cow pea, red kidney bean, velvet bean, and soybean are mostly grown (Soe and Kyaw, 2016). Because of their export potential, mungbean (*Vigna radiata* L.) and black gram (*Vigna mungo* L.) are widely sown as a second crop after monsoon rice in areas where soil residual moisture is adequate for pulses.

The potential yields for mungbean and black gram determined by the Department of Agricultural Research (DAR, 2016) are approximately 1.6 - 2.0-ton ha^{-1} and 1.6 - 3.2-ton ha^{-1}, respectively. However, the actual yield obtained at the farm level is lower than this and pulse farmers face various problems and constraints, which result in a yield gap exists between farmers' actual yields and potential yields. In order to enhance and sustain pulse productivity closer to potential, considerable improvements in crop management practices are necessary.

Some of the factors responsible for the low yields are the poor preparation of soil prior to sowing, the unbalanced use of fertilizers and ineffective practices used to protect growing plants (Bakoriya, 2015). An improved package of crop management practices, including ensuring the timely availability of all inputs and more efficient application of these would enhance not only productivity, nutritional quality and profitability but also environmental and social sustainability. Timely sowing, regular weeding, effective and staged control of pests and diseases and better harvesting methods could all play a part the development of a viable strategy.

OBJECTIVES

The objective of this research is to investigate the effect of crop management practices on yield and to determine the most suitable varieties of mungbean and black gram to cultivate in the study areas.

METHODOLOGY

Study Site

The growing period for mungbean and black gram as a second crop after the monsoon rice harvest is short, and the study sites selected are in Yangon Region and Nay Pyi Taw Union Territory where residual soil moisture conditions allow these pulse crops to be widely grown. Field experiments were conducted at Nankale Village, Thongwa Township, Yangon Region which lies between 16°73‘01"- 16°74'68" N and 96°56'08"- 96°57'87" E and Kyee Inn Village, Pyinmana Township, Nay Pyi Taw Union Territory which lies between 19°70'66"- 19°72'62" N and 96°22'43"- 96°25'73" E from November to March during 2017 and 2018 (Fig. 1).

Fig. 1 Study areas at Nankale Village, Thongwa Township and Kyee Inn Village, Pyinmana Township, Myanmar

Experimental Design

Each experimental area was laid out in a split-plot design with four replications. Two crop management practices (Recommended practice and Farmers' actual practice) were employed on the cultivation of four varieties of mungbean (Yezin-1, Yezin-9, Yezin-11 and Yezin-14) at Thongwa Township and four of black gram (Yezin-2, Yezin-5, Yezin-6 and Yezin-7) at Pyinmana Township in sub plots. The total area of each sub plot was $25m^2$ and these were 1m apart.

Crop Management Practices

The package of DOA recommended practices and the farmers' actual practices commonly used in the study areas were followed as crop management practices in main plot for each experimental variety (Table 1) and (Table 2).

Table 1 DOA recommended practices and Farmers' practices for mungbean cultivation

Factors	Recommended practices	Farmers' practices
Land preparation	Plowing - 1 time Harrowing - 2 times	Plowing - No Harrowing - 3 times
Sowing time	October - November	November - December
Variety used	Yezin - 1	Yezin -1, Yezin - 9, Yezin - 14
Sowing method	Line sowing - 30 to 40 kg ha^{-1} Broadcast - 60 kg ha^{-1}	Broadcast - 60 kg ha^{-1}
Seed treatment	Seed treatment with fungicide	Not practiced
Weed management	Weeding as necessary	No weeding
Basal fertilizer used	Urea 50 kg ha^{-1}, Triple super phosphate 125 kg ha^{-1}, Potash 60 kg ha^{-1}, Gypsum 125 kg ha^{-1}	Basal - Urea 60 kg ha^{-1},T super 60 kg ha^{-1}
Foliar fertilizer used	4 times for the whole season	2-12 times for the whole season
Pesticide used	As necessary based on scouting	2-12 times for the whole season
Fungicide used	As necessary	1-3 times for the whole season

Table 2 DOA recommended practices and Farmers' practices for black gram cultivation

Factors	Recommended practices	Farmers' practices
Land preparation	Plowing - 1 time Harrowing - 2 times	Plowing - No Harrowing - 2 times
Sowing time	October - November	November - December
Variety used	Yezin - 6	Yezin -2, Yezin - 5, Yezin - 6
Sowing method	Line sowing - 30 to 40 kg ha^{-1} Broadcast - 60 kg ha^{-1}	Broadcast - 60 kg ha^{-1}
Seed treatment	Seed treatment with fungicide	Not practiced
Weed management	Weeding as necessary	No weeding
Basal fertilizer used	Urea 50 kg ha^{-1}, Triple super phosphate 125 kg ha^{-1}, Potash 60 kg ha^{-1}, Gypsum 125 kg ha^{-1}	Basal - Not practiced
Foliar fertilizer used	4 times for the whole season	2-12 times for the whole season
Pesticide used	As necessary based on scouting	2-12 times for the whole season
Fungicide used	As necessary	1-4 times for the whole season

Data Collection

Two sites, each of 1 m^2 were sampled randomly from each plot at harvest time and plant population (m^{-2}) was determined. Using five tagged sample plants from each plot the number of pods $plant^{-1}$ and yield (g $plant^{-1}$) was recorded. The 100 seeds weight (g) per plot was also recorded.

Economic Analysis

Total cost of production incurred to economic returns from the crop, Gross monetary return, Net monetary return and Benefit Cost ratio were calculated (Cimmyt and Cimmyt, 1988).

B : C ratio = Net monetary returns (MMK ha^{-1}) / Cost of cultivation (MMK ha^{-1})

Statistical Analysis

All relevant data were subjected by using the Statistix 8 program and sample mean comparisons were computed using Least Significant Difference (LSD) at 5% level.

RESULTS AND DISCUSSION

Plant Population (m^{-2})

Plant population (m^{-2}) at harvest shows statistically significant differences for the crop management practices applied to the pulse varieties tested in both study areas (Table 3 and Table 4). Because of the broadcast sowing method farmers' practice, plant population at harvest may be greater than areas where was sown usint the recommended line sowing method. Although plant population (m^{-2}) for the mungbean varieties tested was not affected by crop management practices, significant differences occurred for black gram varieties tested.

Table 3 Yield and yield components of mungbean at Thongwa Township

Treatments	Plant m^{-2}	Pods $plant^{-1}$	100 Seed weight (g)	Yield $plant^{-1}$ (g)
Practices (A)				
GAP	33 b	14.81 a	5.55 a	3.62 a
Farmers' practices	48 a	11.69 b	5.24 b	2.48 b
$LSD_{0.05}$	4.2	2.37	0.04	0.62
Variety (B)				
Yezin-1	44 a	13.87 a	5.17 c	3.17 ab
Yezin-9	44 a	12.50 a	5.84 a	2.89 bc
Yezin-11	43 a	12.25 a	5.22 bc	2.34 c
Yezin-14	28 b	14.37 a	5.35 b	3.81 a
$LSD_{0.05}$	3.2	2.49	0.17	0.48
Main	**	*	**	*
Sub	**	ns	**	**
Practices × Variety	ns	ns	ns	ns
CV% (a)	9.40	15.94	0.61	22.54
CV% (b)	7.68	17.89	3.08	20.90

There was a statistically significant difference for the number of pods $plant^{-1}$ depending on crop management practices for mungbean, however, not so for black gram (Table 3 and Table 4). Perhaps aeration among mungbean plants in line sowing may induce the bearing of more pods $plant^{-1}$ than broadcast sowing. Although the number of pods $plant^{-1}$ showed no significant difference for the pulse varieties tested, the Yezin-6 black gram variety attained the highest number

of pods plant^{-1} (Fig. 2b). Also, the number of pods plant^{-1} for the tested major pulse varieties crop were not affected by the different management practices.

Number of Pods Plant^{-1}

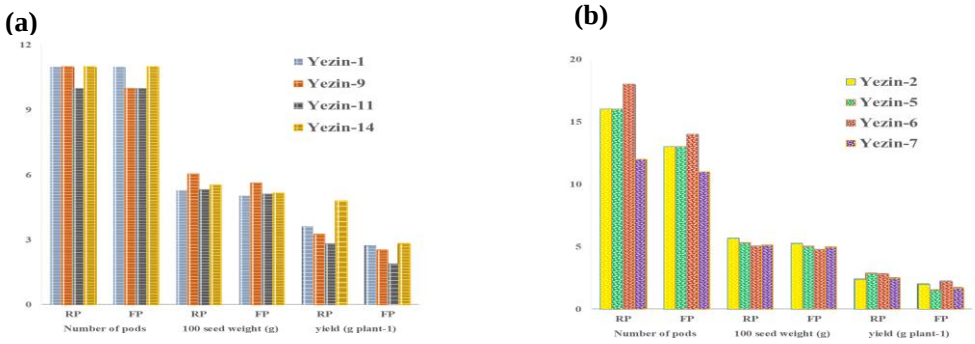

Fig. 2 Effect of recommended practices (RP) and farmers' practices (FP) on yield and yield components of (a) mungbean and (b) black gram

100 Seeds Weight (g)

There was a statistically significant difference for 100 seeds weight for the mungbean varieties tested as a result of different crop management practices (Table 3). Consistent with the varietal characteristic of Yezin-9, the highest 100 seeds weight was recorded for this strain (Fig. 2a). Though the 100 seeds weight among black gram varieties did show significantly difference, Yezin-6 exhibited the lowest 100 seeds weight (Fig. 2b).

Table 4 Yield and yield components of black gram at Pyinmana Township

Treatments	Plant m^{-2}	Pods plant^{-1}	100 Seed weight (g)	Yield plant^{-1} (g)
Practices (A)				
GAP	31 b	15.56 a	5.28 a	2.63 a
Farmers' practices	57 a	12.94 a	5.00 a	1.85 a
LSD$_{0.05}$	4.4	5.21	0.66	0.91
Variety (B)				
Yezin-2	47 a	14.50 ab	5.46 a	2.18 a
Yezin-5	45 a	14.62 ab	5.16 ab	2.18 a
Yezin-6	45 a	16.25 a	4.90 b	2.51 a
Yezin-7	39 b	11.62 b	5.05 ab	2.09 a
LSD$_{0.05}$	5.3	3.90	0.51	0.43
Main	**	ns	ns	ns
Sub	*	ns	ns	ns
Practices × Variety	*	ns	ns	ns
CV% (a)	8.86	32.51	11.43	36.15
CV% (b)	11.46	26.08	9.43	18.40

Yield Plant^{-1} (g)

For the mungbean varieties, yield plant^{-1} (g) there was a statistically significant difference according to crop management practice employed (Table 3). Mungbean variety of Yezin-14 attained the highest yield plant^{-1} (g) and the lowest was recorded in Yezin-11. On the contrary, although there was no significant difference observed for black gram varieties tested under different crop management practices, the lowest yield plant^{-1} (g) was observed for farmers'

practices (Table 4). It is evident that plant population at harvest has a significant effect on pods plant^{-1}, seed weight and yield plant^{-1} for both mungbean and black gram varieties tested in the study (Table 5).

Table 5 Correlation between crop management practices and yield components of mungbean and black gram

Green gram	Plant population	Pods plant^{-1}	seeds weight	Black gram	Plant population	Pods plant^{-1}	seeds weight
Pods plant^{-1}	- 0.531 **			Pods plant^{-1}	- 0.237		
Seed weight	- 0.283	0.119		Seed weight	- 0.200	0.438 *	
Yield plant^{-1}	- 0.643 **	0.345	0.045	Yield plant^{-1}	- 0.671 **	- 0.093	- 0.254

Economic Analysis

Table 6 reveals that a higher benefit cost ratio (B:C) of 1.16 and 0.90 were recorded for mungbean and black gram production respectively, using farmers' practices. Because of the lower market price of black gram compared to that of mungbean, black gram production has the lower benefit cost ratio. The results clearly indicate that the market price of the crops significantly influence the net monetary returns for farmers.

Table 6 Effect of crop management practices on economic of mungbean and black gram

(MMK ha^{-1})	Mungbean		Black gram	
	Recommended practices	Farmers' practices	Recommended practices	Farmers' practices
Cost of cultivation	643,900	562'100	606,400	411,250
Gross monetary return	1,155,000	1,216,875	631,250	781,250
Net monetary return	511,100	654;775	24,850	370,000
Benefit cost ratio (B:C)	0.79	1.16	0.04	0.90

CONCLUSION

On the basis of the findings of one-year field investigation for both study areas, it can be concluded that more yield (g plant^{-1}) was obtained for mungbean varieties grown according to recommended practices than those grown using farmers' practices. In contrast, there was no significant difference for black gram varieties grown under different crop management practices. Moreover, the significant effect of plant population (m^{-2}) at harvest, on yield (g plan^{-1}) for both mungbean and black gram varieties, under both recommended and farmers' practices should be considered not only to increase productivity of pulse production but also increase net monetary returns of farmers.

All mungbean varieties tested except Yezin-11 were suitable in Thongwa Township. Of those black gram varieties tested, Yezin-7 was not suitable for cultivation in Pyinmana Township. Therefore, it is necessary to investigate the recommended practices for a particular area to sustain the production of particular varieties of mungbean and black gram in that area. In addition, demonstration plots that are location-specific should be cultivated to improve farmers knowledge.

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Research article

Determination of Physicochemical Properties and Characterization of Soil from Gold Mining Areas of Kachin State, Myanmar

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Abstract This study revealed the determination of physicochemical parameters and characterization of mineral constituents of soils affected by the low-tech gold mining communities in the vicinity of Myitkyina town. The multi-increment soil samples with four replications were collected from two active mines (Location-1 and 2) and an abandoned mine (Location-3) during the first week of January 2018. Soil samples were analyzed for particle size distribution, pH, electrical conductivity, organic carbon, NH_3-N, and available phosphorus. Soluble salts of soil water extract were also examined by titration method. Then characterizations of soil mineral constituents were investigated by advanced spectroscopic techniques such as Fourier Transform Infrared Spectroscopy (FT-IR), Energy Dispersive X-ray (EDX) and Scanning Electron Microscope (SEM). The result showed that soil sample from location-1 was loam sand and the other two soil samples were sand textural class. Soil pH, electrical conductivity, organic carbon, and available phosphorus were significantly different among the three gold mining areas whereas NH_3-N content was not different by the gold mining. There was a high soluble salt accumulation in all locations. The highest soluble salt was Ca^{2+} followed by Mg^{2+}. It was found that iron (Fe) contained as the highest relative amount in the soil which could exist with gold altogether and the second largest amount was given by titanium (Ti).

Keywords physicochemical parameters, mineral, FT-IR, EDX and SEM

INTRODUCTION

Sand and gravel are produced economically from the bank and floodplains of river. Gold mining on the sand body of these areas can cause the damage of water table and distribution of sand structure. After taking some time, water way alters as a result of erosion and deposition of sand structure. Too much extraction of sand and gravel from rivers, streams, floodplains and channels for the construction of civil development and gold mining effects the ecosystems and functions of natural water resources. Most of water pollutants are closely related with the methods and machineries of gold mining. Among the gold mining, sand and gravel mining becomes the most treat to sustain the nature of the river and its surrounding area. It is also regarded as the current global issue and gradually increased with the reduction of fisheries, recreation and the stability of river channels (Images Asia and Pan Kachin Development Society, 2004). Much work has been carried out to access the environmental impacts of sand and gravel (Ako et al., 2014; Enkhzaya et al., 2016; Eludoyin et al., 2017). Artisanal mining is mainly based on the tools and manual activities by production small amounts of gold and minerals (Canaveslo, 2014). Informal procedure of gold mining associated hazardous water place, land structure degradation and contamination with heavy toxic minerals (Emel et al., 2011).

The research reported an investigation on the physical and chemical characteristics of soil from three riverbank gold mine sites near to Myitkyina Township (Fig. 1). Hydraulic mining and

traditional panning techniques were observed in the study site for Location-1. Placer mining and traditional panning methods were applied in the Location-2. The selected study site for Location-3 was on abandoned mine area. There was a comparison between the characteristics of soil from two active mines, and those of abandoned mine. Lode gold districts in Myanmar are presented in Table 1.

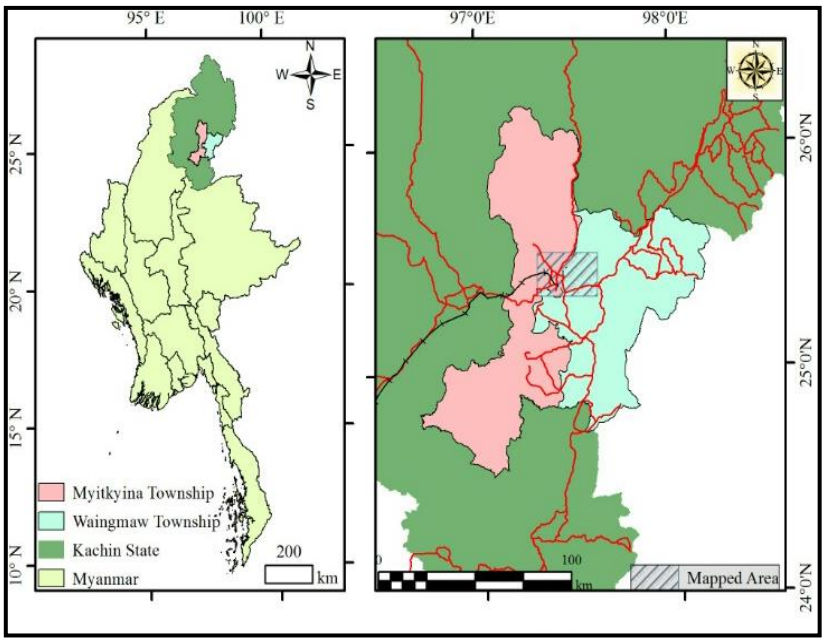


Fig. 1 Location map of study sites

Table 1 Lode gold districts in Myanmar

District	Setting	Type	Age
Wuntho and Mabein	Magmatic arc	Mesothermal veins	Latest Cretaceous
Daungyu-Monywa and Pegu Yoma	Magmatic arc and old-back	Sediment-hosted epithermal Au (As, Sb, Zn)	Miocene
Kyaukpahto-Gegalaw	Sagaing Fault	Sediment-hosted Au (Sb, As)	Late Eocene to Miocene
Phayaung Taung-Kyaikto	Proterozoic-state belt	Sandstone-hosted Au(Cu)	Jurassic to Paleocene
Thabyu	Fold-thrust belt	Sediment-hosted Sb (Au, As)	Post-Jurassic
Shante and Pyinmana	Medial metamorphic belt	Mesothermal (Au, Zn, Pb and Au)	Post-Cretaceous
Putao-Taungkamauk	Wuntho arc segment	High sulphidation Au(Cu)	Miocene
Mt Victoria-Kawlum	E Chin Hills antiform	Listwaenite Au	Upper Cretaceous-Paleocene

OBJECTIVES

The objective of this research was to determine physicochemical properties of soils affected by artisanal gold mining areas on the Irrawaddy riverbank in the vicinity of Myitkyina, Myanmar.

METHODOLOGY

Study Area

All selected artisanal gold mines in the vicinity of Myitkyina town to study for this research were situated on the Irrawaddy riverbank and therefore only sub-soil samples within two to six feet were collected. Soil samples were collected from Makawnyan (Latitude 25° 27.31' N and Longitude 97° 26.639' E) (designated as Location-1), Labanrosana (Latitude 25° 28.492' N and Longitude 97° 27.231' E) (designated as Location-2) and Thida-Aye (Latitude 25° 25.009' N and Longitude 97° 25.144' E) (designated as Location-3) as shown in Fig 2, 3, and 4, respectively.

Fig. 2 Location-1

Fig. 3 Location-2

Fig. 4 Location-3

Preparation of Multi-increment Soil Samples and Analysis

The individual soil increment collected was spaced out across each gold mining location as shown in Fig. 5. Ten individual soil samples or "increments" collected from each location were combined in one container to make up a multi-increment soil sample. Two other soil increments were also combined into two separate sample containers. Ten multi-increment soil samples were collected from each location during the first week of January, 2018. Then, the soil samples were allowed to air dry. Large lumps were broken up by hand and then the soil was ground by milling with a wooden roller. After grinding, the soil was screened through a 2 mm (10 meshes) sieve. The pH was measured by a pH meter. The electrical conductivity (EC) of the soil sample was determined electrometrically with a calibrated electrical conductivity meter. Determination of texture of collected soil sample was done by a Hydrometer method.

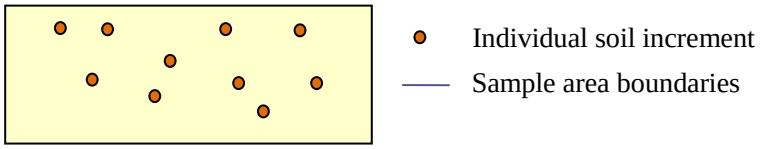


Fig. 5 Example with approximate locations of ten soil sample increments spread across the specific sample area

The determination of ammonia nitrogen (NH_3-N) and available phosphorus were done by alkaline permanganate method and Truog's method, respectively. Total organic matter contents in the soil samples were determined by titrimetric method at Soil Science Section, Department Agricultural Research, Yezin, NayPyiTaw. The determination of soluble salts such as calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}), potassium (K^{+}), carbonate (CO_3^{2-}), bicarbonate (HCO_3^{-}), sulphate (SO_4^{2-}) and chloride (Cl^{-}) were measured by titration method at the Soil Survey Section, Irrigation Department, Yangon.

The characterization of soil mineral constituents such as iron (Fe), titanium (Ti), calcium (Ca), zirconium (Zr), manganese (Mn), potassium (K), chromium (Cr), vanadium (V), yttrium (Y), strontium (Sr), niobium (Nb), silicon (Si) and gold (Au) and morphological structures were investigated by advanced spectroscopic techniques such as Fourier Transform Infrared Spectroscopy (FT-IR), Energy Dispersive X-ray (EDX) and Scanning Electron Microscope (SEM) at the Applied Geology Department, Yangon.

Statistical Analysis

Differences among the three gold mining locations were analyzed by one-way analysis of variance for each parameter and mean comparison among them were compared by least significant different (LSD) method at 5% level. All data analysis was done using STAR software and Microsoft Excel program (2010).

RESULTS AND DISCUSSION

Soil Physicochemical Properties in Gold Mining Areas

In textural analysis, it was found that soil from Location-1 was loam sand textural class while other two soil samples from Location-2 and 3 were sand class (Table 2). All soil samples showed similar pH values and nearly neutral in all locations (Table 3). Among all soil samples, Location-1 had low electrical conductivity (25.00 µmhos/cm) than Location-2 (32.80 µmhos/cm) and Location-3 (31.10 µmhos/cm).

NH_3-N, available phosphorus and organic matter contents were found in Table 4. All soil samples showed similar NH_3-N contents in all locations as indicating that there was no significant different among three gold mines. Location-1 gave the high available P and soil organic matter contents than others Location-2 and 3.

Table 2 Textural analysis in three gold mining areas

Location	Composition			
	Sand (%)	Silt (%)	Clay (%)	Texture class
Location-1	75	12	13	Loam sand
Location-2	89	9	2	Sand
Location-3	89	9	2	Sand

Table 3 Physicochemical properties in three gold mining areas (mean±S.E., n=4 per location)

Location	pH	EC (µmhos/cm)	Color
Location-1	7.43 ±0.03 a	25.00 ±0.13 c	Yellow
Location-2	7.25 ±0.03 b	32.80 ±0.36 a	Grey
Location-3	7.30 ±0.04 b	31.10 ±0.39 b	Grey

Mean values followed by different letters in the same column are not significantly different at 5% level by the LSD test

Table 4 Chemical properties in three gold mining areas (mean±S.E., n=4 per location)

Location	NH_3-N (ppm)	Available P (ppm)	Organic matter (%)
Location-1	6.39 ±0.01 a	5.07 ±0.14 a	0.71 ±0.02 a
Location-2	6.39 ±0.01 a	4.50 ±0.09 b	0.55 ±0.01 b
Location-3	6.37 ±0.01 a	4.30 ±0.10 b	0.52 ±0.02 b

Mean values followed by different letters in the same column are not significantly different at 5% level by the LSD test

Table 5 Soluble salt contents (cations) in the gold mining areas (mean±S.E., n=4 per location)

Location	Na^+	Ca^{2+}	Mg^{2+}	K^+
	meq/100 g of soil			
Location-1	0.22 ±0.01 a	4.01 ±0.06 a	0.98 ±0.03 b	0.10 ±0.01 b
Location-2	0.22 ±0.02 a	2.40 ±0.02 b	1.46 ±0.02 a	0.05 ±0.01 c
Location-3	0.20 ±0.02 a	2.31 ±0.02 c	1.01 ±0.06 b	0.12 ±0.01 a

Mean values followed by different letters in the same column are not significantly different at 5% level by the LSD test

There could be observed that a high soluble salts accumulation in all locations (Table 5 and 6). Soil sample from Location-1 showed the highest soluble salt, Ca^{2+} with the amount of 4.01

meq/100g of soil whereas the lowest SO_4^{2-} with the amount of 0.011 meq/100g of soil among the tested soil samples. Similarly, Location-2 and Location-3 also showed that the highest Ca^{2+} with the amount of 2.40 and 2.31 meq/100g of soil, respectively, while the lowest value of SO_4^{2-} was found with the amount of 0.011 meq/100g of soil.

Table 6 Soluble salt contents (anions) in the gold mining areas (mean±S.E., n=4 per location)

Location	CO_3^{2-}	HCO_3^-	SO_4^{2-}	Cl^-
	meq/100 g of soil			
Location-1	Non-detectable	0.60 ±0.009 a	0.011 ±0.003 b	0.18 ±0.020 a
Location-2	Non-detectable	0.40 ±0.013 b	0.011 ±0.003 a	0.09 ±0.010 b
Location-3	Non-detectable	0.41 ±0.011 b	0.011 ±0.003 b	0.09 ±0.011 b

Mean values followed by different letters in the same column are not significantly different at 5% level by the LSD test

Characterization of Soil Samples from Three Gold Mining Areas

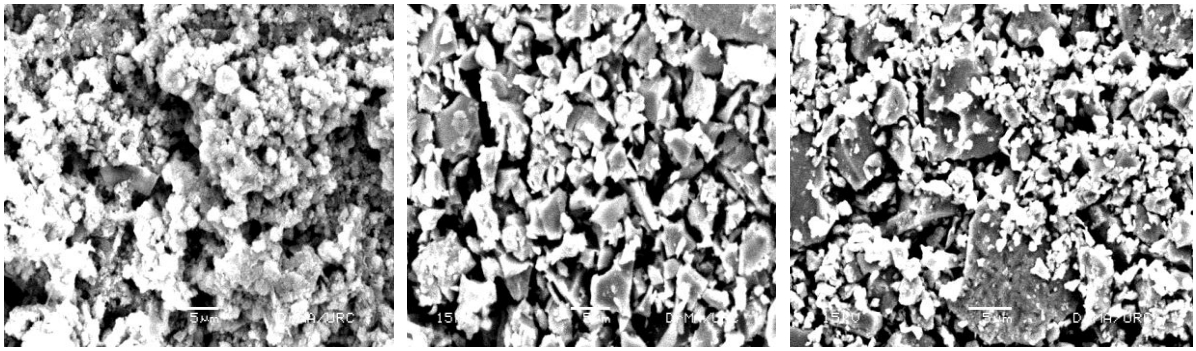
Shwe-chi in Myanmar which was finally obtained by traditional panning method was applied for the characterization of soil samples. All features appearing in the FT-IR spectral data pointed out a variety of Fe–O, Ti–O, Ca–O and Zn–O stretching and bending vibrations. According to Energy-Dispersive X-ray spectral data, all soil samples gave the highest relative proportion of Fe mineral in (Table 7). It was followed by Ti and then Au had the lowest proportion among the mineral constituents.

Table 7 Proportion of mineral constituents of soil sample in three gold mining areas

No.	Analyte metal	Location-1	Location-2	Location-3
		Per cent		
1	Fe	77.040	84.325	86.700
2	Ti	7.590	6.977	7.163
3	Ca	3.707	3.860	2.811
4	Zr	1.498	2.371	1.028
5	Mn	0.965	0.957	1.192
6	K	0.528	0.504	0.347
7	Cr	0.412	0.358	0.232
8	V	0.373	0.330	0.354
9	Y	0.172	0.130	0.058
10	Sr	0.077	0.131	0.113
11	Nb	0.058	0.058	-
12	Si	7.579	-	-
13	Au	0.001	-	0.001

The SEM microimage (Fig. 6) showed that the minerals were composed mostly of aggregates with sizes generally within 5 μm and indicated homogeneous distribution of granules throughout soil sample in Location-1. The SEM microimages also showed that the surface soils from different locations indicated that the minerals in these soil samples were composed of aggregates of different particles as given in the figures of Location-2 and 3 (Fig. 6) with no specific regular morphological structure. SEM micro-images indicated clearly the different soil morphologies between the loam sand and sand textural classes.

According to EDX analysis on three soil samples, Fe showed its highest relative amounts of (77.040%, 84.325% and 86.700%) and it was followed by the amount of Ti, (7.590%, 6.977% and 7.163%) respectively. Ca and Zr composed together with intermediate amount and K, Cr, V, Y, Sr, Nb and Au minerals were observed as the lowest constituents of these soil samples.



Location-1 **Location-2** **Location-3**

Fig. 6 SEM micro-images of Locaton-1, 2 and 3

CONCLUSION

According to the analyses of this study, riverbank sand mining can cause not only physical properties such as pH, EC, color and texture and destruction of the original landscape of the area and collapse of riverbank but also chemical effects like water pollution with many mineral contaminants from mine running off into river water and wetlands.

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Research article

Functional Evaluation of Groundwater Level Decrease in Non-sloped Subsurface Drainage Systems in Upland Field on Peatland

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Abstract In lowland farmland, the maintenance cost of conventional inclined subsurface drainage systems is high because the drainage pipes must be laid at depth, or the tile deepens as the farm field enlarges. To reduce the maintenance cost, the Hokkaido Provincial Government of Japan has introduced a subsurface drainage system with a smaller inclination angle than the conventional method. However, the drainage effects of non-sloped subsurface drainage systems have been rarely reported, and insufficient evidence has prevented their widespread acceptance. The present study investigates how the slope of the drainage pipe influences the groundwater-level decrease in poorly drained fields. The survey was conducted in the upland field on peatland located in the Ishikari River Basin, Hokkaido. In 2015, two types of subsurface drainage systems were constructed in the same lot: a conventional subsurface drainage (sloped area) system, and a subsurface drainage system with low inclination (non-sloped area). After measuring the groundwater level at 12 points and the precipitation from 2016 to 2017, we found that: i) the groundwater level was higher in the non-sloped area than in the sloped area, ii) between 2016 and 2017, the groundwater level decreased in the sloped area and rose in the non-sloped area. The above results suggest that the efficiency of decreasing the groundwater level during 3 years after the construction was lower in non-sloped subsurface drainage than in sloped subsurface drainage, which is different from that observed in the previous study.

Keywords subsurface drainage, groundwater level, large-scale field, peatland

INTRODUCTION

In some developed countries, including Japan, the economic growth of the agricultural industry has declined while that of the secondary and tertiary industries has increased. This problem has severely affected rural communities in Japan. Maintaining agricultural production and enhancing the competitiveness of agriculture are urgent demands in Japan's agricultural policy. As the farming population decreases, agricultural production must be maintained by astute agricultural business, improvement of work efficiency, and labor-saving measures. As a precondition of arresting this decline, the enlargement of farm fields has been promoted. Subsurface drainage has been widely implemented for improving the yield and quality of farm products. In the future, the competitiveness of agriculture must be bolstered by lowering the installation cost of facilities and constructing irrigation and drainage systems, including subsurface drainage systems.

In Hokkaido, northern Japan, lowland farmlands developed from peatland are widespread, and subsurface drainage is employed to improve the soil condition. Recently, the average field size has progressively enlarged to enhance the productivity. Deeper pipes and ditches are needed to install conventionally sloped subsurface drainage pipes in large fields, which increases the implementation cost. In an attempt to alleviate this problem, subsurface drainage pipes with no inclination (<1/600) have been trialed in a suitable geographical feature (Koshiba et al., 2005). However, as very few studies have evaluated the function of non-sloped subsurface drainage, the practicality of this approach is currently unknown. Non-sloped subsurface drainage reduces over time as the drainpipes become uneven and accumulate soil sediments. Koshiba et al. (2005) reported no significant malfunction caused by pipe sedimentation and unevenness after five years' implementation of non-sloped subsurface drainage in a farm field with sandy loam soil. They also reported the same drainage through non-sloped and sloped pipes. They concluded that non-sloped pipe drainage effectively reduces the installation cost (Koshiba et al., 2005).

However, the functioning of non-sloped subsurface drainage has not yet been investigated in Hokkaido, where peat layer is distributed. Peat is an organic-rich soil consisting mainly of undecomposed plant material, which accumulates in saturated environments. Such environments require intense drainage to reach suitable conditions for agriculture, but owing to their unique composition, inevitably subside under agricultural drainage and artificial loading. Armstrong and Castle (1999) stated that peat subsidence frequently misaligns the drainpipes and inverts the gradient along the pipes. They also mentioned that because peat is rich in iron, pipes laid in peatland are often clogged with deposits of iron ochre, an orange-colored mud made of iron compounds (Armstrong and Castle, 1999). The question remains whether non-sloped drainage performs well in peatlands, where the drainage conditions are difficult. Therefore, to evaluate the function of non-sloped subsurface drainage on peatland fields, this study compares the groundwater-level changes in conventional (sloped) and non-sloped pipe subsurface drainage systems installed in the same field.

METHODOLOGY

Overview of the Research Site

The study was carried out in an upland field in Iwamizawa (43°12′ N, 141°43′E), located in the east of the Ishikari plains in Hokkaido (Fig. 1). The mean annual temperature and precipitation are 7.6°C and 1,163 mm, respectively. In the research field, the peat layer underlies a 30 cm-thick upper artificial soil. In August of 2015, subsurface drainage pipes with low inclination were installed in one-half of the field (forming the non-sloped area), and conventional subsurface drainage was implemented in the other half (sloped area) (Fig. 2). This setup permits a performance comparison between the drainage experiment and a control experiment with a different drainpipe slope in the same lot. The field size is 1.1 ha, and onions were grown from May to August in 2016 and 2017. The drainpipes are buried 70 cm below the surface at 9-m intervals. In the sloped area, the drainpipes are inclined at 1/500, and their diameter is 60 mm (versus 80 mm in the non-sloped area). This difference in diameter is based on the design criteria. The drainpipes are filled with gravels. Prior to cultivation, the subsoil was broken to improve the drainage.

Survey Equipment

The precipitation in the field was measured hourly by a tipping-bucket rain gauge with a diameter of 20 cm (HOBO event, Climatec Incorporated, Tokyo, Japan) placed near the study field. Groundwater-level gauges for absolute pressure measurements (S & DL water level, Oyo Corporation, Tokyo, Japan) were set at six points (five between the drainpipes, and one just above the drainpipe) in both the sloped and the non-sloped areas, giving 12 observation points in total (Fig. 2). The groundwater level was measured every 30 minutes. The measured absolute pressures were converted to gauge pressures by a barometer installed near the field.

Fig. 1 Location of the research site

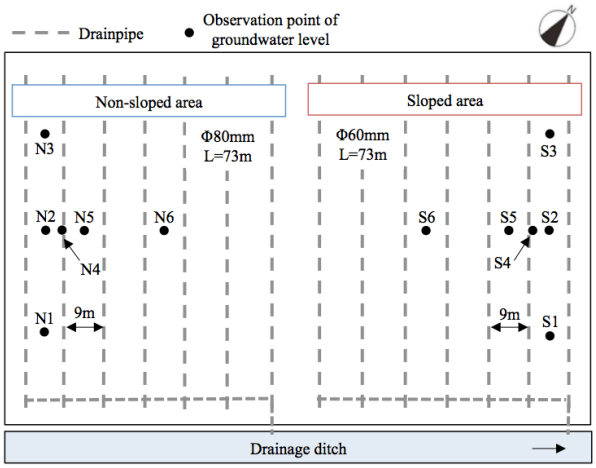


Fig. 2 Overview of the research site

Evaluation Method

The groundwater level generally rises immediately after rainfall, and gradually declines after the rain. The drop-down phase depends on the characteristics of the draining process. From the obtained rainfall data and the groundwater levels in the field investigations, we evaluated the following contents: i) groundwater-level dynamics, ii) groundwater-level drop response after a rainwater-induced rise in the groundwater level, and iii) achievement rate of the design target set by Hokkaido Prefecture Agricultural Administration Department. The subsurface drainage efficiency was evaluated by comparing the rainfall-related contents and groundwater table fluctuations in the sloped and non-sloped areas. We also evaluated the time-series changes in the function of each drainage system by comparing the results of 2016 and 2017. The observation data from June to mid-August in 2016 and 2017 were used for the drainage evaluation. For determining the drainage efficiency, we defined the following terms.

Groundwater level: Vertical distance from the ground surface to the groundwater table at each observation point.

Rain event: Rainfall within 24 hours of the rainfall start is regarded as a *rainfall series*. Rainfall of 1 mm/h or more within 24 hours after the rain stopped was included in the same event. Rain events with a total rainfall of 10 mm or more were used in the evaluation.

Amount of groundwater level increase: The groundwater-level difference between immediately before the rain event and the highest water level during the rain event.

Amount of groundwater level drop: The groundwater-level difference between the highest water level during the rain event and the lowest water level after the rain event.

Groundwater level drop rate: The ratio of the amount of groundwater level drop to the amount of groundwater-level rise after the rain event.

RESULTS AND DISCUSSION

Fluctuation of Groundwater Level

The drainage was evaluated by comparing the fluctuations in the groundwater levels at each observation point. The results are presented as box plots. Fig. 3 shows the distribution of groundwater levels at six observation points located at the same distance from the drainage ditch (N2, N5, N6, S2, S5, S6) in 2017. Comparing the fluctuations in groundwater levels in 2017, the fluctuation range of groundwater levels at N5 tended to be narrower than other points. The groundwater fluctuations except N5 remained at a higher level in the non-sloped area than in the

sloped area. Fig. 4 compares the distributions of groundwater level at the above-mentioned six observation points in 2016 and 2017. The 2016 survey result confirmed the high performance of the non-sloped subsurface drainage relative to the sloped system, similar to previous studies (e.g. Koshiba et.al., 2005). However, the groundwater distribution in the non-sloped area was higher in 2017 than in 2016. In contrast, the groundwater in the sloped area was lower in 2017 than in 2016, possibly because the subsoil was broken by subsoiler before tilling in 2017, and the precipitation was lower in that year than in 2016. However, despite the same climate conditions and the same farming method in both areas, subsoil breaking exerted no effect in the non-sloped area. This suggests that, for some reason, the subsurface drainage functioning (maintenance of low-level groundwater) was lower in the non-sloped area than in the sloped area.

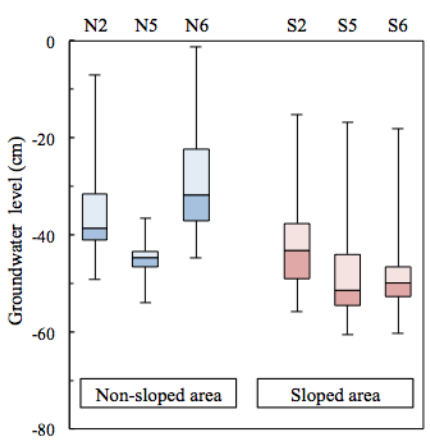
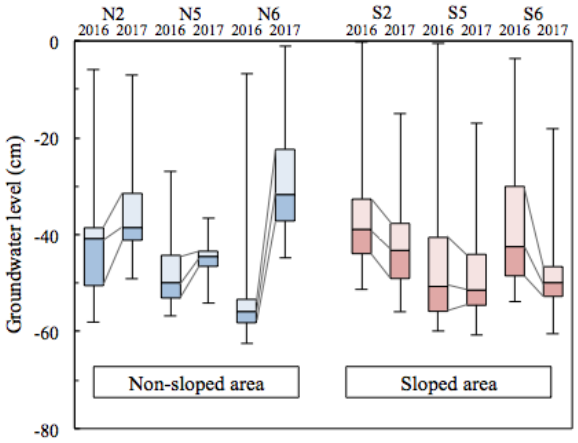


Fig. 3 Groundwater level changes at 6 observation points in 2017



The top and bottom extremes of the whiskers indicate the maximum and minimum groundwater levels, respectively, and the segment inside the box is the median groundwater level. The lower and upper base lines of the boxes indicate the first quartile (25th percentile) and third quartile (75th percentile), respectively.

Fig. 4 Comparison of groundwater-level fluctuations between 2016 and 2017 at 6 observation points

Rain Response of Groundwater Level

In a properly functioning drainage system, the raised groundwater table quickly falls after the rainfall cessation. The drainage function was evaluated by relating the rises and falls in the groundwater level after several rain events. The evaluation was performed at 10 observation points (N1, N2, N3, N5, N6, S1, S2, S3, S5, S6) located between the drainage pipes. Points located above the drainage pipes (N4, S4) were excluded because their locations relative to the drainpipe differed from those of the other points. Figs. 5 and 6 plot the groundwater-level drop versus the groundwater-level rise at 24 and 72 hours, respectively, at all observation points after each rain event. The average groundwater-level drop rate over all rain events and observation points can be determined from the regression coefficient; when the regression line is steep, the soil is well drained after the rainfall-induced rise in groundwater level. The drainage efficiencies were compared by comparing the steepness of the regression lines between the sloped and the non-sloped areas, or between 2016 and 2017. The statistical significances of the groundwater-level drop rates were assessed by a 2-sample *t*-test at the 95% confidence level.

We first compared the drainages in the sloped and non-sloped areas in 2017. As shown in Fig. 5, the gradient of the regression line was smaller in the non-sloped area than in the sloped area. In the sloped area, 67% of the groundwater level raised by rainfall (on average) was withdrawn within 24 hours, versus 52% in the non-sloped area. The groundwater-level drop rate was significantly higher in the sloped than in the non-sloped area (2-sample *t*-test; $p < 0.01$). At 72 hours following the rain events, the groundwater drop rates were statistically the same (2-sample *t*-test; $p > 0.1$). The results imply that immediately after the rain events, the drainage system with sloped pipes better withdrew the groundwater level than the drainage system with level pipes.

Next, the time-series changes of drainage function in the non-sloped area were compared between 2016 and 2017. At 24 hours following the rain events, the groundwater-level drop rate was smaller in 2017 than in 2016, and the reduction was significant (2-sample *t*-test; p <0.01). The same result was obtained at 72 hours following the rain events (Fig. 6). Specifically, the groundwater level at 72 hours following the rain events dropped by 100% in 2016 (meaning that the groundwater level had recovered to its pre-rain level within 72 hours), but reduced by only 82% in 2017. In the sloped area, a reduction in the groundwater-level drop rate between 2016 and 2017 (from 96% to 85%) was found only at 72 hours following the rain events. If it is assumed that there are no differences in soil physical properties based on farming operations, the decline of the subsurface drainage function after rainfall was more conspicuous in the non-sloped area than in the sloped area, implying that inclining the drainpipes plays an important role in maintaining drainage function.

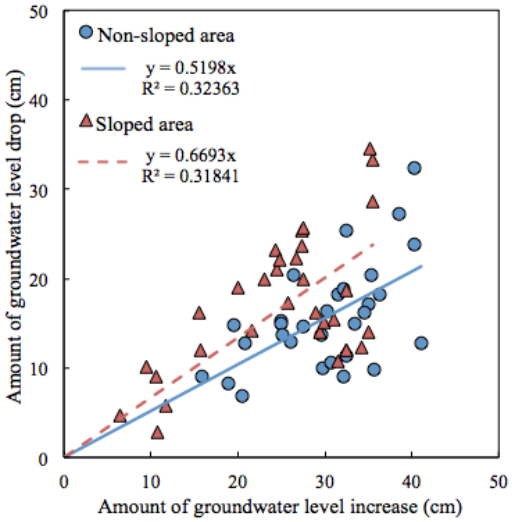


Fig. 5 Relationship between rise and fall in groundwater level at 24 hours after rain events in 2017

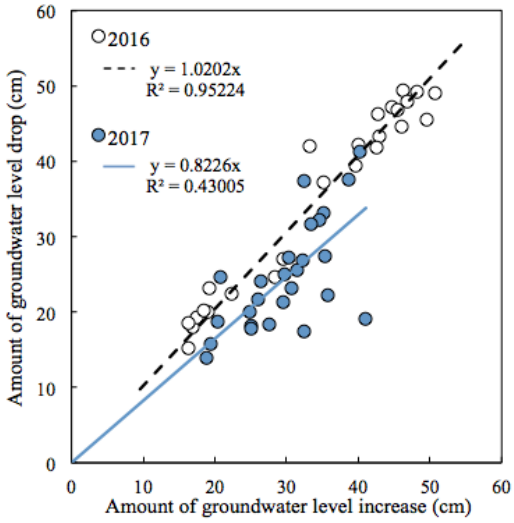


Fig. 6 Relationship between rise and fall in groundwater level at 72 hours after rain events in the non-sloped area

Achievement Rate of the Groundwater Level Standard

Table 1 Achievement rates of groundwater-level standard

		2016	2017
Non-sloped area	N1	100%	63%
	N2	86%	38%
	N3	100%	63%
	N4	100%	—
	N5	100%	100%
	N6	100%	0%
	Avg.	**97%**	**53%**
Sloped area	S1	100%	100%
	S2	43%	63%
	S3	71%	100%
	S4	100%	100%
	S5	100%	100%
	S6	86%	100%
	Avg.	**83%**	**94%**

The desired groundwater level has been set as a design target of subsurface drainage systems. According to the Hokkaido Prefecture Agricultural Administration Department (2010), a well-

designed groundwater level should be −60 to −50 cm under dry conditions, and −50 to −40 cm at two or three days after cessation of a rain event. However, during the observation period of the present study, the no-rainfall periods rarely continued for more than seven days; therefore, we decided to set the standard for a well-functioning groundwater level below −40 cm at 72 hours after cessation of a rain event. The achievement rate of this standard was calculated at each observation point, and used in the drainage-efficiency evaluation. Table 1 lists the achievement rates at all observation points in 2016 and 2017. The achievement rates and averages in the sloped area improved from 2016 to 2017. On the other hand, many points in the non-sloped area showed low achievement rates in 2017, and the average achievement rate was considerably decreased from that of 2016 in spite of subsoil breakage. Furthermore, the achievement rate was higher in non-slope area than in the sloped area in 2016; therefore, it seems that pipe inclination is not a direct cause of the decrease in the subsurface drainage function. From these results, we considered that some factors, except for soil physical changes, influencing drainage function decline may have occurred by the elapsed time since the construction. Thus, the cause of drainage function decline may be related to changes in conditions inside the pipe, similar to water pass prevention due to sediment accumulation.

CONCLUSION

The present study investigated how the slope of the drainage pipe influences the groundwater-level decrease in poorly drained fields on peatland located in the Ishikari River Basin, Hokkaido. After measuring the groundwater level at 12 points and the precipitation from 2016 to 2017, we found that: (i) the groundwater level was higher in the non-sloped area than in the sloped area; (ii) between 2016 and 2017, the groundwater level decreased in the sloped area and increased in the non-sloped area; and (iii) the drainage efficiency in the non-sloped area tended to decrease after 3 years of installation.

The 2017 findings revealed a large difference between the groundwater behavior in the sloped and non-sloped areas, although the same farming method was implemented in both areas, and the drainage function obviously declined in the non-sloped area. These results contradict a previous field study conducted on loam soil (Koshiba et al., 2005). Unlike loam soil, peatlands cause special problems in subsurface drainage, such as subsidence-associated misalignment of the pipes and deposition of iron ochre (*Thiobacillus ferrooxidans* colony) in the pipe interiors. Subsurface drainage through sloped pipes may tolerate these problems because the pipe gradient increases the flow velocity of the drainage water. At sufficiently high flow velocities, the deposit is easily washed away. The gradient might also prevent misalignment and inverse gradients of the pipes. On the other hand, the non-sloped drainage may be adversely affected by these peatland characteristics. Our results implied that inclining or periodic cleaning the drainpipes is important for maintaining the performance of the drainage system.

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Research article

Identifying the Minimum Number of Observed Rainfall Events Required for Optimal TOPMODEL Parameters in Mid-sized Equatorial Catchments

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Abstract TOPMODEL, a topography-based, semi-distributed hydrological model was applied to the 84 km^2 Atari catchment in Eastern Uganda. The study sought to identify the minimum number of rainfall events needed to optimally calibrate 5 unknown parameters for yearly hydrological simulation. Model input data was daily averaged precipitation, river discharge and evapotranspiration for the year 2015 with the output being simulated discharge. A rainfall event was defined as consecutive days of effective rainfall - effective rainfall being a daily rainfall ≥ 5.0 mm. Parameterization was done for *Sequentially Accumulated Rainfall Events* (*SARE*), beginning with 1 event and sequentially progressing until all 54 observed rainfall events in the year were used. All SARE had similar starting dates with the end dates being variable. The 'true' parameters were those derived from inputting all observed rainfall events while the other instances of the parameters from partial SARE were classified as 'non-true'. Elimination criterion of 'non-true' parameters was set at an error of ±30%. Parameter values varied with the change in number of rainfall events, showing their dependence on rainfall characteristics. Downslope saturated transmissivity (T_e) and maximum root zone storage deficit (SR_{max}) were the most and least variable from their means respectively. Also, exponential decay parameter (*m)* and delay time constant (t_d) needed the least and the greatest number of rainfall events to stabilise within the ±30% error bounds respectively. Therefore, the minimum number of rainfall events required to calibrate TOPMODEL and to optimise t_d in mid-sized equatorial catchments in Eastern Uganda are equivalent. Consequently, it required at least 49 rainfall events to calibrate TOPMODEL in 2015.

Keywords calibrate, modelling, rainfall event, SARE, TOPMODEL

INTRODUCTION

Observed hydro-meteorological data are useful for irrigation and drainage planning. In areas that lack this data, hydrological models are used to predict stream discharge. One such model is TOPMODEL, a conceptual, semi-distributed hydrological model (Beven and Kirkby, 1979) that has been used worldwide. In Africa, TOPMODEL was applied in a humid tropical climate in

Nigeria (Campling et al., 2002) and in an Ethiopian catchment (Gumindoga et al., 2014). To date, the authors have not found published evidence of the application of TOPMODEL in Uganda.

Generally, Uganda has a scarcity of hydro-meteorological data, and worse still, even the available data is of poor quality, e.g., temporal gaps, unreliability, and inaccuracy of rating curves. Notably, most Ugandan rivers are ungauged, and bleaker still, only about 33% of installed water level gauging stations are currently operational (MWE, 2013).

Given the challenges above, hydrological models could come in handy. But hydrological models need calibration, a process that requires the input of observed hydro-meteorological data. For this reason, Atari catchment was chosen as a target site for the study. Unlike many catchments in Uganda, it is equipped with modern hydrological and meteorological monitoring facilities. The TOPMODEL concept was thus applied to the Atari catchment located in Eastern Uganda.

According to Coles et al. (1997); (1) Rainfall intensity influences rainfall-runoff response of a catchment, and (2) Calibrated parameters are only relevant to the rainfall event(s) that was used for their calibration. From these findings, it would be ideal to use all possible permutations of rainfall events to achieve representative parameters suitable for yearly hydrological simulations. However, given the previously mentioned observed data deficiencies in Uganda, it is necessary to have insight into the premise that limited observed data may be sufficient to calibrate model parameters which can be used for yearly hydrologic simulation. Therefore, the purpose of the study is to identify the minimum number of rainfall events required for optimal yearly TOPMODEL parameter calibration.

METHODOLOGY

Study Site

The study area is Atari, a headwater catchment of Mt. Elgon in Eastern Uganda, with a drainage area of 84 km^2 above the stream gauging station and a corresponding channel length of 33 km. Its topography is comprised of mountainous areas from where the main stream (Atari River) originates and flows to the relatively flat plains. From ASTER GDEM, the difference in height between the lowest and the highest point is 2,389 m. Of the 84 km^2, 35 km^2 (42%) is forest, 28 km^2 (33%) is agricultural area and 21 km^2 (25%) is rangeland.

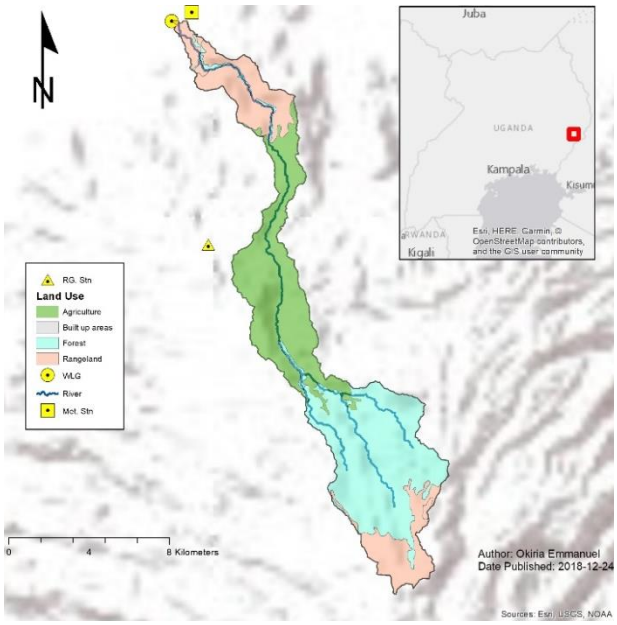

Fig. 3 Instrumentation and land use in Atari catchment

RG. Stn is rain gauge, WLG is water level gauge, Met. Stn is meteorological station

Under the Project on Irrigation Scheme Development in Central and Eastern Uganda (PISD) (JICA, 2017), hydro-meteorological monitoring equipment were set up in Atari catchment in 2015, viz., a mid-stream rain-gauge to detect catchment rainfall, a downstream meteorological station to measure evapotranspiration parameters and a water level sensor at a control section of Atari River.

TOPMODEL

1) Description of TOPMODEL

TOPMODEL is a conceptual, semi-distributed model suggested by Beven and Kirkby (1979). It divides the soil layer into root zone, unsaturated zone and saturated zone. The upper soil layers (root zone and unsaturated zone) are analysed at grid-scale as distributed models while the lower layer (saturated zone) is computed as a catchment scale lumped model. TOPMODEL evaluates the state of wetness of the surface layer of a basin from the Topographical Index (*TI*).

$$\boldsymbol{TI = ln\frac{a_i}{\tan\beta_i}} \quad (1)$$

Where a_i is upstream contributing area per unit contour length, $\tan\beta_i$ is local slope and *i* is grid number.

TI is derived from a Digital Elevation Model (DEM) and it spatially evaluates the amount of surface flow. Details of TOPMODEL are in Mukae, et al. (2017) and Beven and Kirkby (1979).

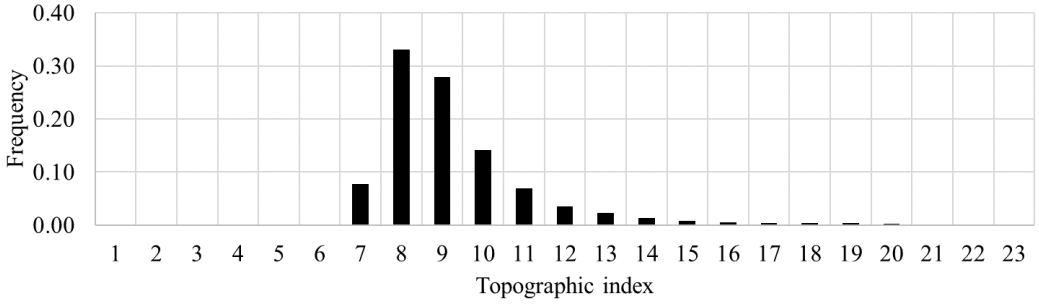

Fig. 4 Histogram of *TI* distribution for Atari catchment

2) Computational Procedure of TOPMODEL

Input data is observed daily precipitation, observed river discharge, actual evapotranspiration (ET_a) and a *TI* that is derived from 30 m grid DEM. Rainfall was measured for each event and other hydro-meteorological parameters were recorded at 10-minute logging intervals, but the daily averages were used for computation.

a. The water balance equation of the root zone:

The amount of water that is stored in the root zone is calculated from the water balance of rainfall [L], ET_a [L], maximum storage deficit in the root zone (SR_{max}) [L] and storage deficit in the root zone (*SRZ*) [L]. When *SRZ* < 0, the excess water (EX_i) flows to the unsaturated zone (SUZ_i) [L]. Potential evapotranspiration (ET_0) is calculated by the Penman-Monteith method (Allen et al., 1998). ET_a is treated as a function of ET_0, SR_{max} and *SRZ*.

$$\boldsymbol{ET_a = ET_0\left(\frac{SRZ_i}{SR_{max}}\right)} \quad (2)$$

b. The water balance equation of the saturated zone:

Base flow discharge, (Q_{sub}) [LT^{-1}] is calculated using the parameters *m*, and T_e [L^2T^{-1}], catchment mean *TI*, (λ) [-] and the mean storage deficit in the watershed $\overline{S_i}$ [L]:

$$\boldsymbol{Q_{sub} = T_e e^{\lambda\overline{S}_i/m}} \quad (3)$$

c. The water balance equation of the unsaturated zone

The unsaturated zone is a temporary water storage zone that links the root zone to the saturated zone. The mean storage deficit in the watershed at the start of the calculation (initial time step), $\overline{S}_i$ is obtained from Eq. (3), assuming that the initial discharge is Q_0 [LT^{-1}].

$$\overline{S}_i = -m \ln \frac{Q_0}{T_e e^{-\lambda}} \tag{4}$$

Like in Fig. 3, S_i [L] expresses the storage deficit of each grid and UZ_i [LT^{-1}] is the amount of water supplied from the unsaturated zone to saturated zone, with i being the grid number. Since, cells with the same value of TI are considered to be hydrologically similar, computation is done for each TI class (Fig. 2) and not for every individual grid. If S_i is ≤ 0, then the TI class is considered to be saturated, and excess water inflow from the root zone (EX_i) becomes surface flow, as shown in Fig. 3. If $S_i > 0$, the excess water inflow is temporarily added to SUZ_i.

$$UZ_i = \frac{SUZ_i}{S_i t_d} \tag{5}$$

where t_d [TL^{-1}] is the delay time constant, a parameter that expresses the period of retention.

TOPMODEL requires the calibration of 5 unknown parameters, namely; exponential decay parameter (m), mean value of downslope transmissivity when the soil is just saturated (T_e), delay time constant (t_d), maximum root zone storage deficit (SR_{max}) and initial root zone storage deficit ($SRZ_{initial}$) using the Monte-Carlo method. Nush-Sutcliffe efficiency (NS) and Root Mean Square Error ($RMSE$) are the evaluation functions adopted to compare agreement between observed and simulated discharge. Having evaluated the parameters, it is then possible to simulate river discharge following a rainfall-runoff event.

$$\mathbf{NS} = \mathbf{1} - \left(\frac{\sum_1^n EV}{\sum_1^n MV}\right) \tag{6}$$

$$\mathbf{RMSE} = \sqrt{\frac{\sum_1^n EV}{n}} \tag{7}$$

Where EV is error variance ((observed value - simulated value)^2), MV is mean variance ((observed value – mean observed value)^2) and n is number of observation days.

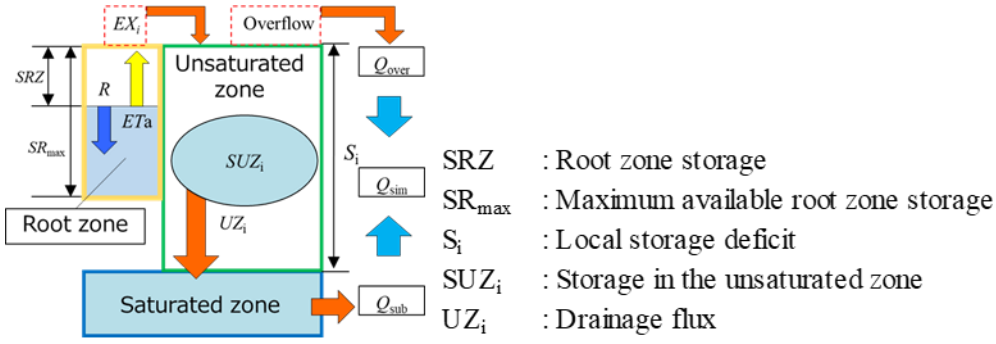

Fig. 5 Schematic of TOPMODEL (Source: Mukae, et al., 2017)

Data Requirement

The input data for TOPMODEL is precipitation, river discharge and meteorological data used to estimate ET_0. Averaged daily data for 2015 was used. A rainfall event was defined as consecutive days of effective rainfall, and effective rainfall as that daily rainfall ≥ 5.0 mm (Ali and Mubarak, 2017).

From 2015-March-24 to 2015-December-14, 54 rainfall events were observed. Correspondingly, the total amount of precipitation, evapotranspiration and river discharge was

1,646 mm, 1,149 mm and 499 mm from where it was inferred that 30% of the precipitation is discharged to the downstream via the river.

Description of Study-defined Terminologies and Methods

Table 1 is a representation of the *Sequentially Accumulated Rainfall Events* (*SARE*) concept. All the SARE had the same starting date but the end dates were variable.

The 'true' parameters were those derived from inputting *all SARE* in 2015 while 'non-true' parameters were those got by using *partial SARE* during model calibration. The 'true' parameters were considered to be optimal for full year hydrological simulation because they were assumed to represent an *average characteristic* of all observed events in 2015, which is not the case with 'non-true' parameters.

The percentage error of 'non-true' parameters was determined by comparison with the 'true' parameter value – The 'non-true' parameters with maximum error of ± 30% were classified as good and therefore close enough to 'true' value. Equation (8) shows computation of error of 'non-true' parameter,.

$$\boldsymbol{Error} = \left(\frac{\boldsymbol{ntp}-\boldsymbol{tp}}{\boldsymbol{tp}}\right) \times \mathbf{100}\% \qquad (8)$$

where *ntp* is 'non-true' parameter value and *tp* is 'true' parameter value.

Parameterisation was done for SARE beginning with the 1st event and sequentially progressing until all 54 rainfall events in 2015 were used. In total, model calibration was done 54 times. However, it was impossible to evaluate the 1st event alone since its *NS* value was infinity. Results from 1 SARE were thus omitted from further analysis.

Table 1 The SARE Concept

Rainfall event count	Sequentially Accumulated Rainfall Events (SARE)								Calculate unknown parameters (m, T_e, t_d, $SRZ_{initial}$ and SR_{max})
1	1st event							→	non-true parameter value of 1 SARE
2	1st event	2nd event						→	non-true parameter value of 2 SARE
3	1st event	2nd event	3rd event					→	non-true parameter value of 3 SARE
.	.	.	.						.
.	.	.	.						.
.	.	.	.						.
53	1st event	2nd event	3rd event	. . .	53rd event			→	non-true parameter value of 53 SARE
54	1st event	2nd event	3rd event	. . .	53rd event	54th event		→	true parameter value

Yellow indicates the partial target rainfall event(s), which is used to calculate the unknown parameters for each SARE occurrence. Orange indicates all SARE.

RESULTS AND DISCUSSION

Parameter Descriptive Statistics

Table 2 'True' and 'non-true' parameters

		m	T_e ($\times 10^6$)	t_d	$SRZ_{initial}$	SR_{max}	NS	$RMSE$
'true' value		24	762	0.013	0.006	0.008	0.57	0.73
'non-true' value	Min	18	40	0.011	0.002	0.004	0.48	0.00
	Max	53	987	0.020	0.009	0.009	0.92	0.73
	Mean	21	587	0.017	0.006	0.007	0.68	0.53
	s.d*	5	257	0.003	0.001	0.001	0.10	0.19
	CoV**	0.25	0.44	0.16	0.24	0.16	0.15	0.36

* *Standard deviation,* ** *Coefficient of variance = Standard deviation / Mean*

Table 2 shows the descriptive statistics of the calibrated parameters. 'Non-true' parameter values vary from 18 to 53, 40 to 987, 0.011 to 0.020, 0.002 to 0.009 and 0.004 to 0.009 for parameters *m*, T_e, t_d, $SRZ_{initial}$ and SR_{max} respectively. In addition, *NS* and *RMSE* varies from 0.48 to 0.92 and from

0.00 to 0.73 correspondingly. Based on the classification criterion of *NS* values by Foglia et al. (2009), the goodness of fit varies from 'good' to 'excellent'. The coefficients of variance (CoV) for 'non-true' parameters are 0.25, 0.44, 0.16, 0.24 and 0.16 for m, T_e, t_d, $SRZ_{initial}$ and SR_{max} in that order. It follows that, T_e and SR_{max} are the most and least variable respectively. It is then clear that the 5 parameters are changeable depending on the number of rainfall events.

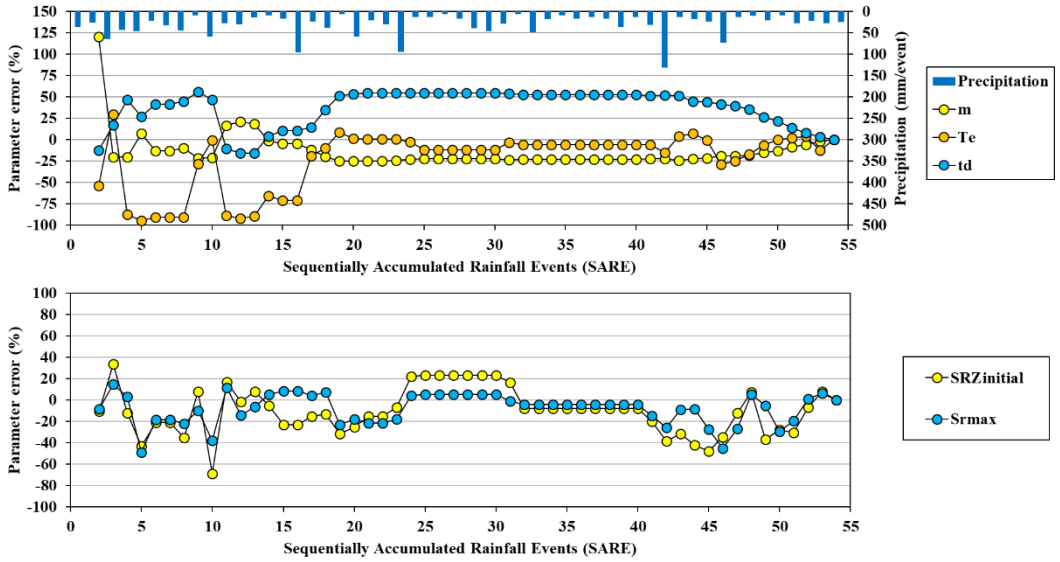

Fig. 6 Error plots of calibrated parameters

Parameter Trends

Fig. 6 is a graph of the parameter error under different numbers of SARE conditions and Fig. 5 shows the trend of evaluation functions with the number of SARE.

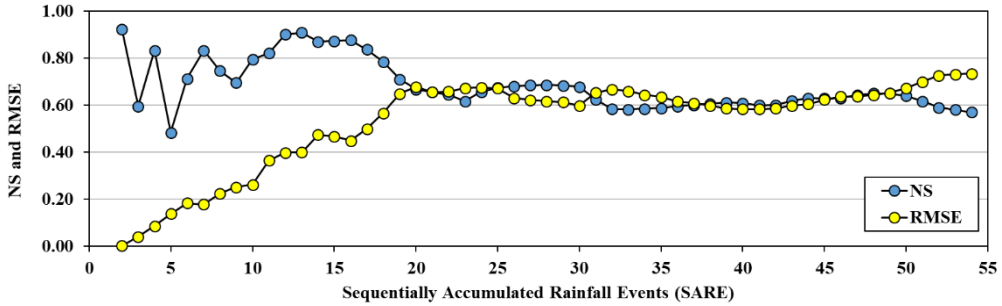

Fig. 7 Evaluation function under different SARE

The mean errors for SR_{max}, $SRZ_{initial}$, m, T_e and t_d are -8%, -10%, -13%, -23% and 37% correspondingly. It takes 3 SARE for parameter m to stabilise within an error rage of ±30%. From 1 up to 16 SARE, T_e is highly changeable, with error ranging from -95% to -54%. It requires at least 17 SARE to stabilise parameter T_e within ±30% error range. The first instance of low observed event precipitation (9.4 mm at 10^{th} event) seemed to cause T_e value to increase sharply. From 1 up to 18 SARE, t_d shows no observable trend, with error ranging from 4% to 56%. However, from 19 to 43 SARE, parameter t_d stabilises within a narrow error range of 52% to 55%. The parameter value then begins to steadily decrease at 44 SARE, eventually falling within acceptable error range at 49 SARE. Although SR_{max} and $SRZ_{initial}$ are the least variable parameters with respect to their means, there is no discernible trend of their behaviour with the number of SARE. This might be because of the gross uncertainties in calibrating soil storage deficits, as

observed by Coles et al. (1997) and Campling et al. (2002). But, different from T_e, it is seen that there is a large reduction in both SR_{max} (-38%) and $SRZ_{initial}$ (-69%) at 10 SARE.

NS and *RMSE* decrease and increase respectively with increasing SARE. It seems that as the number of SARE increases, the parameters become an average representation of many more varied rainfall characteristics, but not the best representation for each individual rainfall event.

Parameter *m* is the least affected by the rainfall events inputted while parameter t_d is the most affected, requiring at least 3 and 49 SARE respectively to stabilise within ±30% error bounds. Therefore, the minimum number of rainfall events required to calibrate TOPMODEL and to optimise t_d in mid-sized equatorial catchments in Eastern Uganda are equivalent. Consequently, it requires at least 49 rainfall events to calibrate TOPMODEL in 2015.

Summarily, it is seen that rainfall characteristics influence the parameterization of TOPMODEL in mid-sized equatorial catchments.

CONCLUSION

A hydrological model, TOPMODEL, was applied to a different number of *Successively Accumulated Rainfall Events* (*SARE*) to examine parameter sensitivity to rainfall characteristics. In this study we deduce the following: (1) Dependence of calibration parameters on rainfall characteristics was evident, with exponential decay parameter (*m*) being the least affected and delay time (t_d) being the most affected by rainfall event characteristics; Further, (2) in mid-sized equatorial catchments, t_d was the determining parameter for the minimum number of SARE needed for calibrating TOPMODEL for yearly hydrological simulation. To confirm the observations presented here, more yearly observed hydro-meteorological data and studies on other catchments is needed. Furthermore, future studies should consider hydrological conditions like base flow, rainfall intensity and effective discharge in order to better understand the effect of rainfall events.

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Research article

Effects of Earthworm Megascolicidae Population and Litter Quantity on Soil Properties in Experimental Containers

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Abstract Earthworms are important soil animals and perform vital functions in the soil that make better conditions for ecosystem, especially agriculture. Earthworms are involved in decomposing organic matters and mineralizing nutrients, controlling populations of pathogens, improving and maintaining soil structure and mixing organic matters in the soil. In this study, we discussed the effects of earthworm population and litter quantity on soil properties. Earthworm from the family of Megascolicidae was used in this study which is a native family of earthworm in Japan and accounts for more than 95% of earthworm family there. Experimental containers were set in the laboratory where earthworm population and litter quantity were controlled to observe its effect on soil properties. The results showed that, there was tendency of increasing survival percentage of earthworm. The Pearson correlation coefficient analysis showed that with increase in earthworm population and litter amount, there was increasing tendency in soil aggregates and available nitrogen content. The results for available phosphorus content and soil microbes did not show any relation with earthworm number and litter quantity.

Keywords earthworm, Megascolecidae, soil properties, soil aggregates, soil available nitrogen

INTRODUCTION

Nitrogen in soil is mainly bound in organic matter (e.g. litter) and the amount of nitrogen available for plant growth depends on complex interactions between roots, microorganisms and soil animals (Bonkowski et al., 2000). Earthworms play an important role in decomposing plant residue in the short-term through their intensive interactions (Aira et al., 2008; Gomez-Brandon et al., 2010) with the microbial communities. There are approximately 3000 to 4000 different species of earthworms and are distributed according to environment conditions like temperature, soil type, water availability in soil and organic content.

Earthworms are broadly divided into two families, Lumbricidae and Megascolicidae. Also, they are divided into three groups according to their ecological behavior and feeds on leaf litter. Epigiec earthworm, which lives on the surface of soil. Endogeic earthworm, which live in the soil and feed on the soil. Lastly, anenic earthworm, which makes permanent vertical burrows on the soil. All of them feed on leaves on the soil surface and they drag the leaves into their burrows (Bouche, 1977). There are more than 100 species of earthworms found in Japan and more than 95% of earthworms are considered to be those from Megascolecidae family. The earthworm can have notable effects on soil structure where the density of the earthworm is high. According to Brown et al. (2001), earthworms directly affect organic matter behavior by their feeding and casting activity.

Feeding of organic matter by Lumbricidae on organic matter increase in N, P, and K content in soil surface and mounds of earthworm (Darwin, 1881; Salisbury, 1923; Evans, 1948). Different earthworm ecological roles have different effects on soil aggregation and nutrient cycling. But there are few studies on soil properties affected by earthworm population and organic matter quantity. Also, most studies on relationship between earthworm activities and soil properties have been on those from Lumbricidae. The investigation of the change in the effects of Megascolicidae by the number and soil organic matter content should be needed to estimate the earthworm contribution on soil properties in Japan. And the size, abundance and activity of earthworm can change in soil physical and chemical properties.

OBJECTIVE

The objectives of this study were to assess the effects of Megascolicidae population and litter quantity on soil properties in the experimental containers.

MATERIALS AND METHODS

Sampling of Earthworms, Soil and Litter

Epigeic earthworms from Megascolicidae family (Fig. 1) were collected from depth of 5 cm soil using hand-sorting method. Epigeic earthworms are characterized with making transient galleries and are found till 30 cm deep in subsurface soil. The soil used in this experiment was Andosol which are volcanic soils and covers 47% land in Japan. The soil was passed through 2 mm sieve (Fig. 2). Litter were collected from fallen leaves of oak and cereus trees (Fig. 3). The leaves were cut up into small pieces and mixed with soil. All the samples were collected from the same field in Kanagawa prefecture, Japan.

Fig. 1 Megascolicidae used in this study

Fig. 2 Field where samples were collected

Fig. 3 Litter used in this study (mainly oak and cereus)

Experimental Set-up

The size of experimental containers consisted of plastic box was 30 cm in length, 16 cm in breadth and 5 cm in height (horizontal cross-sectional area 1/2100 a) for making similar conditions as the field (Fig. 4). The experiments were conducted for 62 days at room temperature maintained between 10 to 15℃ in the laboratory (Fig. 5).

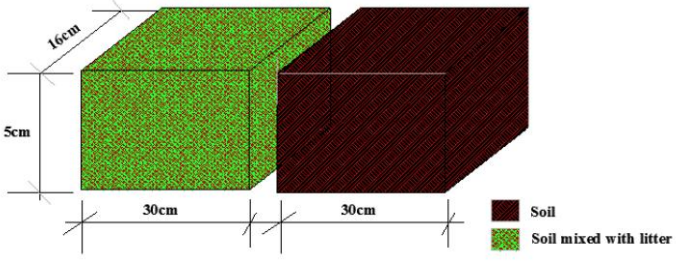


Fig. 4 Schematic diagram of experimental containers

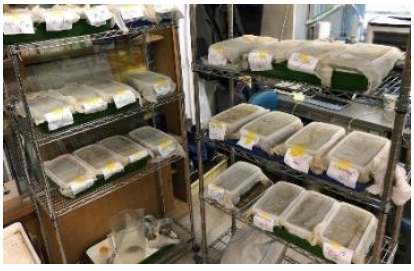


Fig. 5 Experimental containers set in laboratory

The sieved soil was placed in the containers and litter and earthworms were added. Soil and litter were mixed thoroughly. The patterns of soil organic matter content were set into three groups of no added litter of 0% added litter, 5% added litter and 15% added litter. Each group had 5 subgroups of 0, 1, 3, 5 and 10 numbers of earthworms. For 0% added litter group, the five microcosm treatments were named from A1 to A5. Likewise, for 5% added litter group, B1 to B5, for 10% added litter group, C1 to C5, respectively (Table 1). Moisture content for each treatment was tested by using gravimetric method and maintained at 50-60% with regular checking.

Table 1 Experimental treatment patterns

Litter added (%)	Number of earthworms /box	Treatments
0%	0	A1
	1	A2
	3	A3
	5	A4
	10	A5
5%	0	B1
	1	B2
	3	B3
	5	B4
	10	B5
15%	0	C1
	1	C2
	3	C3
	5	C4
	10	C5

Sampling and Parameters Measured

Soil was sampled on 0, 14, 31 and 62 days from the start of the experiments. Soil was sampled from different points from surface of the soil. The samples were mixed thoroughly and analyzed for organic content using ignition loss method, water stable aggregate using Yoder's Method. And, pH was measured using portable pH meter, total available phosphorus using Trough method, total available nitrogen using UV absorption method and colonies of actinomycetes and fungus were analyzed using serial dilution and plate count method, respectively.

Statistical Analysis

Pearson coefficient correlation analysis was performed between 2 mm aggregates, total available nitrogen, organic carbon, pH, total available phosphorus, and biological properties for results obtained during the experiment.

RESULTS AND DISCUSSION

Survival Percentage of Earthworms

Table 2 shows the survival percentage of earthworms with different amounts of added litter. The survival rate under the treatment with no added litter was smaller than others. Treatments where 5% of litter was used, survival rate of earthworms increased slightly compared to treatments without any litter. Treatments with 15% of litter amount showed the highest percentage of survival rate compared to 0% and 5% litter amount treatments. Survival rate of earthworm was in order of

0%> 5%> 15% to the litter amount. This result attributes to the fact that, the amount of feeding material increasing, prolonging the survival rate of earthworms. This tendency that organic matter in the form of litter is the important factor for earthworm survival coincides with that reported in the Brown et al., (2010) which states that earthworms directly affect matter dynamics by their feeding and casting activity.

Table 2 Result of survival percentage of earthworm

Treatments	Number of earthworms 0 day	Number of earthworms 62 days	Survival (%)
A2	1	1	100
A3	3	2	67
A4	5	4	80
A5	10	5	50
B2	1	1	100
B3	3	2	67
B4	5	4	80
B5	10	7	70
C2	1	1	100
C3	3	2	67
C4	5	4	80
C5	10	9	90

Relationship Between Various Parameters of Soil Properties

Significant correlations with 99% significance between 2 mm aggregates and mean weight diameter (MWD) in treatment C5 were shown from the result of Pearson correlation coefficient analysis conducted between all the experiment parameters in 15 different treatments (Table 3). Similar correlation was also found in other treatments. This result is supported by the result of Kladivko et al., (1986) which states earthworm activities increases in MWD and stability of aggregates.

No correlation was found between other parameters except for 2 mm and MWD in all treatments in the applied conditions. The reason for no correlations can be discussed on the behavior of anecic earthworm, in experiment duration and scale, which might have limited the activity of earthworms. It also coincides with results of various researches, such as Lavelle and Martin (2012) which states that earthworm influence organic matter and nutrient during long term genesis.

Table 3 Result of Pearson correlation coefficient analysis of treatment C5

	MWD	>2mm	Organic carbon	pH	Available phosphorus	Available nitrogen	Actinomycetes	Filamentous fungi
MWD	1							
>2mm	0.9917**	1						
Organic carbon	0.7633	0.7216	1					
pH	0.7552	0.8327	0.4360	1				
Available phosphorus	-0.2661	-0.3864	-0.0206	-0.8322	1			
Available nitrogen	0.1707	0.2102	-0.5023	0.2745	-0.2216	1		
Actinomyctes	-0.4791	-0.5212	0.2012	-0.5424	0.3600	-0.9430	1	
Filamentous fungi	-0.5272	-0.4192	-0.4696	0.1457	-0.6662	-0.0801	0.1754	1

*Note) Significant difference at **p<0.01*

Water Resistant Aggregate

Soil aggregates affects porosity, water retention ability, accumulation and decomposition of organic matter in soil (Ketterings et al., 2002; Winsome and McColl, 1998). According to Decaens (2000), Six et al. (2002), earthworm casts are major source of soil aggregates.

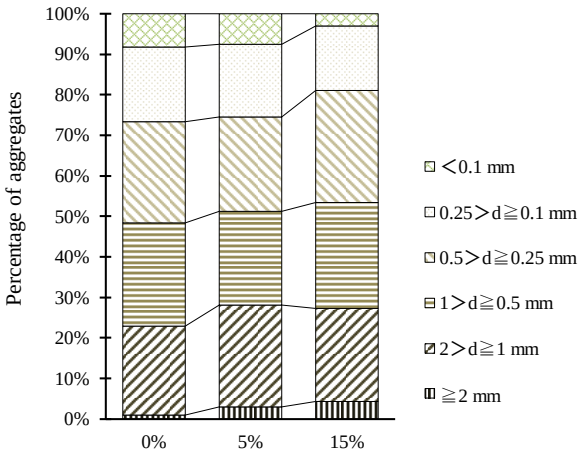


Fig. 6 Initial conditions of aggregates at 0%, 10% and 15% litter

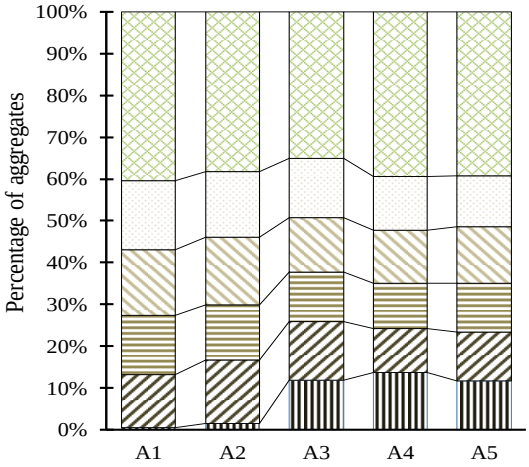


Fig. 7 Changes in the size of aggregate from A1 to A5

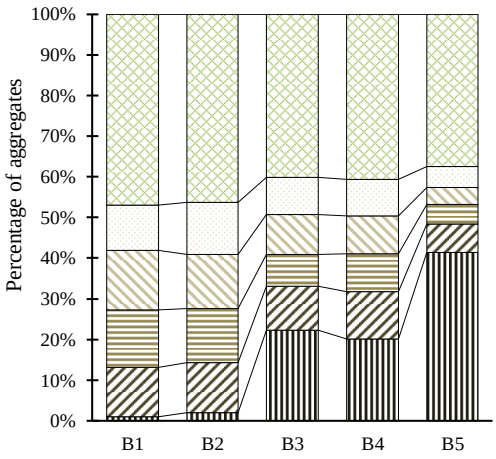


Fig. 8 Changes in the size of aggregate from B1 to B5

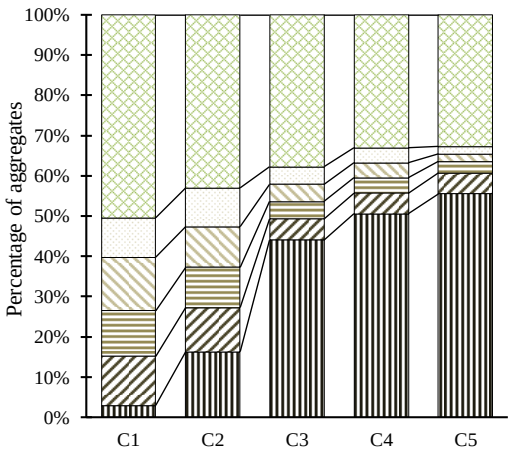


Fig. 9 Changes in the size of aggregate from C1 to C5

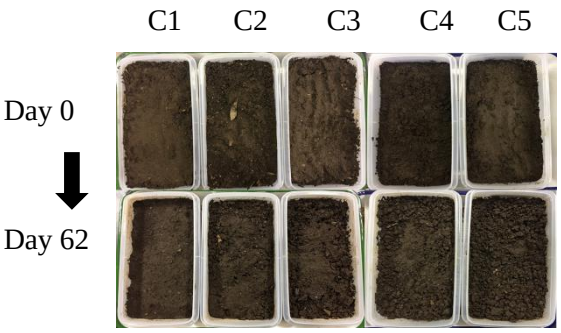


Fig. 10 Changes in aggregates formation in treatments from C1 to C5

Fig. 11 An aggregate formed during the experiment (C5)

It also enhances microbial activity in the soil. The changes in percentage of the aggregation by the amount of litter shown in Fig. 6 shows the initial aggregate concentration in 0%, 5% and 15% of added litter amount. Water resistant aggregate of 2 mm increase with both the number of the earthworm population and litter amount shown in Fig. 7, Fig. 8 and Fig. 9. Treatments with highest number of earthworm population and added litter amount had highest percentage of 2 mm aggregates. Treatment C5, with highest earthworm and added litter had 55% of aggregates formed. From the obtained result, it can be concluded that, litter, a nutrient source for earthworms, greatly influences the formation of water-resistant aggregates.

Available Nitrogen Concentration

Earthworms increase nitrogen content availability for plants (Callaham and Hendrix, 1998) and the activity of earthworms is important to plant nutrition and nitrogen cycling in the soil. The change in available nitrogen by earthworm activity are showed in Fig. 12, Fig. 13 and Fig. 14. The results showed that increase in the number of earthworm population increased the available nitrogen content. A tendency of the highest increase in available nitrogen content was seen in treatment with highest amount of added litter quantity and earthworm population. Earthworms consume large amounts of plant organic matter that contain considerable quantities of nitrogen, and most of the nitrogen that assimilate into their tissue is released to the soil in the form of excreta. It is concluded that organic nitrogen changed into available nitrogen with the action of earthworms from the experiment.

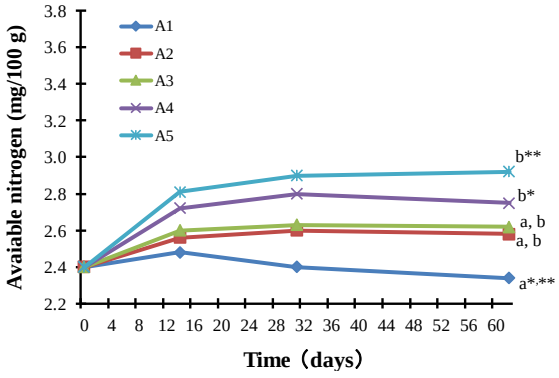


Fig. 12 Changes in available nitrogen concentration of A1 to A5

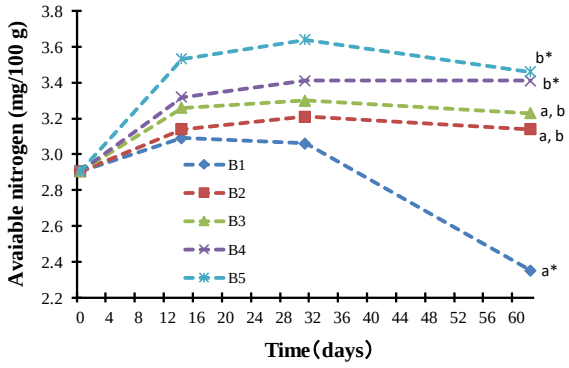
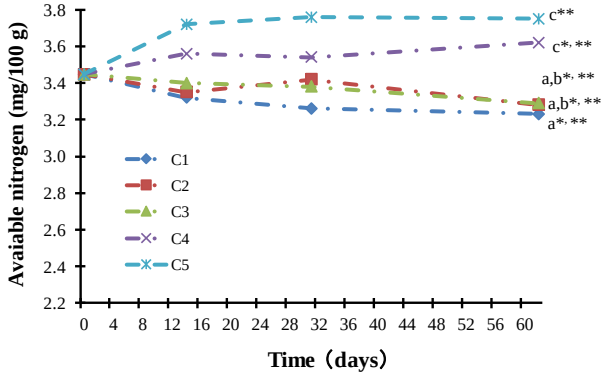


Fig. 13 Changes in available nitrogen concentration of B1 to B5



*Significant difference at **p<0.01, *p<0.05*

Fig. 14 Changes in available nitrogen concentration of C1 to C5

Lunt and Jacobson (1944), Graff (1971) reported that considerably increase in the amount of nitrogen in soil surface in the field condition. Nitrogen in soil is mainly bound in the form of litter and is available to plants with complex interaction of roots, soil microbes and soil animals. Earthworm feeds on litter and release casts which increase amount of available nitrogen. Therefore, incorporation of litter in the soil where earthworm is present can increase casts or aggregates which contains nitrogen. The results also indicate that the more earthworm population and litter, the more increase in casts.

CONCLUSION

This study was conducted to clarify the effects of earthworm population and litter quantity on soil properties by the action of earthworm of Megascolicidae in experimental containers. The results of the experiments showed that, with increase in litter amount, survival of earthworms increased. Similarly, increasing tendency of water-resistant aggregates and available nitrogen was observed. There was no clear relation found in available phosphorus and microbes in the given conditions. In future, to better understand the dynamics of earthworm's action on soil physical and chemical properties, analysis of subsurface soil with depth due to Megascolicidae movements should be conducted.

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Research article

Ecotourism-related Strategies toward Increasing Tourism Destination Competitiveness: The Case of Biliran Island Province

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Abstract Tourism has scaled into one of the biggest and fastest economic drivers in the world today. With the increasing number of new attractions, the imperative of assessing the competitiveness of tourism destinations is seen to be beneficial in improving its capability to create competitive advantages while ensuring adherence to sustainable development goals. Dubbed as "the best kept secret haven of Eastern Visayas", Biliran Island Province as a tourism destination was assessed and analyzed using Porter's Diamond Model of national competitiveness to propose useful strategies headed towards increasing its potentials and tourism competency. A total of 33 tourism stakeholder-respondents have undergone one-on-one interview survey in the said province to describe their perspectives on the importance and performance of various factors and conditions towards increasing its tourism competitiveness. Importance-Performance Analysis (IPA) revealed that the tourism competitiveness of the province is directed to its eminent natural resources, safe and secured environment, and provisions of basic facilities. However, performance improvement of other factors especially marketing and advertising must be addressed promptly. Various concerns and challenges that the province facing include lack of government support in terms of product development and promotion, high taxes and cost of other basic utilities, and environmental challenges as a result of climate change. To address these adversities of, ecotourism-related strategies were recommended in line with the positioning of the province as an "Agri-Garden and Premier Ecotourism destination in Eastern Visayas Region". These must involve responsible marketing and advertising, human resource development and environmental-friendly infrastructures, and emphasis on intensifying safety and disaster risk reduction and preparedness management.

Keywords ecotourism-related strategies, tourism, destination competitiveness, Porter's Diamond Model, Importance-Performance Analysis

INTRODUCTION

Tourism has been eyed as one of the biggest and fastest economic drivers in the world. With the increasing number of new destinations along with the increasing investments and financing poured to tourism worldwide, the industry transformed itself into a key driver in socio-economic progress (UNWTO, 2016). Due to its potentials for growth and contributions derived from the industry, tourism is seen to be taking an important role in implementing strategies for local and regional development, especially for developing countries like the Philippines.

The tourism industry portfolio of the Philippines constitutes mostly of various tourism and native products. Among the highest ranked tourism products in the country in terms of priority are nature-based, sun and beach, and diving/marine sports tourism (DOT, 2016). This denotes that the tourism industry in the Philippines has been greatly dependent on the natural resources for its continued growth and existence. To ensure that these resources are responsibly used, destinations can adopt the concept of ecotourism which offers conservation-oriented and sustainable form of tourism.

Increasing the tourism competitiveness of a destination means enticing potential tourists and offering and serving them with products and services better than other destinations (Mazurek,

2014). In order to ensure strong and sustainable development, analysis of competitiveness should be taken to form a sound basis for strategy formulation and policy implementation (Melisidou, et al., n.d.). Tourism competitiveness studies revolved around the identification of factors that affect the destinations ability to attract tourists and development of possible management strategies (Crouch, 2010; Goffi, 2013; Bobircă and Cristureanu, 2006). Porter's Diamond Model is also widely used in studies on competitiveness (Wahogo, 2006; Bobircă and Cristureanu, 2006)

Biliran is the best kept secret haven in Eastern Visayas. With its charming community, rich and wonderful coastlines and island attractions, majestic mountains, jaw-dropping waterfalls, and high concentration of hot springs surrounded with rich flora and fauna, the province has the potential to become a sought-after destination for local and foreign tourists as it envisioned to become a premier ecotourism destination.

Ironically, with all the beauty and vibrancy of the tourism endowments, for the past years, Biliran Island Province occupied the last place in terms of its share in tourism arrival in Eastern Visayas Region (Table 1), and 31st among the 72 provinces in the country according to the National Competitiveness Council in 2017. Analyzing the competitiveness of the tourism sector of Biliran Island Province is seen to be a must. This identifies the competitive strengths of the province as well as the barriers that impede the development of the tourism sector (Navickas and Malakauskaite, 2009), more so, a fundamental concern for successful tourism management and planning.

Table 1 Provinces in Region 8 and their major characteristics

Provinces	Population in thousands (2015)	Land area (sq. km)	Tourism performance*	
			Arrivals	Rank
Biliran	172	536	31,219	6
Eastern Samar	467	4,660.5	72,060	5
Leyte	1,967	6,515.1	722,010	1
Northern Samar	632	3,692.9	240,972	4
Samar	780	6,048	480,275	2
Southern Leyte	422	1,798.6	391,108	3

*Sources of data: DOT, PSA *Based on the cumulative tourism arrivals (2011-2015)*

OBJECTIVE

This research study which assessed the tourism competitiveness of Biliran Island Province used the Porter's Diamond Model of Competitiveness that generated proposed strategies to aid in the policy and management planning of the Provincial Tourism Office and stakeholders towards enhancing its tourism competitiveness. Specifically, the study aimed to: (1) analyze the tourism competitiveness of Biliran Island Province using the Importance-Performance Analysis; (2) ascertain the challenges faced by the tourism sector in the study area that impedes its competitiveness; and (3) proposed strategies to enhance the tourism competitiveness of Biliran Island Province.

METHODOLOGY

Research approach: As a descriptive research, this assessment study employed quantitative research approach which involved the collection of data in order to quantify them and subject the information gathered to statistical treatment to predict, explain, and confirm knowledge claims. The personally collected numerical data were analyzed to address the research objective(s) defined for a particular study (Williams, 2007). Like most of the assessment studies on competitiveness done by Wahogo, (2006), Goffi (2013), and Dwyner (2010), the survey method was used as data collection method.

Research area: It located on the western side of the Eastern Visaya region, also Biliran is bounded by the province of Leyte on the south, Western and Northern Samar on the east, and Masbate on the

northwest. The province is considered to be the smallest island province in the region and one of the smallest in the entire Philippines (Fig. 1).

Fig. 1 Location map of Biliran Island Province
Retrived from en.wikipedia.org

Research respondent: A total of 33 tourism stakeholder-respondents were surveyed, of whom, 27 were owners/managers of tourism enterprises and six were staff and tourism officer of the Provincial Tourism Office of Biliran. Respondents were chosen based on their availability and convenience.

Data collection: The two-part survey questionnaire was used in gathering the needed data to address the research objectives. The first part identified the profile of the respondent's business/company while part two determined the level of importance and performance of the various factors and conditions towards competitiveness that Biliran Island Province had as a tourist destination. Micheal Porter's Theory of Competitiveness (Porter, 1998) as illustrated by the Diamond Model of Competitiveness is contextualized and applied to the tourism industry. The questionnaire contained 29 items grouped in accordance to the four factors in the diamond model-factor conditions, demand conditions, related and supporting industries, and context for firm strategy and rivalry. The data were gathered between May to July 2018.

Data analysis: The responses of the respondents were coded using a five-point Likert scale, encoded in Microsoft Excel, and descriptive statistical analysis were sorted and summarized.

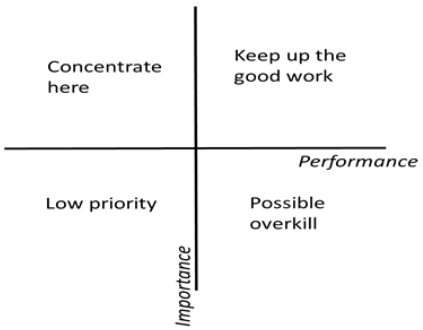

Fig. 2 The IPA grid
Adopted from Dwyner, L., 2010

Furthermore, the computed mean scores of the variables were analyzed and plotted in the Importance-Performance Analysis (IPA) grid which aided the development of management strategies. The median of the variables' mean values, on the other hand, served as the central values of the grid, forming four quadrants. For this study, the computed central values were 4.3 (importance) and 3.42 (performance). IPA combines measures of attribute importance and

performance into a two-dimensional grid to easily interpret the data and derive practical suggestions (Fig. 2).

RESULTS AND DISCUSSION

Tourism Competitiveness of Biliran Island Province

Increasing the competitiveness of Biliran Island Province requires efforts to improve the performance of various factors that have significant effect on its ability to attract and entice tourists. Showing the result of the analysis in Table 2, the tourism competitiveness of the province relies on its outstanding natural resources, safe and secured environment, and provision of some basic facilities.

Table 2 Factors of competitiveness (Direct IPA)

Factors	Mean Values		Quadrant
	Importance (y)	Performance (x)	
Safety and security	4.79	3.88	Keep up the good work
Electricity	4.73	3.52	Keep up the good work
Awareness/Recognition of Hazards	4.64	3.67	Keep up the good work
Scenery	4.48	3.85	Keep up the good work
Roads	4.49	3.67	Keep up the good work
Demand by foreign customers	4.39	3.64	Keep up the good work
Landscapes and seascapes	4.36	3.67	Keep up the good work
Demand by local customers	4.36	3.72	Keep up the good work
Quality/ Skills of employees	4.33	3.45	Keep up the good work
Water system	4.64	3.24	Concentrate here
Communication network	4.52	3.3	Concentrate here
Legal, regulatory, and administrative framework	4.36	3.18	Concentrate here
Development of strategy	4.3	3.42	Concentrate here
Marketing and advertising	4.3	3.09	Concentrate here
Airports and seaports	4.3	2.76	Concentrate here
Product pricing	4.24	3.48	Concentrate here
Cost of personnel	4.24	3.42	Low priority
Availability and access to locally based suppliers	4.18	3.33	Low priority
Flora and Fauna	4.12	3.21	Low priority
Climate	4.09	3.33	Low priority
Cost of capital expansion	4.09	3.42	Low priority
Joint Promotion of exhibitions, and trade fares	4.03	2.42	Low priority
Membership in organizations	4	2.67	Low priority
Quantity of employees	3.88	3.24	Low priority
Science and technology	3.82	2.18	Low priority
Availability of capital	4.15	3.55	Possible overkill
Level of rivalry	3.78	3.52	Possible overkill

Source: Survey data

However, efforts should be made in order to improve the performance of the factors positioned on the "Concentrate Here" quadrant. Marketing and advertising and product pricing are significant factors affecting tourists' decision-making in exploring and visiting the area (Batra, 2016). Weak tourism promotion and advertisement manifested by the absence of a website and social media presence, brochures and other promotional collaterals and materials impede the competitiveness of tourism in the province. Supporting facilities like strong and integrated communication network, assistance for its marketing efforts, and improved transportation facilities

are likewise necessary to increase the flow of tourists. Sound regulation and strategy to serve as the overall umbrella need to be in place to ensure sustainable development of resources, and a competitive tourism destination.

Challenges and Proposed Strategies toward Increasing Tourism Competitiveness

Table 3 shows the challenges and strategies that Biliran Island Province can adapt as it positioned itself as an agri-garden and premiere ecotourism destination in Region VIII. A competitive eco-tourism destination would require the presence of standard-compliant tourism facilities, high quality of service and skilled workers, accessible sites and destinations, distinctive souvenirs and local products, and a peaceful and secured environment. Moreover, the provision of infrastructure and other support facilities towards competitiveness implies that transportation, electricity and water are readily available for domestic and commercial consumption, and reliable internet and functional network coverage. As an island destination located at a hazard-prone area, the imperative of developing sustainable tourism products, coupled with disaster-prepared community is of paramount concern in increasing the competitiveness of Biliran Island Province. On the other hand, Biliran's competitiveness could be enhanced with certain environmental marketing activities and initiatives (Mihalic, 2000) which convey messages related to environmental awareness and protection (Batra, 2006).

Table 3 Summary of Challenges and Strategies for Biliran Island Province

Challenges	% response	Strategies	% response
High cost and inconsistent supply of basic facilities	84.84	Developing environment-friendly infrastructure	60.60
Underdeveloped ports	45.45		
Lack of support from the government	30.30	Establishing a Destination Management Office	45.45
Climate change	60.60	Sustainable development of natural resources	81.81
		Developing responsible marketing and advertising program	51.51
		Intensifying safety and disaster preparedness initiatives	75.75
		Enhancing human resource capacity	36.36

Source: Survey data

CONCLUSION

The competitiveness of Biliran Island Province rests on the outstanding state of its natural resources, safe and secured environment, and availability of basic utilities. Thus, in order to realize its vision as a premier ecotourism destination in Region VIII, and at the same time, increasing its ability to attract tourists, management strategies and policies anchored on the principles of ecotourism should be considered and enacted.

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Research article

GIS-based Analysis for the Energy Potential and Social Feasibility of Small-Scale Run-Off-River Hydropower in Yahagi River, Japan

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Abstract Due to the increase in international energy demand and the focus on the realization of a decarbonized society, small-scale hydropower plant is attracting attention in Japan as an important supply of renewable energy. While Japan has a significant amount of precipitation and mountains, it is suitable to establish hydropower plants; however, hydropower energy currently represents only about 10% of the total energy mix. Generally, a small-scale hydropower facility has relatively little impact on the environment and is expected to play a role as a distributed power source. However, it has not been included in the survey of hydropower potential, and a study on its viability and the development of potential sites is limited. Here, we created an electricity generating capacity map for small-scale run-off-river hydropower plant of the Yahagi River system in Aichi, Japan. We calculated the river flow rate and potential electricity generating capacity at every 10 m on the river line of the Yahagi River system using the digital elevation model, published by the Geospatial Information Authority of Japan. We overlapped various kinds of social conditions and risks on the map of electricity generating capacity and proposed a suitable site where the development of potential small-scale run-off-river hydropower plant is high.

Keywords small-scale run-off-river hydropower plant, renewable energy, GIS, Yahagi River

INTRODUCTION

Due to rapid increase in the number and degree of natural disasters in Japan, the dissemination and promotion of renewable energy and distributed power sources have become a more critical policy issue (Agency for Natural Resources and Energy, 2018). In recent years, the following three conditions have been identified for energy supply: (1) securing small-scale and distributed generation functions to mitigate the risk of a sudden drop in power supply in the event of a disaster, (2) enhance base-power supply capacity to respond to peak demand in summer and winter, and (3) a generator that is self-sufficient and does not emit greenhouse gases (Ueda et al., 2012). Small-scale hydropower is generally considered to create a low environmental load and a high degree of affinity for distributed power supply.

However, there are few noticeable cases of mini and micro hydropower projects that target the

power generation output of around 100 kW. Hydropower plants are mainly of two types of namely, reservoir and run-off-river hydropower plants. While reservoir-types such as dams can generate medium to large-scale hydropower, the places where power plants can be installed are limited, and the installation costs are relatively high. Conversely, a run-off-river type can generate small-scale hydropower and the installation of plants is relatively easy. Also, power generation is possible even in complex terrain conditions such as mountainous areas. Recently, European attractive policies are favoring the construction of new small-scale hydropower plants, i.e., in most cases, correspond to run-of-river hydropower plants (Garegnani et al., 2018).

While estimating the feasibility of renewable energy development projects, a fundamental challenge is to determine the availability of the natural resources. In the planning process, further restrictions in the exploitation of natural resource (e.g., technical, environmental, legal, and social) should be considered (Moriarty et al., 2012; Resch et al., 2008). For example, in Japan, the Ministry of the Environment Government of Japan estimates the medium to small-scale hydropower energy potential values in rivers and agricultural water by prefecture (the Ministry of the Environmental Government of Japan, 2011). Also, the potential of small hydropower is estimated around the world (Cuya et al., 2013; Kusre et al., 2010; Yah et al., 2017).

In this study, the development of a potential estimation method for small-scale hydropower, which can be applied more simply and on a global scale in the future, is considered by assuming a run-of-river type and low-drop type power plants. Also, the electricity generating capacity of small-scale hydropower and the amount of power required were compared.

METHODOLOGY

Study Sites

In this case, the Yahagi River system was targeted for the case study (Fig. 1). The Yahagi River system flows down to Nagano Prefecture, Gifu Prefecture, and Aichi Prefecture, which has a total stream length of 117 km and a catchment area of 1,830 km^2.

Creation of Potential Estimation Point for Small-scale Hydropower

The ArcGIS (Ver.10.4 and Ver.10.6) calculated the stream length and the catchment area, and the Digital Map 10 m Grid (Elevation) published by the Geospatial Information Authority of Japan (GIS) and the Hydrology analysis tools of Spatial Analyst (ArcGIS) were used. The streamline was selected using the Digital Map, and the point data were created on the streamline at 10-meter intervals as a potential estimation point of hydropower (Fig. 2). We calculated the watershed area at each point.

Estimation of the River Discharge

The river discharge at each potential estimation point was estimated. A specific discharge rate was used to calculate the river discharge. The actual river discharge values obtained from six observation sites of Water Information System (MILT of Japan, 2018), i.e., Sumigase, Kugyudaira, Yonedu, Kido, Takahashi, and Iwadu, were then corrected. At these sites, normal flow rates were calculated using the river discharges per day from January 1st, 2016 to December 31, 2016. A normal flow rate represents river discharges that do not fall below this value for 185 days throughout one year. There was a significant correlation between the watershed area and a normal flow rate at these six observation sites (correlation coefficient (r) = 0.93, p values of significance test (p) < 0.01). In addition, the potential estimation points correspond to the six observation sites of Water Information System. There was a significantly strong correlation of watershed areas between of the potential estimation points and of the six observation sites (r = 0.99, p < 0.01). From these results, the specific discharge rate of the Yahagi River system (0.0254) was calculated,

and the river discharges at each potential estimation point was calculated by multiplying a watershed area by the specific discharge rate.

Calculation of Electricity Generating Capacity

The electricity generating capacity of a small-scale hydropower is expressed by the formula (1).

$$P_e = 9.8 \times Q \times H_e \times \eta \quad (1)$$

where P_e is the amount of power generated (kW), Q is the river discharge (m^3/s), H_e is the height difference between inlet and outlet of stream (m), and η is a dimensionless efficiency of the turbine.

Out of these, the height difference can be adjusted according to the local topography or the amount of electricity. In this study, since the target is the small-scale and low-drop hydropower plants, the H_e is uniformly set to 5 m at each point. Furthermore, in this study, we targeted on the power generation amount ranged from 30 to 500 kW, and values less than 30 kW and greater than 500 kW were excluded from the potential estimation analysis.

Extraction of a Social Condition

(1) Spatial duplication in a nature reserve area:
Since the artificial development practices are regulated in the area designated as the nature reserve are, the points located in the nature reserve area among the potential estimation points were excluded. The potential estimation points were excluded in the Natural park areas (MILT of Japan, 2015a), Nature conservation areas (MILT of Japan, 2015b) and Wildlife management areas (MILT of Japan, 2015c) and within their 100 m buffer areas.

Fig. 1 Location of the Yahagi River

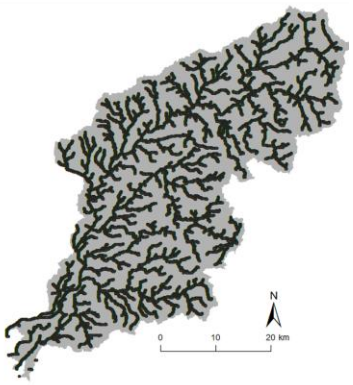

Fig. 2 The potential estimation points of small-scale hydropower

(2) Spatial duplication in disaster risk areas:
Since the establishment of small-scale hydropower facilities in areas designated as disaster risk areas are not realistic, the points located in the disaster risk area of the potential estimation points were excluded. Sediment disaster hazard areas (MILT of Japan, 2010) and landslide special warning areas (MILT of Japan, 2017) are targeted in a 50 m buffer area, and the flood eliminate area (MILT of Japan, 2012) excluded points that were included within a 100 m buffer area.

(3) Distance from the existing road:
When constructing a small-scale hydropower facility, its distance from the existing road influences the installation cost. Therefore, the linear distance from the newly-installed power generation facility to the existing road was calculated using the Road Edge data published by Geospatial Information Authority (GSI, 2017), assuming the necessity of laying the power distribution for the

construction and management of roads. Out of the estimated linear distances, the potential value was calculated as the maximum value of 1.0 in the case of 100 m or less, and the potential value using formula (2) when it was larger than 100 m.

$$P_n = \frac{100}{D_n} \quad (2)$$

where P_n is a potential value of the potential estimation point's number n, and D_n (m) is the nearest distance from the potential estimation point. The potential value decreased as the distance from the potential estimation point to the existing road increased.

Estimation of the Required Power

The amount of power required per year was calculated by multiplying the number of houses, included in the concentric circle at center of the potential estimation point, by the power usage per household at each potential estimation point. With respect to the number of houses, assuming one urban area cell (10 m) as one household from the JAXA (2016) High Resolution Land-Use and Land-Cover Map (Ver. 16.09; 10 m × 10 m spatial resolution), the total number of urban area cells included in the 1.0 km circles are used to obtain the potential estimation point. An average value ((kWh / h / household) of electricity consumption in the five years from 2005 to 2010 is calculated from the "Trend of power consumption per household" provided by The Federation of Electric Power Companies of Japan (2017), which is multiplied by the number of households to calculate the power requirement.

Reclassifying of the Potential Estimation Points into Sections

The consecutive points, excluding spatial duplication points in the nature reserve and disaster risk areas, were grouped as one section. Using neighbor analysis of ArcGIS, the points adjacent in eight directions from the potential estimation point were reclassified as a single section.

Site reconnaissance:
We investigated the local conditions of the potential estimation points created and excluded by GIS. On December 21, 2018, seven locations in Ena City and Toyota City were surveyed. Survey items included river width, seawall structure of riverbed, right bank and left bank, and the presence of transmission line.

RESULTS AND DISCUSSION

In the Yahagi River system, the potential estimation points were created at 10 m intervals. Then we excluded the potential estimation points by the spatial duplicated area of the nature reserve and the disaster risk areas. Moreover, where the amount of power generation is less than 30 kW and greater than 500 kW were also excluded. The potential estimation points were narrowed down to 4,038 points from 106,494 points (Fig. 3).

The minimum value of power generation at 4,038 points was 30.1 kW, the maximum value was 397 kW, and the average value was 113 kW. Besides, 57% of the 4,038 points had a micro-scale power generation of 50 kW or less (Fig. 4). When classifying the points as connected in eight directions out of a potential estimated number of points, 4,038 points were sorted into 125 sections. Moreover, 125 sections were located in five areas of the Yahagi River system.

Based on the distance of the existing road from the small-scale hydropower facility, we determined the cost of installation of this facility. The distance to the existing road at 4,001 points out of 4,038 points was 100 m or less. Hence, it is possible to install and manage the facilities using existing roads at most potential estimation points.

The amounts of required power generation within 1 km from the potential estimation point were compared. In this instance, the power generation amount and the required power amount were converted into annual values. The annual power generation amount at 4,038 points ranged from

264 to 3,480 MW/y, and the average value was 996 MW/y (Fig. 5). The number of points where the ratio of the power generation amount to the required amount was less than 100% (except 0%) was 1,186 points, i.e., 51 sections. Among these points, the points below 10% of the ratio of the power generation amount to the required amount were 402 points, i.e., 24 sections, and these sections were located in the population concentrated areas within Toyota City (Fig. 6). The population within 1 km from these potential estimation points is relatively large; the required amount is also large compared to the amount of power generation. For this reason, the installation of small-scale hydropower facilities in this section can be considered unsuitable.

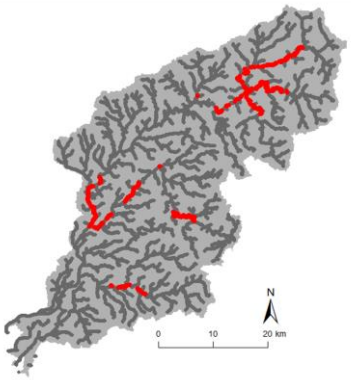

Fig. 3 Potential estimation points (red colored points)

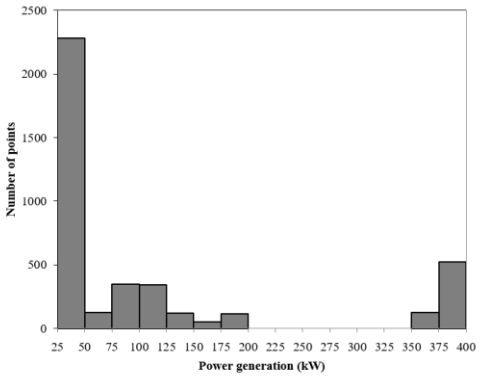

Fig. 4 Histogram of power generation

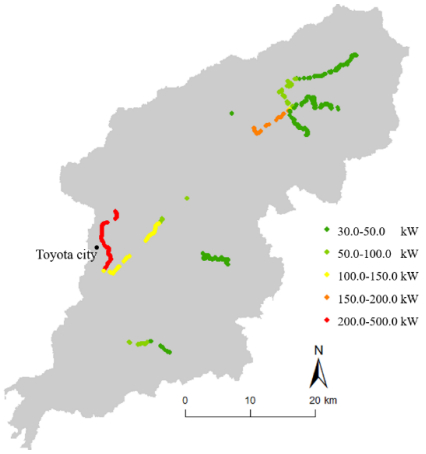

Fig. 5 Power generation of 4,038 of potential estimation points

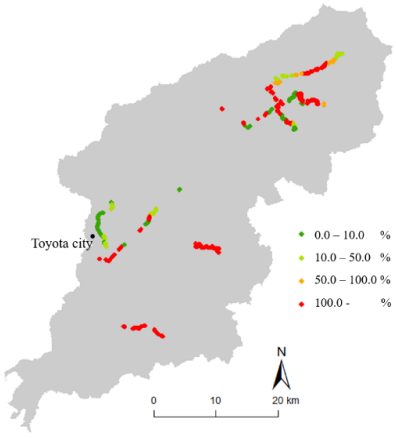

Fig. 6 Ratio of the demand to the power generation

Conversely, at 784 points, where the ratio of the power generation amount to the required amount is higher than 10% and less than 100%, small-scale hydropower facility is useful for local production and consumption.

At around 100% (2,443 points), where the population concentration is low, and the amount of power generated exceeds the requirement, small-scale hydropower facility can be used for power-selling.

Based on these results, to evaluate the validity of the potential estimation points of small-scale hydropower facility published by GIS, a site reconnaissance was conducted in three areas, as shown in Fig. 7. These three areas have relatively lower population concentration and are located in the mountainous regions of Japan.

In the section where the village is near the river, it is generally accepted that the small-scale hydropower facility for the local production and consumption type is sufficient. By site reconnaissance, roads and power transmission lines are being maintained, the river is also managed,

and the flow conditions are stable. From this, it was inferred that even in the mountainous areas, it is possible to install a power generation facility at a relatively low cost near the settlement, and a small-scale power generation facility according to the size of the village is suitable.

Conversely, since most of the target sections have few settlements, it is considered that the use as a power-selling type is suitable.

In these sections, it was confirmed that there is an existing road near the river, but there is no power transmission line. In addition, there are many natural rivers, including sprawl points, where flow paths are complicated with big rocks of river beds. At such points, there is a concern that high costs will be incurred for the installation of power generation plants. In the case of valley terrain, the distance from the existing road to the river is long, and there is a concern that the installation and management of the power plant are complicated.

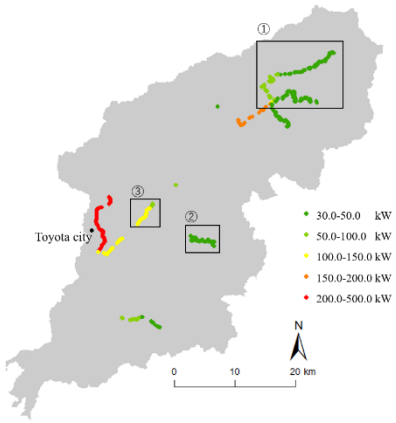

Fig. 7 Location of site reconnaissance

However, even if there are no settlements near the points, small-scale hydropower plant with existing irrigation facilities such as weirs is considered to be effective. In the vicinity of irrigation facilities, since the river flow is stable, low cost and stable power generation are expected. By combining existing irrigation facilities with small-scale hydropower facilities, it is possible to allocate administrative expenses for irrigation facilities.

Several tasks remain to apply the potential estimation method of this study in other regions and on a global scale. In this study, we set the buffer to 100 m in the extraction of social conditions; it is necessary to verify the proper distance. In the calculation of the distance to existing roads, 100 m buffer from the center point of the river was used as the standard. However, it is expected that the river width dramatically varies depending on the size of the river. For example, the river width in the upstream river is small in general, and even if the distance from the center of the river is within 100 m, the distance could be far away from the estimation point.

Conversely, when large rivers are included, the river width may be 100 m or more, and it may be impossible to calculate the distance to existing roads. It is necessary to change the distance to the existing road for each point considering the width of the river, the topography, and the flow rate. Based on the results of the site reconnaissance, it showed that the utilization of existing irrigation facilities is useful. However, position information on small facilities such as weirs is often not released as GIS data, and it is difficult to estimate the potential considering existing facilities. Likewise, we have not considered the positional relationship with existing power generation facilities. However, considering the balance with the demand amount, it will be necessary to consider the necessity of the power generation facilities to be nearby.

CONCLUSION

In this paper, we suggest a potential estimation method for a small-scale hydropower plant. The results showed a suitable point for small-scale hydropower generation facilities in more detail by

public information. It is necessary to confirm the environmental conditions around the river and near the field by the site reconnaissance in the mountainous areas where the population is low. Also, in order to evaluate the more realistic energy potential, it is necessary to identify the location of existing irrigation facilities and power generation facilities and to examine the relevance of small-scale hydropower generation.

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Research article

Farming Practices Assessment and Economic Analysis of Organic Rice Farming in Cambodia: Case Study of a Commune in Preah Vihear Province

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Abstract Through the Cambodian government program, adoption of organic rice farming started in 2003. Although some farmers re-converted back to conventional rice farming, there are still some farmers who have continued producing organic rice under contract farming and non contract farming. This study aims to (1) clarify the cultural practices of organic rice farming; (2) compare the productivity and profitability of organic rice under contract farming and non-contract farming, and (3) identify the perception of farmers towards organic rice farming and reasons why they have continued. This study interviewed 85 randomly selected farmers in a commune of Preah Vihear province and further divided them into three types: 32 contract farmers, 32 non-contract farmers, and 21 organic rice contract farmers who partly sold produce outside the contract. Results showed that although transplanting and direct-seeding were prevalent, direct-seeding was the most common practice due to limited labor and rice field location. With regards to productivity and profitability, organic rice contract farmers had more yield and earned more profit than non-contract farmers. Moreover, farmers practicing transplanting had higher yield than those of direct-seeding. However, availability of exchange labor seemed to be a critical factor for farmers to gain profit. The reasons for farmers to continue doing organic rice farming were higher income, better health and contribution to conserve the environment. The reasons for engaging in contract farming were receiving stable and high price and gaining new knowledge. This study hopes to initially contribute to the further development of organic rice farming in Preah Vihear province.

Keywords contract farming, cost and return analysis, cultural practices, organic rice, perception

INTRODUCTION

In Cambodia, agriculture contributed to 28.6% of GDP (2015), while contribution of rice alone accounted for 10%. Recently, the demand for organic products (e.g. organic rice) is significantly increasing due to the increasing number of local people who prefer to consume safe food and live a healthy lifestyle. Moreover, organic rice production for export to European countries is increasing year by year. However, the adoption of organic rice practice only started in 2003. Thus, it is undoubtedly a latecomer on the international organic agriculture scene (COrAA, 2011).

Taing (2008) mentioned that social and economic benefits of organic rice farming are not yet sufficiently clarified. During the first few years, Cambodian rice farmers produced organic rice with surprising success, and many organic rice cooperatives were established throughout the main rice production areas in Cambodia. However, many organic rice farmers diminished in scale, and

many organic rice farmers re-converted to conventional farming even though Taing (2008) and Sa (2011) reported that organic farming could increase farmers' rice yield and profit.

According to Preah Vihear Provincial Department of Agriculture (2017), there are agricultural cooperatives that still produce organic rice in a natural way without external inputs such fertilizers and pesticides in Preah Vihear province. In 2017, this province produced almost 30,000 tons of organic rice from 5,162 smallholder farmers who engaged in contracts with three different private companies (contractors).

OBJECTIVE

This study aims to (1) clarify the cultural practices of organic rice farming; (2) compare the productivity and profitability of organic rice under contract farming and non-contract farming, and (3) identify the perception of farmers towards organic rice farming and reasons why they have continued.

MATERIALS AND METHODS

This study was conducted in a commune of Preah Vihear Province, which is the second largest agricultural area in Cambodia. The main commodities are rice, rubber, and cashew nuts. It is located in the Northern area of the country and shares international border with Thailand and Laos. This province is also considered as the "Kingdom of Organic Rice." Most people are farmers who grow rice during wet season only because of no irrigation or canals. On another hand, the selected commune had a population of 8,296 person (2016) and covered a total area of 36,535 ha of mostly hilly forest, located 396 km. from Phnom Penh City. This commune was selected because many farmers are cultivating organic rice (Provincial Department of Agriculture, 2017).

Primary data were collected through questionnaire survey of randomly selected organic rice farmers and key-informant interviews (e.g. agriculture officers and other stakeholders) in March and August 2017. A total of 85 organic rice farmers were interviewed and further divided them into three types: 32 contract farmers, 32 non-contract farmers, and 21 organic rice contract farmers who partly sold their produce outside the contract (hereafter, mixed farmers).

Descriptive analysis and cost and return analysis were utilized in this study.

RESULTS AND DISCUSSION

Socio-Economic Characteristics of Selected Organic Farmers

New farmers who engage in contract farming are usually required to pay 50% of certification fee, while the other 50% is paid by the private company (contractor). However, during the introduction of contract farming in 2017, an NGO extended support to all contract farmers through payment of the farmer's share to the certification fee. Moreover, contract farmers were provided organic rice seeds and training sessions on organic rice standards, certification application process, organic cultivation, and internal control system.

Table 1 Socio-economic characteristics of selected organic farmers (n=85)

Items	Contract farmer	Non-contract farmer	Mixed farmer[1]
Number of household (HH)	32.0	32.0	21.0
Average age (years old)	37.8	39.9	34.8
Average family size (person)	5.3	5.7	5.5
Average education (years)	4.9	4.7	4.4
Average farming experiences (years)	19.8	22.6	18.7

Source: Field survey, 2017

Note: Mixed farmers refer to those farmers who engaged in contract farming but sold part of their organic rice produce outside the contract.

Table 1 shows the general profile of the three groups of farmers. The average household was about five members in each group. Non-contract farmers were the oldest and had the longest farming experience among the groups. On another hand, contract farmers had the highest educational attainment.

Cultural Practices

The field survey revealed that selected farmers commonly cultivated white rice variety (known as Neang Om and Neang Ouk in Khmer language). This variety has long maturity (specifically, 8 months) and is suitable for wet season and land condition in the study area. Farmers commonly start land preparation from May and do harvesting between late-November and early December.

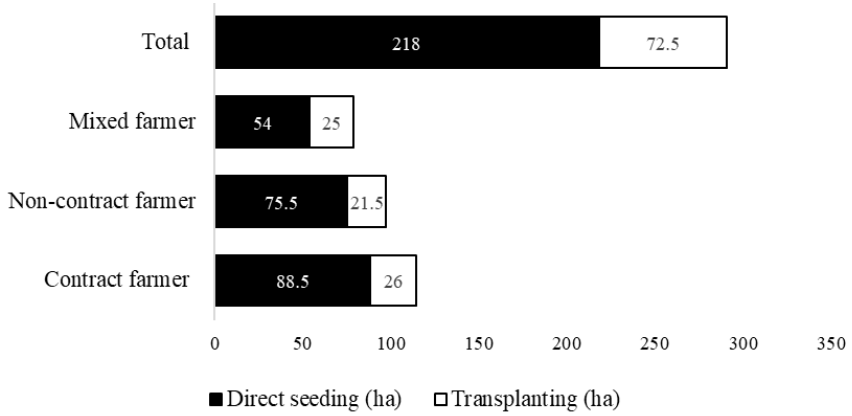

Fig. 1 Total land size by farmer type and crop establishment
Source: Field survey, 2017

As shown in Fig. 1, all groups practiced both types of crop establishment (e.g. direct-seeding and transplanting). Particularly, all farmer respondents preferred direct-seeding due to shortage of labor and the long distance of rice paddy field from home.

Table 2 Cultivation practices by farmer group and crop establishment

		Transplanting		
	Cultivation stage	Contract farmer	Non-contract farmer	Mixed farmer
Pre-cultivation	Farm location	Near home	Near home	Near home
	Seed (kg/ha)	73.95	78.62	81.37
Cultivation	Land preparation	3 times	2 times	Less than 3 times
	Seedling age	18- 21 days	More than 20 days	3 weeks
	Space between line and row	20-25 cm	<20cm	25-30cm
	Transplant (seedling per hill)	1 seedling	2 or 3 seedlings	1 seedling
	Seedling depth into soil	2-3 cm deep	>3cm	2-3cm
	Weed control	Hoes and hand	Hoes and hand	Hoes and hand
	Pest control	Spiders and frogs	Spiders and frogs	Spiders and frogs
	Irrigation	Rainfed	Rainfed	Rainfed
		Direct-seeding		
Pre-cultivation	Farm location	Far from home	Far from home	Far from home
	Seed (kg/ha)	148.28	150.03	125.21
Cultivation	Land preparation	3 times	2 times	Less than 3 times
	Weed control	Hoes and hand	Hoes and hand	Hoes and hand
	Pest control	Spiders and frogs	Spiders and frogs	Spiders and frogs
	Irrigation	Rainfed	Rainfed	Rainfed

Source: Field survey, 2017

It should be noted that non-contract farmers had limited or no special trainings, thus most of them followed their own cultivation practice. On the other hand, contract farmers and mixed farmers attended some short trainings organized by the NGO, agricultural cooperative union and/or contract companies on organic rice cultivation in order to get international organic certification. Table 2 shows the differences in cultivation practices by farmer group and crop establishment. The main differences found were seed input and land preparation. First, non-contract farmers selected seeds for next production by themselves, so seeds were not genetically selected. The selection was based on the physical aspect of the rice plant and seed (e.g. thickness and weight). Before sowing, the unhealthy grains are taken out. However, although contract farmers were initially provided with organic rice seeds for free by the contractor in 2017, they had the option to buy or keep seeds for the next cropping. Second, with regards to land preparation, contract farmers did three times, while non-contract farmers did two times.

During harvesting, all the farmers harvested by hand and sun-dried rice grain on the field. This practice significantly affected grain quality. All farmers utilized threshing machine.

Production Cost of Organic Rice Farming

The analysis was done separately in three groups namely contract farmer, non-contract farmer, and mixed farmer. Each group was divided into two different kinds of cultivation practices such as direct-seeding and transplanting. It should be noted that all the cash cost and non-cash cost such as family labors cost, exchange labors cost, and depreciation cost on farm assets were included in the calculation. Family labor cost, exchange labor cost, and seeds cost were considered as non-cash costs. Family or exchange labor cost was estimated as 2.5 USD per person (about half day or 4 hours).

Table 3 Total labor cost of organic rice production

Items	Contract farmer				Non-contract farmer				Mixed farmer			
	Direct-seeding		Transplanting		Direct-seeding		Transplanting		Direct-seeding		Transplanting	
	Family labor	Exchange labor	Family labor	Exchange labor	Family labor	Exchange labor	Family labor	Exchange labor	Family labor	Exchange labor	Family labor	Exchange labor
1st plowing	5.75	-	6.37	-	5.60	-	5.98	-	5.38	-	5.70	-
2nd plowing	5.44	-	5.29	-	-	-	-	-	4.98	-	5.55	-
Harrowing	2.49	-	2.53	-	2.52	-	2.44	-	2.36	-	3.20	-
Direct-seeding	9.95	-	-	-	9.79	-	-	-	9.73	-	-	-
Transplanting	-	-	11.82	108.36	-	-	11.66	109.30	-	-	12.75	105.63
Weeding	34.05	-	31.79	-	21.79	-	29.85	-	29.21	-	30.87	-
Harvesting	13.84	111.16	14.46	110.23	13.22	111.94	12.90	107.28	12.51	106.90	15.03	108.74
Threshing	17.41	5.91	17.10	5.13	15.55	4.35	15.86	4.04	11.64	7.52	10.02	5.59
Transportation	5.21	-	4.90	-	5.21	-	4.98	-	4.43	-	3.93	-
Total	**94.14**	**117.07**	**94.26**	**223.73**	**73.67**	**116.29**	**83.66**	**220.62**	**80.24**	**114.41**	**87.03**	**219.97**
	211.21		**317.99**		**189.97**		**304.28**		**194.65**		**307.00**	

Source: Field survey, 2017 *Unit: USD/ha*

Table 3 shows that farmers did not have enough capability to hire and pay many laborers to do transplanting and harvesting, so farmers commonly used exchange labor. The result of the study revealed that the total labor cost of contract farming was about 211.21 USD/ha and 317.99 USD/ha of direct-seeding and transplanting, respectively. The total labor cost of direct-seeding and transplanting of contract farming were higher than the other two groups. Harvesting time had the highest share of labor inputs because it was done by hand.

Table 4 shows that contract farmers and mixed farmers spent higher fuel consumption during land preparation than non-contract farmers because non-contract farmers did only two times in land preparation while other groups three times in land preparation. Hand tractor was the highest fixed cost for all groups. The total fixed cost is equivalent to deprecation cost, which calculated using the straight-line method of depreciation (Rahman et al., 2013).

Table 4 Total variable cost, fixed cost, and production of organic rice production

Items	Contract farmer		Non-contract farmer		Mixed farmer	
	Direct-seeding	Transplanting	Direct-seeding	Transplanting	Direct-seeding	Transplanting
NHH	32	18	31	22	21	13
Variable cost						
Fuel consumption of [1]						
1st plowing	5.27	5.38	5.45	5.38	5.31	5.45
2nd plowing	4.57	4.47	-	-	4.60	4.53
Harrowing	3.01	2.98	2.99	2.98	3.05	3.02
Transportation	9.23	7.20	9.53	7.83	9.10	7.83
Seed [2]	44.26	22.07	44.79	23.47	37.38	24.29
Threshing [3]	18.15	19.09	16.94	17.36	17.19	17.56
Fixed Cost						
Hand-tractor	57.12	54.58	66.57	53.81	62.32	54.80
Sickle	0.32	0.27	0.34	0.33	0.31	0.33
Hoe	0.58	0.47	0.55	0.56	0.51	0.56
Blue sheet	5.53	5.07	5.61	4.36	5.56	4.36
Sack	5.03	5.29	4.69	4.81	4.76	4.86
Total Labor cost	**211.21**	**317.99**	**194.79**	**309.26**	**194.65**	**307.00**
Total production cost	**364.28**	**444.87**	**352.24**	**430.14**	**344.74**	**434.60**

Source: Field survey, 2017 *Unit: USD/ha*

Note:1. Diesel cost was 0.7 USD per 1L.

2. Seed cost was 0.3USD per kg.

3. Threshing cost 1/30 of total production paddy rice.

Productivity and Profitability of Organic Rice Production

Regarding profitability, this study examined several indicators such as gross revenue, total cash income, and net profit of organic rice production in each group. Gross revenue was calculated by yield (tons/ha) multiplied with the price (USD/ton). There are two different ways to examine profitability such as net profit which was calculated by gross revenue minus total production cost, and total cash income which was calculated by gross revenue minus total production cost and minus non-cash cost. The cost of certification was not included in the calculation because no farmer paid since it was subsidized by the contractor and NGO.

Table 5 Net profit of organic rice farming production

Items	Contract farmer		Non-contract farmer		Mixed farmer	
	Direct-seeding	Transplanting	Direct-seeding	Transplanting	Direct-seeding	Transplanting
Yield (tons/ha)	2.19	2.30	2.04	2.09	2.07	2.12
Paddy price (USD/ton)	243.47	242.38	185.52	184.94	208.78	203.32
Gross revenue	**533.05**	**557.90**	**379.13**	**387.26**	**432.74**	**430.66**
Total variable cost	84.50	61.20	79.69	57.02	76.62	62.69
Total fixed cost	68.58	65.68	77.76	63.86	73.46	64.91
Total labor cost	211.21	317.99	194.79	309.26	194.65	307.00
Total noncash cost [1]	255.47	340.06	234.75	327.75	232.03	331.29
Total production cost	**364.28**	**444.87**	**352.24**	**430.14**	**344.74**	**434.60**
Total cash income[2]	**424.24**	**453.09**	**261.64**	**284.87**	**320.03**	**327.35**
Net profit [3]	**168.77**	**113.04**	**26.89**	**(42.87)**	**88.00**	**(3.94)**

Source: Field survey, 2017 *Unit: USD/ha*

Note: 1. Total noncash cost = Seed cost+ Labor cost

2.Total cash income = Gross revenue - (Total production cost -Total noncash cost)

3.Net profit = Gross revenue - Total production cost

Table 5 shows that contract farmers received the highest price and yield among the groups on both cultivations. These are the reasons why contract farmers could generate gross revenue more than other farmer groups. Even contract farmers had higher production cost than others, contract farmers still earned higher net profit and cash income. Ingeneral, farmers earned higher total non-

cash income in transplanting than direct-seeding. On the other hand, farmers could earn more net profit in direct-seeding rather than transplanting because transplanting need much more labor requirement. Moreover, non-contract farmers and mixed farmers were not able generate net profit in transplanting.

Farmer Perception

In general, the main reasons for farmers to engage in organic rice were no fertilizer expense, receive high price, and have healthy farming life. With regards to their perception of contract farming, each group had different reasons. Contract farmers engaged in contract farming because they could receive stable and high price, learn new techniques, and share experiences with other farmers. On the other hand, non-contract farmers did not believe on contract farming system, and they preferred to easily sell to many buyers at different prices with no restrictions. For mixed farmers, they engaged in contract farming to learn new techniques but were not sure if their produce will be regularly sold at a high price.

CONCLUSION

This research found the existence of three types of farmers, namely contract farmers, non-contract farmers and mixed farmers. All farmers cultivated organic rice once a year, particularly during wet season. With regards to crop establishment, direct-seeding was more practiced than transplanting because of lesser labor requirement. Harvesting was commonly done by hand.

With regards to profitability, all organic rice farmers earned positive total cash income, but contract farmers got the highest income. In general, contract farmers on both cultivations can increase their income with higher yield and higher price compared to other farmers. Transplanting cultivation can produce higher yield but require more labor inputs than direct-seeding. In case farmers do exchange labor, transplanting can give farmers more profit. In contrast, if there are no exchange labors, it is better for farmers to do direct-seeding with less labor input.

Although the main reasons for farmers to engage in organic rice were the same (e.g. no fertilizer expense, receive high price, and have healthy farming life), their perception of contract farming varied. Contract farmers engaged in contract farming because they could receive stable and high price, learn new techniques, and share experiences with other farmers. On the other hand, non-contract farmers did not believe on contract farming system, and they preferred to easily sell to many buyers at different prices with no restrictions.

For further study, there is a need to assess the existing organic rice certification and contract farming models, specifically clarify the impact of organic rice contract farming model to small-scale farmers' livelihoods; and to determine the most suitable organic rice contract farming model.

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Research article

Economic Performance of Using Combine Harvesters in Rice Cultivation in Northwest Cambodia

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Abstract Labor scarcity is the most common problem for Cambodian farmers during harvesting season since they commonly harvest rice manually. To reduce harvesting loss, expenses and time, a well-designed combine harvester is gaining popularity. This study aims to evaluate the economic performance of using combine harvesters in rice cultivation. Specifically, this study aims to (1) clarify the reasons farmers adopted the use of combine harvesters, and (2) compare the profitability of rice farming between combine harvester owner-farmer and non-owner-farmer. This study was conducted in Banan district, Battambang province, where utilization of combine harvesters is prevalent. A total of 68 respondents who use combine harvesters were randomly selected and interviewed using a questionnaire and further categorized into 34 combine harvester owner-farmers and 34 non-owner-farmers. The study has four main findings. First, most farmers started using combine harvesters in 2010 due to labor shortage and high wagers. Combine harvester owner-farmers spent lesser total production cost compared to non-owner-farmers. Second, the total production cost of both farmer types varied mainly on the variable cost since the non-owner-farmers spent more on rice harvesting fee, while combine harvester owner-farmers spent only on the cost of diesel, depreciation, and driver. Third, combine harvester owner-farmers received the higher profitability compared with the other. Fourth, the three main reasons for adopting the use of combine harvester were labor shortage during peak harvesting season, convenient harvesting on time, and opportunity to provide custom service to other farmers.

Keywords combine harvester, custom service, cost and return analysis

INTRODUCTION

Rice is the traditional source of income for rural Cambodian people and the essential staple food of the country and other Asian countries (World Bank, 2014). In general, rice cropping cycle takes about three months to seven months, depending on the geographical and climate conditions, and rice varieties (CARDI, 2013). Harvesting is an important operation to maintain the productivity and quality of rice which require about labor input of 150-200 man-hours/ha (Salassi and Deliberto, 2010). With the advent of industrialization, many agricultural laborers have been moved to industrial and service sectors or migrated to neighboring countries (Chhim et al., 2015; MAFF Cambodia, 2016).

Recently, rice harvesting became a relevant issue for farmers due to labor scarcity. Combine harvesters (CH) have become useful and popular to address the problem of labor shortage in manual harvesting practices. CH can perform several operations such as harvesting, threshing, cleaning, and discharging grain into a bulk wagon or directly into a bag. Paraweewongwuthi et al. (2010) and Samaraweera (2012) mentioned that net profit of CH was about 30.3% higher compared

to manual harvesting and threshing, and there was a significant difference between the average production costs of CH and manual harvesting methods. Although only limited farmers can afford to purchase one, many farmers tend to rent CH from other farmers, districts or provinces.

OBJECTIVE

In order to evaluate the economic performance of using CH in rice cultivation, this study aims to (1) clarify the reasons farmers adopted the use of CHs, and (2) compare the profitability of rice farming between CH owner-farmers and non-owner-farmers.

METHODOLOGY

This study was conducted in Banan district, Battambang province. Located 28 km away from Battambang city, this district is known as the second largest rice-growing area in the province. There is also a significantly large number of farmers using combine harvesters. The total area of the district is 789 sq. km., of which paddy fields occupy about 43,969 ha (approximately 62% of total agricultural land) (Banan District, 2016).

Primary data were collected through farm questionnaire survey of randomly selected 68 farmer-respondents and series of key-informant interviews (e.g. district administrator) in August and September 2017 in three communes of the district. The farmer-respondents were identified to be CH users during the time of field survey. They were further equally categorized into 34 CH owner-farmers and 34 CH non-owner-farmers. Non-owner-farmers refer to those who avail custom service or rent CH.

Simple descriptive methods and cost and return analysis were utilized.

RESULTS AND DISCUSSION

Characteristics of the Farmer-Respondents

Table 1 General characteristics of farmer-respondents

	CH owner-farmers	CH non-owner-farmers
N	34	34
Average family size (persons)	4	4
Average age (year old)	43.6	44.0
Average educational level (years)	7.6	6.2
Average farming experience (years)	16.2	13.5
Average planted land per HH		
Wet season rice (ha)	4.4	2.6
Dry Season rice (ha)	5.9	2.4

Source: Field Survey, 2017

In the study, most farmers mentioned that they have engaged in rice farming since they were young and have made decisions and improvements based on their own experience and knowledge shared by their ancestors. Although average age of both types was 44 years old, the average education level and years of farming experience of CH owner-farmers were higher than CH non-owner-farmers. Moreover, with regards to average planted area, CH owner-farmers had larger size for both wet (4.4 ha) and dry season rice (5.9 ha) than CH non-owner-farmers.

The Reasons for Using Combine Harvester in the Study Area

In relation to CH adoption, field survey revealed that farmers started using CH in 2010 due to labor shortages during the harvesting period. Moreover, around 90% of the 34 CH owner-farmers purchased Kubota brand because of its light-weight body, suitability for harvesting rice in both wet

and dry seasons, and affordability. In addition, roughly 25% of CH owner-farmers owned two or three machines depending on their land size and budget.

Table 2 Main reasons for using combine harvesters

Reason of using CH	CH owner-farmer (n=34)	CH non-owner-farmer (n=34)	Total
Have difficulty in securing hired labor	9	10	19
Conveniently harvest on time	7	11	18
Can provide custom service	10	2	12
Have large farm area	5	3	8
Used by many farmers	2	4	6
Millers do not buy rice harvested by hand	1	4	5
Total	34	34	68

Source: Field Survey, 2017

Table 2 shows the reasons for using CH. The following three main reasons were identified: (1) have difficulty in securing hired labor during peak harvesting season, (2) conveniently harvest on time, and (3) can provide custom service to other farms. Furthermore, according to interviewed farmers, family factor highly influenced their decision to purchase or use combine harvesters. The level of living condition of farmers in rural areas and educational attainment of farmers were low. Thus, many young people tend to move from rural to urban areas and work in garment factories and/or other industries or migrate to other countries. Only elderly farmers were left to farm. CH owner-farmers added that CH was preferred for reducing harvest losses and maintaining rice quality and quantity. In general, both group farmers showed satisfaction in CH usage.

Rice Production Cost of Studied Farmers in Wet and Dry Seasons

Table 3 Rice production cost of selected farmers in wet season

Items	Wet season (early maturity, 2016)							
	CH owner-farmers				CH non-owner-farmers			
Land size	Small	Medium	Large	Extra-large	Small	Medium	Large	Extra-large
Number of HH	2	5	6	5	10	5	4	2
Equipment (1)	17.97	12.81	12.25	11.60	17.52	11.73	12.13	12.16
Hand tractor	66.00	40.32	38.34	33.70	104.52	80.93	66.49	65.53
Tractor	0.00	69.11	63.29	61.28	0.00	58.96	53.07	48.08
Pumping pipe	11.91	5.82	4.12	3.08	12.49	8.85	6.96	6.67
Tractor trailer	0.00	16.39	14.22	13.64	0	0	0	0
Combine harvester	62.67	48.02	45.30	39.73	0	0	0	0
Total fixed cost	**158.55**	**192.47**	**177.52**	**163.03**	**134.53**	**160.47**	**138.66**	**132.44**
Cost of seed	39.36	44.95	49.09	49.46	44.45	44.55	48.14	49.01
Fertilizing	85.27	90.54	97.96	106.53	88.70	90.10	100.73	107.98
Herbicide	9.90	11.14	12.38	13.86	10.80	13.61	12.38	12.38
Pesticide	9.90	10.02	11.21	12.45	9.41	9.90	10.56	12.38
Land preparation fee	27.23	0.00	0.00	0.00	25.68	0.00	0.00	0.00
Land preparation (fuel)	4.97	20.36	17.15	15.89	4.84	24.36	23.17	21.13
Material input cost (2)	7.02	8.61	9.60	10.94	5.29	8.94	10.94	13.95
Harvesting cost (3)	20.38	19.84	19.58	19.46	100.98	103.34	102.10	100.56
Family labor cost	37.13	24.94	18.54	13.71	30.40	21.66	19.59	17.82
Hired labor cost	15.10	31.19	43.49	57.10	25.12	34.90	47.65	52.54
Total variable cost	**256.26**	**261.60**	**279.00**	**299.40**	**345.67**	**351.36**	**375.26**	**387.74**
Total production cost	**414.81**	**454.07**	**456.52**	**462.43**	**480.20**	**511.83**	**513.92**	**520.18**

Source: Field Survey, 2017 *Unit = USD/ha*

Note 1) Equipment included blue-sheet, sprayer, sickle and sack.

2) Material input cost included cost of pumping water and transportation.

3) Harvesting cost refer to fuel cost of CH owner; harvesting fee of CH non-owner-farmer.

Production cost for early maturity rice and irrigated type rice was calculated by season, farmer type and operated land size (e.g. small 0.1 to 2.9 ha; medium 3 to 5.9 ha; large 6 to 9.9 ha; extra-large 10 ha and above).

Looking at the rice production cost during wet season by farmer type and operated land size, production costs of both farm types were correlated with the increase in operated land size (Table 3). For example, extra-large CH owner-farmers spent the most, amounting to 462.43 USD/ha, followed by large CH owner-farmers (456.52 USD/ha), medium (454.07 USD/ha) and small (414.81 USD/ha).

However, CH non-owner-farmers seemed to spend more compared to CH owner-farmers. The significant difference can be attributed to the higher spending of CH non-owner-farmer on harvesting fee (about 100 USD/ha), while CH owner-farmers spent on diesel, depreciation and driver fee only.

Table 4 Rice production cost of selected farmers in dry season

Items	Dry season (irrigated type, 2017)							
	CH owner-farmers				CH non-owner-farmers			
Land size	Small	Medium	Large	Extra-large	Small	Medium	Large	Extra-large
Number of HH	3	11	9	6	9	10	4	0
Equipment cost (1)	12.78	13.25	13.06	13.22	14.91	14.53	13.76	-
Hand tractor	44.64	38.66	37.43	37.04	77.93	74.44	67.75	-
Tractor	50.04	45.30	38.31	30.76	61.09	52.94	52.12	-
Pumping pipe	6.96	5.97	4.11	3.43	9.80	8.75	7.41	-
Tractor trailer	19.10	18.45	18.06	16.63	0.00	0.00	0.00	-
Combine harvester	55.13	51.74	44.79	41.64	0.00	0.00	0.00	-
Total fixed cost	**188.66**	**173.36**	**155.76**	**142.73**	**163.73**	**150.66**	**141.05**	**-**
Cost of seed	44.78	47.65	48.57	51.98	49.79	50.00	50.31	-
Fertilizing	112.62	116.58	122.28	124.50	107.82	111.14	110.10	-
Herbicide	9.90	12.38	13.00	14.85	12.38	14.85	21.35	-
Pesticide	9.90	10.15	12.38	13.61	12.38	13.61	20.11	-
Ploughing (fuel)	19.81	19.36	18.51	17.48	22.24	21.39	19.28	-
Material input cost (2)	10.43	11.62	13.58	15.39	9.95	11.15	15.30	-
Harvesting cost (3)	19.77	19.53	19.27	19.05	74.94	72.40	72.52	-
Family labor cost	28.96	20.85	16.24	11.26	32.80	23.39	18.56	-
Hired labor cost	26.61	41.34	62.38	75.50	26.83	44.62	58.17	-
Total variable cost	**282.79**	**299.45**	**326.19**	**343.62**	**349.13**	**362.55**	**385.71**	**-**
Total production cost	**471.45**	**472.81**	**481.95**	**486.35**	**512.86**	**513.21**	**526.75**	**-**

Source: Field Survey, 2017 *Unit = USD/ha*

Note 1) Equipment cost included blue-sheet, sprayer, sickle and sack.

2) Material input cost included cost of pumping water and transportation.

3) Harvesting cost refer to fuel cost of CH owner; harvesting fee of CH non-owner-farmer.

Table 4 shows that production cost in dry season rice seemed to be higher than wet season rice varieties in both farmer type due to shorter cropping duration (only 3 to 4 months) than wet season rice varieties. In order to achieve higher yield, both farmer types from small to extra-large farm needed to input more material and labor inputs. Furthermore, farmers who did rice farming with these varieties spend more diesel cost because they did not do harrowing, but they commonly plowed twice before direct-seeding. Looking at the labor cost, both farmer types who owned large and extra-large farms seemed to spend on hired labor cost than small farms, who were likely to do by themselves. CH non-owner-farmers had higher rice production cost than CH owner-farmers in each category because of the high harvesting fee (around 72 USD/ha).

Rice Farming Profitability of Combine Harvester Owner-Farmers and Non-Owner-Farmers

Net profit of CH owner-farmers and non-owner-farmers in wet season are presented in Table 5. Average paddy yield of both farmer type ranged from 2.90 ton/ ha to 3.75 ton/ha. The result also found that extra-large CH owner-farmer gained the highest gross revenue (906 USD/ha) and followed by large, small and medium farm. Similarly, extra-large CH non-owner-farmers also received the highest revenue amounting to 872.90 USD/ha and followed by large (816.60 USD/ha), small (714.57 USD/ha) and medium farm (689.11 USD/ha), respectively.

Looking at the net profit of CH owner-farmers, extra-large farm had the highest amounting to 443.65 UDS/ha; and small farm received the lowest profit at 412.47 USD/ha. In addition, small CH owner-farmer earned almost twice profit than small CH non-owner-farmer.

Table 5 Net profit by type of selected farmers in wet season

Items	CH owner-farmers				CH non-owner-farmers			
Land size	Small	Medium	Large	Extra-large	Small	Medium	Large	Extra-large
Number of HH	2	5	6	5	10	5	4	2
Paddy yield(ton/ha)	3.75	3.30	3.55	3.60	3.10	2.90	3.37	3.75
Price (USD/ton)	220.61	242.57	249.21	251.69	230.51	237.62	241.96	232.77
Total cash expense	338.32	384.18	388.89	399.26	405.35	445.62	446.19	453.35
Total expense	414.81	454.07	456.52	462.43	480.20	511.83	513.92	520.18
Gross revenue	**827.27**	**800.50**	**883.57**	**906.08**	**714.57**	**689.11**	**816.60**	**872.90**
Gross margin	**488.95**	**416.31**	**494.69**	**506.82**	**309.22**	**243.49**	**370.41**	**419.55**
Net Profit	**412.47**	**346.42**	**427.05**	**443.65**	**234.37**	**177.28**	**302.68**	**352.71**

Source: Field Survey, 2017 *Unit = USD/ha*

Table 6 shows the net profit of CH owner-farmers and non-owner-farmers in dry season. Even, the group of CH owner-farmers in extra-large farm and large farm seemed likely to spend the highest amount on total rice production cost than other medium and small farm, but they remained the highest profit after calculation. Similarly, the group of CH non-owner-farmers in large farm received 424.53 USD/ha; and followed by medium and small farm. As mentioned earlier, in average net profit of CH owner-farmer received the highest profitable compared to net profit of another group in each category.

Table 6 Net Profit by type of selected farmers in dry season

Items	CH Owner-Farmers				CH Non-Owner-Farmers			
Land size	Small	Medium	Large	Extra-Large	Small	Medium	Large	Extra-Large
Number of HH	3	11	9	6	9	10	4	0
Paddy yield (ton/ha)	3.33	4.00	4.24	4.67	3.19	3.90	4.00	-
Price (USD/ton)	232.05	235.15	242.78	247.03	237.28	230.82	237.82	-
Total cash expense	397.71	404.31	417.14	423.11	430.27	439.82	457.88	-
Total Expense	471.45	472.81	481.95	486.35	512.86	513.21	526.75	-
Gross revenue	**773.51**	**940.59**	**1030.47**	**1152.81**	**756.92**	**900.19**	**951.29**	**-**
Gross margin	**375.80**	**536.28**	**613.33**	**729.69**	**326.65**	**460.37**	**493.41**	**-**
Net Profit	**302.07**	**467.78**	**548.52**	**666.45**	**244.06**	**386.97**	**424.53**	**-**

Source: Field Survey, 2017 *Unit = USD/ha*

In general, in terms of season, farmers who cultivated irrigated rice varieties in dry season tend to spend higher on total expense than farmers who cultivated wet season rice varieties. However, irrigated rice varieties had higher yield than other varieties. Moreover, CH non-owner-farmers had higher rice production cost than CH owner-farmers in each category.

CONCLUSION

Field survey revealed that farmers started using CH in 2010. Kubota was the main CH brand used in Battambang Province which had an affordable price and was suitable for harvesting during both

wet and dry seasons. The main reasons for CH adoption were (1) have difficulty in securing hired labor during peak harvesting season, (2) conveniently harvest on time, and (3) can provide custom service to other farms. Cost and return analysis revealed that it is more profitable to use CH for both CH owner-farmers and non-owner-farmers in the study area. Besides, CH owner-farmers received higher profit in comparison to the non-owner-farmers.

This study recommends that farmers shift to CH usage for rice harvesting in order to address labor shortage, reduce production cost as well as gain more profit. For further study, there is a need to conduct a detailed study on CH custom services and its social impact on rice farmers' livelihood.

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Research article

Developing of Incinerator with Hydrogen Gas for Hospital Wastes Treatment

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Abstract In this experiment, we studied the construction of incinerators using Hydrogen gas as fuel in small hospitals. The Hydrogen Gas Incinerating System in this study consists of 3 major parts, the Water Separation System, Furnace and Combustion System, and the DC Power Control System. The authors used water mixed with Sodium Bicarbonate ($NaHCO_3$) solution to separate Hydrogen (H) from water by using 12 VDC and 15.50 A which resulted the 909.09 ml/min of gas flow rate to burn 100 grams of infected waste. The experiment showed that the waste was completely burnt into ash within 13.35 minutes and the average power consumption was 0.04 kW-hr. It was concluded that the gas flow rate should not be less than 800 ml/min because it can have a fire back phenomenon. The result also showed that the burning cost of waste incineration in this study equaled to 1.50 baht/kg which was much cheaper than the one of general infected waste in hospital which costs 5 baht/kg.

Keywords electrolysis, medical waste, incinerator

INTRODUCTION

Medical waste with strong infections, toxic and corrosive, emissions, lax management or improper handling characteristics can cause pollutions to water, atmosphere, and soil and it also makes direct harm to human body if people do not handle with care (Abah and Ohimain, 2011). In order to ensure that the medical waste is in efficient management, harmless to be disposed, and prevent the spread of disease, scientific research tries to design medical waste treatment machines, which use high temperature to disinfect and sterilize medical waste and biomass decomposition, and save the cost of transportation which can also create higher economic benefits (Wajs and Golabek, 2019). However, combustion is a rapid and exothermic reaction between a fuel and oxygen. In incineration application, the predominant waste is fuel and the oxygen source is air, and the sources of combustion can be in many forms of products, whether the materials burned are natural gas, coal, wood, gasoline, hazardous waste, or medical waste which can create pollutions (Allsopp et al., 2001).

Hydrogen fuel is regarded as clean energy. It creates zero-pollution emission when burned with oxygen. It can be used in electrochemical cells, or internal combustion engines to power vehicles or electric devices (Bicelli, 1986). Hydrogen energy is a significant alternative energy. It is as an emerging market for energy business because it creates complete combustion. It also makes high efficient combustion. The benefit of hydrogen fuel is that it provides more than 2.5 times of hydrocarbon energy. Due to, combustion with hydrogen fuels produces no greenhouse gases, smoke, dust, and it is regarded as a conventional energy application. Moreover, the production of hydrogen from water by a process called electrolysis has steadily been being developed (Kudo, 2003).

Therefore, the research team has developed a device called “Dry Cell” to produce hydrogen from water which has been applied with a small stove. This small stove can be used to burn

garbage in small hospitals. The infected waste in many small hospitals at rural areas is removed unsuitably, or inconveniently to destroy because of long distance. The development of a hydrogen fuel combustion plant, or the Hydrogen Gas Incinerator Plant is an alternative device to decrease pollution, cost of transportation, and risks from removing waste. The researchers attempt to create a series of dry cells to produce hydrogen gas as a source of fuel for the medical waste incinerator trial version machine which there are many factors in the production of hydrogen gas is needed to control. The quantity of hydrogen gas is more or less depending on these variables such as, the distance between conductance, the electrical current, and the electrolysis method (Kuracina, Fiala and Soldan, 2014). The authors realize the importance of the effectiveness of the medical waste incinerator which has been desired as a water electrolysis machine, including a pipe line, series of hydrogen gas and water separating, and slurry filling box in order to get the best performance in the separation of hydrogen which is used as fuel in combustion infected waste.

OBJECTIVE

The objective is to study the construction of an incinerator using in small hospitals using hydrogen as fuel.

METHODOLOGY

The principle design of medical waste incinerator with hydrogen gas consists of three parts: I, the Water Separation System, using direct current electricity to separate hydrogen and oxygen gas by putting a pure and high quality aluminum electrode plate inside and place in layers. The electrons flow from the negative terminal of the DC power source to the positive terminal, where they are consumed by hydrogen ions to form hydrogen atoms. II, the Furnace and Combustion Systems, for burning the waste, and III, the DC Power Control System used for electrical work. The three parts are described as the followings:

Part I: Water Separation Systems, the general process of water electrolysis, hydrogen ions move toward the cathode, whereas hydroxide ions move toward the anode. A secondary electrochemical cell using aluminum plates as electrode which is drilled for water flowing between each layer. The insulator is made of rubber cutting edge in every sheet preventing water out of the box. Aluminum sheets and rubber sheets are arranged alternately as you can see in Fig. 1. It is pressed tightly with screws and nuts enclosed with acrylic plate to prevent water leakage. The tube is used to connect between the reserved water box and electrolysis box. Hydrogen gas from splitting water by electrolysis procedure then it flows into the reserved water box and flows to the air filtration set. The water inside the reserved water box will flow into the dry cell or electrolysis box. As a result, the water inside the box is full at all the time. Because this design does not have a gas separating type. The gas in electrolysis procedure is a mixture of hydrogen and oxygen which is used as a fuel. It will pass through a one-way pipe towards the following combustion systems.

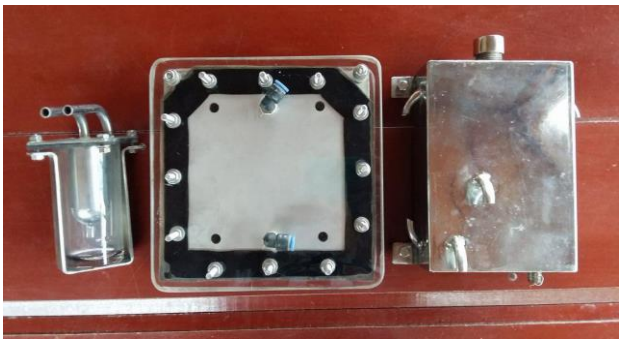

Fig. 1 Hydrogen gas production equipment

Part II: The Furnace and Combustion System consists of a furnace box frame inside which is lined with refractory brick and has steel mesh to allow the ash fall into the bottom. The furnace side is drilled to connect to the pipe with jet valve type to deliver hydrogen and oxygen. To prevent fire back phenomena, the check valve has been installed for controlling the direction of the gas flow. The jet valve is also connected to the spark plug for ignition to burn the garbage.

Part III: The Control System which is for electrical work consists of a 220 VAC switching to a 12 VDC 50 A for power supply. The electrical energy is shown by the voltmeter and the current meter equipment which is supplied to two devices. The first batch of electrical energy supplied to an electrolysis unit is controlled by electric control circuit. The second one is supplied to a set of the sparking that the circuit generates a high frequency and high power for transmission to automotive spark plugs. The pipeline design in all 3 parts can be simplified as illustrated in Fig. 2.

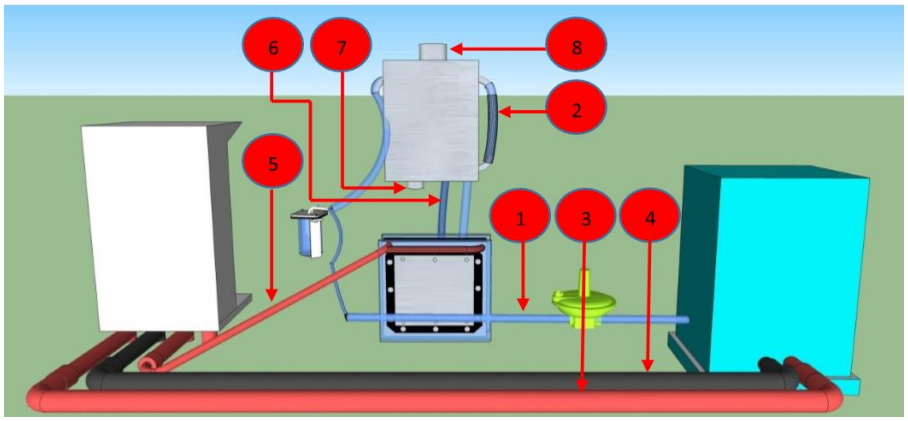

Fig. 2 The pipeline design of the incinerator

1. Hydrogen gas pipeline
2. Water level measuring tube box
3. Cable Anode wire
4. Cable Cathode wire
5. Power supply pipeline
6. Water supply pipeline
7. Drain tube
8. Water and slurry filling pipe

Fig. 3 The hydrogen gas incinerator plant with 3 sections

RESULTS AND DISCUSSION

In the electrolysis process, the separation efficiency of gas with electricity depends on different variables: the spacing of the electrode plate, size of the electrode plate, voltage and electrolyte solution. The quantity of hydrogen gas is proportional to the inverse of the distance between

electrodes, while the size of the electrode plate voltage and the concentration of the electrolyte solution is proportional to the quantity of gas. The distance between the plates sheet was set as close as possible at the range of 0.1 mm. The size of the conduct sheet using 22x22 cm. The supply voltage is 12 VDC. Use sodium bicarbonate (Na_2CO_3) amount of 300 grams in 1 lite of water to prepare of electrolyte solution. The results showed that default value of electricity is quite low as about 10 A when the supply 12 VDC was applied. Initial temperature of water is equal to the temperature of water at room temperature. When the process of electrolysis occurs, water will be change into hydrogen and oxygen gas. This process is exothermic, the temperature of the water is increased, as a result, the electrical resistance is dropped. Consequently, the electric current increases, the rate of gas will also increase. It can be interpreted as the rate of gas that produced is proportional to the voltage and the temperature rise as shown in the Table 1.

Table 1 The flow rate of hydrogen and oxygen

Current (A.)	Temperature of water (°C)	Gas flow rate (mm³/min)
11	33.0	432.90
12	35.0	492.61
13	40.0	699.30
14	44.0	769.23
15	45.6	909.09
16	47.0	942.40
17	48.0	956.70
18	48.5	977.50
19	48.7	982.30
20	48.7	990.40

Although the flow rate of gas is increased according to the value of electrical current, the rate is stable when it reaches the value of electrical current at 15A as shown in Fig. 4, where the flow rate of mixing gas value is close to 1,000 mm^3/min.

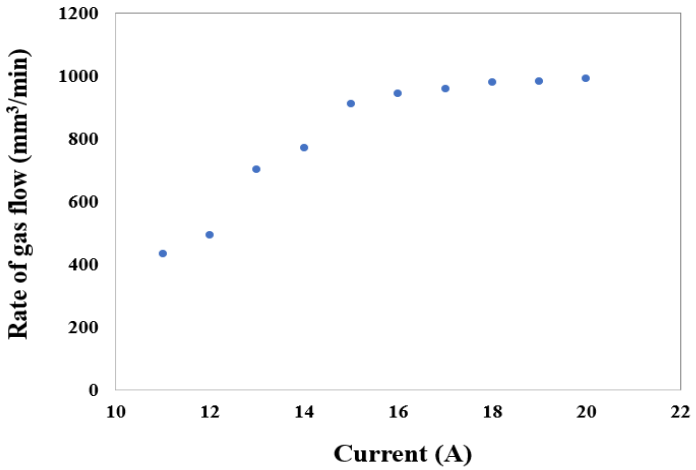

Fig. 4 The Plot between the Rate of gas flow and current

The infectious dry waste in quantity of 100 grams of cotton, gauze and bandage were selected in the experiment. A measurable 12 VDC voltage and an average current of 15.50 A were selected. It was found that the incinerator was able to burn 100 grams of dry waste within 13.35 minutes, and the average power consumption is 0.04 kW-hr.

Table 2 Results by burning dry infectious waste incinerators

No.	Current (A.)	Time (Minute)	Average Power (Watt)	Energy (kW-hr)
1	15.0	13.37	216.2	0.04
2	15.1	13.37	216.3	0.04
3	15.5	13.35	216.6	0.04
4	15.7	13.34	216.6	0.04
5	16.0	13.33	216.7	0.04

The infectious wet waste quantity of 100 grams of cotton, gauze and bandage with humidity at 85% were selected in the experiment. A measurable 12 VDC voltage and average current of 15.1 A were selected. It was found that the incinerator was able to burn 100 grams of wet waste within17.40 minutes, and the average power consumption is 0.07 kW-hr.

Table 3 Results by burning wet infectious waste incinerators

No.	Current (A.)	Time (Minute)	Average Power (Watt)	Energy (kW-hr)
1	15.0	17.36	223.2	0.07
2	15.1	17.36	223.1	0.07
3	15.0	17.41	223.1	0.07
4	15.1	17.40	223.2	0.07
5	14.5	17.44	223.4	0.07

CONCLUSION

From the production of medical waste incinerator using energy from hydrogen and oxygen from water separation process, it was found that the quantity of electricity flowing through the electrode sheet varies to the water temperature. The water resistance is inversely proportional to the temperature. The gas mixture of hydrogen and oxygen used to burn the garbage which shows the approximately minimum gas flow rate should be not less than 800 ml/min. If the flow rate is less than this value, it can have a fire back phenomenon. In addition, the results showed that dry waste consumed less double energy than wet waste as shown in Tables 2 and 3. When calculating the cost of electricity, it was found that the average power for burning dry waste is about 0.04 kW-hr, while burning the wet waste is 0.07 kW-hr respectively. The result also showed that the burning cost of infectious dry waste equaled 1.50 baht/kg, however the medical infectious incineration method in general hospital cost 5 baht / kg.

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Research article

Physicochemicals Properties of Soils with Peanut Shell Amendment and Its Impact to Growth and Yield of Maize

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Abstract The present research studied how the addition of peanut shell to the soil effected on physicochemical properties of soil and plant growth. Waste peanut shells were used to enhance soil properties by composting for cultivation of plants as the organic fertilizer. In the composting step, 2:3 (v/v) of peanut shell and soil was mixed for two months and utilized for the cultivation of maize plants. Some parameters of soil, peanut shell and peanut shell-compost such as pH, moisture, nitrogen, phosphorus, potassium, organic carbon, total sulphur, calcium and magnesium were examined by using their respective standard methods to compare the properties of control and compost-soil. It is observed that the soil added with peanut shell-compost has a potential increasement of nitrogen, phosphorous, potassium, total sulphur, total calcium and total magnesium in plant growth media than control soil. The results obtained in plant growth media also pointed out that the growth rate and yield percent with composed soil were better than those of control soil. These research findings can contribute to the local people from agricultural field with the scientific information of waste peanut shell as low cost alternative fertilizer.

Keywords physicochemical properties, soil, peanut shell, peanut shell fertilizer

INTRODUCTION

Soil quality is the capacity of a soil to a function and this function balances the physical, biological, and chemical components of soil (Karlen et al., 1997). Soil physical properties can give a profound effect on how soils influence soil quality and productivity. Soil quality level is improved by soil physical properties that measure nutrient and moisture present in soils. The physical properties of soil contain soil texture, bulk density, water holding capacity, organic matter content, soil structure, soil color, and soil consistence (Schoeneberger et al., 2012). By adding organic compost to soil before planting gives the soil the boost in nutrients plants depend upon to grow. Fertilizers added later help provide the plants to use nutrients well. Various organic fertilizers amend the soil, including manure, blood meal and wood ash. Among organic materials, peanut shell also has few beneficial minerals plants can absorb and are best use as a protective covering. The beneficial effects on crop production are found and soil properties are directly related to the physical, chemical and biological properties of the composts used (He et al., 1995). Application of organic manures (sewage sludge, compost, manure) in a heavy soil aggregation support porosity, permeability, and air and also in sandy soil to hold water and nutrients help (Abusharer, 1996).

OBJECTIVE

This study focused on the changes in the chemical properties of soil prepared by applying during aerobic decomposition and the plant growth.

METHODOLOGY

Sample Collection

Surface soil samples were collected from farmland of Changgyi Village, Tha- beik- kyin Township, Mandalay region in Myanmar. Peanut shells were collected from peanut shell factory, Mandalay Industrial Zone and they were crushed into small pieces and used as the organic fertilizer for maize plants.

Preparation of Peanut Shell Fertilizer

The combined ratio of peanut shell and soil 2:3 v/v were mixed. The composting process was initialized by preparation of the compost container with suitable size of plastic basket making five small holes in the bottom. During composting process, combined sample was turned periodically for better aeration. After composting 2 months, soil color was found as dark color because of the decomposition of waste materials into the soil.

Determination of Soil Texture

Soil samples (before and after plantation) of texture were analyzed at Department of Agriculture (land use) of Yangon, Myanmar by pipette method (AOAC International, 1999).

Determination of Physicochemical Properties of Three Samples

Determination of pH:
A mixture of air-dried sample and water (1:5) was placed in a 50 mL shaking bottle and shaken vigorously for 5 minutes. The pH of soil suspension was measured with a pH meter (F-51, HORIBA).

Determination of moisture:
The sample was allowed to dry in an electric oven at 105°C, cooled in desiccators and weighed. It was repeated until the constant weight was obtained. From the loss in weight, the percentage of moisture in the sample is calculated (AOAC International, 1999).

Determination of total nitrogen:
The sample at 0.5 g was put in 600 mL digestion tube and added 1 g of catalyst and then it is gently heated until frothing ceases. The flask was removed from the heater and cooled, added distilled water and transferred to the suitable volumetric flask. Accurately 20-25 mL of 2% boric acid was placed in and methyl the receiving conical flask red indicator (2-3) drops was added. Enough water was added to cover the end of the condenser outlet tube. 5 mL of aliquot was pipetted into the distillation tube and 25 mL of 40% NaOH was added and was distilled for about 4 minutes. The receiving flask was removed and the outlet tube was rinsed into the receiving flask with a small amount of distilled water. The ammonia distillate was titrated with excess acid 0.02 N H_2SO_4. The blank was determined in the same manner (AOAC International, 1999).

Determination of total phosphorous:
Aliquot (5-25 mL) depending on phosphorus content was pipetted in a 50 mL volumetric flask and added 5 mL of Barton's Reagent and diluted to 50 mL with distilled water. After 1hour, it was measured with spectrophotometer at 420 nm (AOAC International, 1999).

Determination of available phosphorous:
Air-dried sample at 2 g was weighed and placed in a 500 mL shaking bottle. A 400 mL of buffer solution was poured into the flask and the contents were shaken for 30 minutes. And then it was filtered and 50 mL of extract was pipetted into a 100 mL volumetric flask. Three drops of saturated 2,4 dinitrophenol, 4 mL of 2.5% sulphomolybdic acid solution and 6 drops of freshly prepared chlorostannous acid reductant were added to the solution. The solution was made up to 100 mL with distilled water. The amount of P_2O_5 was determined spectrophotometrically at 660 nm and calibration curve set up employing the standard solution was used to determine to P_2O_5 in the soil (AOAC International, 1999).

Determination of total potassium:
The sample (5 g) was heated in a pre-weighed porcelain crucible by heating slowly without combustion. Then the crucible was placed in the furnace at 550°C for 16 h till a white ash of constant weight was obtained. The ash (0.1 g) was digested for 5 minutes with 2 mL of concentrated hydrochloric acid in a beaker. Then, it was dissolved in 16 mL of 25% hydrochloric acid solution by warming on a water bath for a few minutes. Then it was transferred to a 100 mL volumetric flask and the volume to the mark with distillated water (AOAC International, 1999).

Determination of available potassium:
Air-dried sample at 5 g was placed in a 100 mL shaking bottle containing 50 mL of 1 M ammonium acetate solution. It was shaken for 1 h and filtered. Available K_2O was determined on the filtrate by using a flame photometer (AOAC International, 1999).

Determination of organic matter:
The sample was ash at 500-600°C by placing a suitable weight (0.5-1.0 g) of the sample in a silica crucible and heating it in a muffle furnace for 4-6 h. Loss of weigh on ignition can be used as a direct measure of the Organic Matter (MO) (AOAC International, 1999).

Determination of total sulphur:
Aliquot (2-5 mL) was taken in 50 mL volumetric flask. Acetic acid 50% (5 mL), Gum acacia 0.25% (2 mL) and (1 mL) of orthophosphoric acid were added into this flask and then was shaken for 1 minute. The volume was made up to 50 mL with distillated water and measured the turbidity at 440 nm (AOAC International, 1999).

Determination of total calcium and magnesium:
The stock standards in concentration of 1000 ppm is prepared from pure metal wire, granules, foil, metal oxide or other suitable primary standard compounds of the elements. A calibration curve was applying by recording the absorbance of a series of working standards. The calibration must be done for each set of analysis. Aliquot is taken depending on concentration in a 50 mL volumetric flask and added 5 mL of strontium chloride and dilute 50 mL with distilled water. The content of element is determined from the standard curve (AOAC International, 1999).

Plantation of Maize on Soil Samples

The peanut shells were used as natural-based biofertilizer in the plantation of maize. The maize grains were sowed into the soil that placed in the plastic bags and these bags were regularly watered. After 7 days, the germination of maize grains occurred. Then the high of the nursery plants were about 2 to 2½ inches, they were picked out and transferred to specially prepared roles for plantation experiment. Each same size 10 plants were cultivated in soil without treatment as control and treatment with the peanut shell. A row has 10 ft length and 1 ft width. Comparison of the maize plants in the control soil and treated soil were done after one month, two months, three months and four months and they were shown in Fig. 1 and the height of maize plants were determined.

Determination of Maize Height and Yield

The height of plant were measured at the end of four months, the time of harvest and the yield percent was determined based upon the total weight of maize samples.

After one month (control) | After one month (treatment) | After two month (control) | After two month (treatment)

After three month (control) | After three month (treatment) | After four month (control) | After four month (treatment)

Fig. 1 Comparison of the maize growth in the untreated and treated soil

RESULTS AND DISCUSSION

Soil Texture Before and After Treatment

The texture contents of soil samples before and after treatment were measured and the results obtained shown in Table 1.

Table 1 Soil texture before and after treatment

Sample	Texture				Remark
	Sand (%)	Silt (%)	Clay (%)	Total	
Before treatment	76.76	9.36	13.88	100.00	Sandy loam
After treatment	70.76	18.36	10.88	100.00	Sandy loam

According to Table 1, while the soil before treatment contains sand 76.76%, silt 9.36% and clay 13.88%, the soil after treatment possesses sand 70.76%, silt 18.36 and clay 10.88% and therefore these two soils lie in the sandy loam texture. Double amount of silt percent in treated soil sample inform that it is more suitable for plant crop.

Some Physicochemical Properties of Untreated Soil, Treated Soil and Peanut Shell

From the experimental results, pH, moisture, organic matter, nitrogen, phosphorous, potassium, sulphur, calcium and magnesium of samples were listed in Table 2.

According to the results, the values pH in peanut shell (6.62), soil sample (6.49) and peanut shell fertilizer (6.75) were found to be consistent with the recommended pH level of soil according to the National Gardening Association, i.e., pH values between 5.8 and 6.8 (Thermo Fisher Scientific, 2013). Chemical constituents of peanut shell told the reason of higher level of soil nitrogen, phosphorous, potassium and organic carbon after composting due to the acceptance of

nutrients released from the peanut shells. Nitrogen content increased with the amount of peanut shell composed applied, which is due to high the increased amount of nitrogen was found in the treated soil by applying compost which include nitrogen abundant peanut shell. Moreover similar effects were resulted as better responses in total sulphur (640.5 mg/kg), total calcium (1.44%) and total magnesium (1.51%) contents in the treated soil sample than the untreated one.

Table 2 Physicochemical properties of three tested samples

Parameter	Unit	Samples		
		Untreated soil sample	Treated soil sample	Peanut shell
pH	-	6.49	6.75	6.62
Moisture	%	4.29	5.87	10.98
Total nitrogen	%	0.14	1.16	1.26
Total Phosphorous	%	0.87	0.67	1.57
Available Phosphorous	%	0.25	0.43	0.01
Total Potassium	%	0.59	1.48	0.78
Available Potassium	%	3.07	3.66	3.00
Organic carbon	%	20.67	39.01	30.00
Total sulphur	mg/kg	605.0	640.5	140.0
Total calcium	%	0.91	1.44	0.27
Total magnesium	%	1.35	1.51	0.32

The Effect of Natural Fertilizer on the Maize Growth

The effect of natural fertilizer on the maize growth was determined by applying two indicators, plant height and maize yield and the results obtained were shown Fig. 2.

Maize grains from untreated soil **Maize grains from treated soil**

Fig. 2 Comparison of the yield of maize grains

Table 3 Comparative effect of untreated and treated soil on plant height and maize yield

	Untreated soil	Peanut shell compost
Plant height	150 cm	165 cm
Maize yield (No of maize/plant)	38 %	45 %

As shown in the Table 3, the plant height and yield of maize grain were measured at the end of four months and Compost organic materials led to better qualities to the soil as compared with the soil without compost. These results are in accordance with the literature values (Badar et al., 2015). And then the soil prepared with peanut shell also render slightly better growth rate of plant height (165 cm) than that of untreated soil (150 cm).

CONCLUSION

Peanut shell-compost led to increased amount of physicochemical properties of soil, improvement in plant growth and yield. According to the research studies, the peanut shell-compost had potential

effect on soil especially for the enhancement of essential nutrients. It seems that peanut shell cellulose tissue can create the suitable size of nourishing compost particles and high porosity and these facts can provide high maize yield. The results obtained showed that providing peanut shell-compost as natural fertilizer was an appropriate method to enhance the plant nutrients and growth. It is consistent with environmental standard and recommendation that peanut shell-compost is suitable in the plant growth media and can be applied as a recycled material in the agriculture.

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Research article

The Stream Flow and Water Level Change on Mekong Mainstream from the Hydropower Development Projects at Nakhon Panom, Thailand

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Abstract Mekong, a major trans-boundary river, is one of the main source of hydropower for many Southeast Asian countries. Sources of the hydropower come from many mega-dams along the river. However, constructing mega-dams for hydropower causes numbers of hydrological effect especially with the change of water flow and water level along the river. Nakhon Panom, a province located by the river bank in Thailand, has been severely affected by the hydropower dam operation. To solve these dilemmas effectively, a set of up-to-date data from all perspectives is need for the analysis, however, the data that reports on a transition of hydrological after dam construction are currently limited. This study aims to respond the needs of data by investigate the change of water flow and water level before and after the dam construction using various indicators under the principle of Indicators of Hydrological Alteration (IHA). Hydropower project timeline was created to analyze the daily discharge and water level from 1964 to 2013. Findings portrayed that the water flow had been significantly changing and may directly affects people along Mekong River in terms of their livelihoods, agriculture and tourism activities (e.g. Songkran Festival). The results of this study also can be used as a reference data for hydrological analysis in the future.

Keywords Mekong mainstream, hydropower, hydrological impact, transboundary impact

INTRODUCTION

Mekong River is a major trans-boundary river in Asia which has a lot of potential for hydropower development. The river can be divided into two parts: the Upper Mekong from Tibetan Plateau and China where it is named *Lancang Jiang* and passing Yunnan province of China and Myanmar, and continues the flow through the Lower-Mekong passing Thailand, Laos, Cambodia and Vietnam (Fig. 1a)

The Upper Basin covers 24 percent of the total area and contributes 15 to 20% of the water that flows into the Mekong River. Most of the total flow volume is delivered to the Mekong from tributaries in the Lower Mekong Basin. These tributaries can be separated into two groups: tributaries on the left bank that drain the high-rainfall areas of Lao PDR to the major wet season flows, and tributaries on the right bank, mainly the Mun and Chi rivers, that drain low relief regions of lower rainfall a large part of Northeast Thailand. The major contribution comes from the two major 'left-bank' (eastern) tributaries between Vientiane–Nakhon Phanom and Pakse-Stung Treng that together contribute more than 40% of the flow (Table 1 and Fig. 1b). These two groups of tributaries are also marked by different levels of resource development i.e. in Thailand there is little

room for further expansion of irrigation development and in Lao PDR, there is a lot of potential for water resources development of all kinds (MRC, 2005; 2007; 2018).

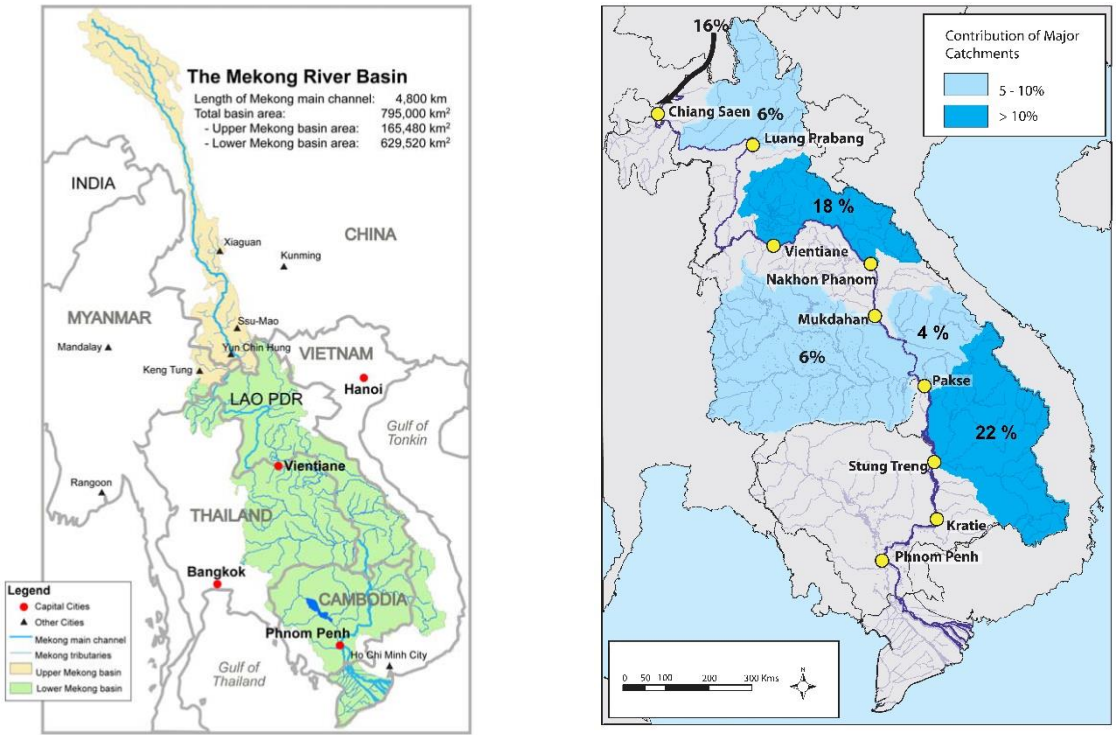
Nakorn Panom, one of eight provinces of Thailand, is directly affected from the operation of hydropower projects in both Mekong mainstream and its branches.

The Upper Basin makes up 31% of the water that flows through Nakhon Panom. While the tributaries during Vientiane – Nakhon Phanom contribute 22% of the flow as shown in Table 1.

Table 1 Proportional contributions to total Mekong River flow

River Reach	Left Bank (%)	Right Bank (%)	Total (%)
China	16		16
China – Chiang Saen	1	3	4
Chiang Saen – Luang Prabang	6	2	8
Luang Prabang – Vientiane	1	2	3
Vientiane – Nakhon Phanom	18	4	22
Nakhon Phanom – Mukdahan	3	1	4
Mukdahan – Pakse	4	6	10
Pakse – Kratie	22	2	24
Tonle Sap	9		9
Total	55	20	100

Source: MRC (2018)



(a) Overview (Rossi et al., 2009) (b) Major contributions to flow (MRC, 2009; 2018)

Fig. 1 Mekong River and its characteristics

Currently, the mainstream in China is dammed by 6 hydropower projects in planned cascade of up to eight storage hydropower projects i.e. Xiaowan Dam, Jinghong Dam, Dachaoshan Dam, Manwan Dam, Nuozhadu Dam and Gongguoqiao Dam. While the first dam of 10 proposed run-of river hydropower projects in Lower Mekong River i.e. Xayaburi Dam is under construction. Moreover, most Mekong River tributaries have cascades of dams in place or planned (MRC, 2010).

Mega-dam structure construction usually results in huge hydrological effect regarding the water flow and water level. This alteration also causes worrisome to people along the river about

the direct and indirect impacts to their livelihoods in terms of their small-scaled fisheries, the economic system and the ecology system of the river.

From the above-mentioned consequences, the monitoring system of transboundary impacts should be established to monitor the impact prior to the construction, during the construction process and after the construction has finished.

OBJECTIVE

The objective of this research is to investigate the result of pre and post constructing the dams using various indicators under the principle of Indicators of Hydrological Alteration (IHA) in Nakhon Panom province, Thailand.

METHODOLOGY

The Indicators of Hydrologic Alteration (IHA) model is used to provide information to understand the hydrologic impacts of human activities as a result of the dam construction. This model can calculate 67 statistical parameters that later are subdivided into 2 groups i.e. 33 IHA Parameters and 34 Environmental Flow Component (EFC) parameters. For IHA parameters, it can be calculated using parametric (mean/standard deviation) or non-parametric (percentile) statistics. (Nature Conservancy, 2009).

Daily time series of discharge and water levels from 1964 to 2013 from provided by Thailand National Mekong Committee were used to investigate the results of pre and post dam construction using various indicators from IHA by Nature Conservancy (2009), and indicators from the studies of Piman (2013) and World Bank (2004).

In this study, the time duration was divided into four phases depending mainly on the operations of the two dams locating on the Upper part of Mekong River: Dachaoshan Dam (2003); Manwan Dam (1996) and two dams on the tributaries: Nam Ngum Dam (1972); and Theun-Hinboun Dam (1998). The water flow status and the water level in the past before dam operation was likely in its natural condition however, natural flow of the mainstream water was changed because of the dam construction (2014) as illustrated in Fig. 2.

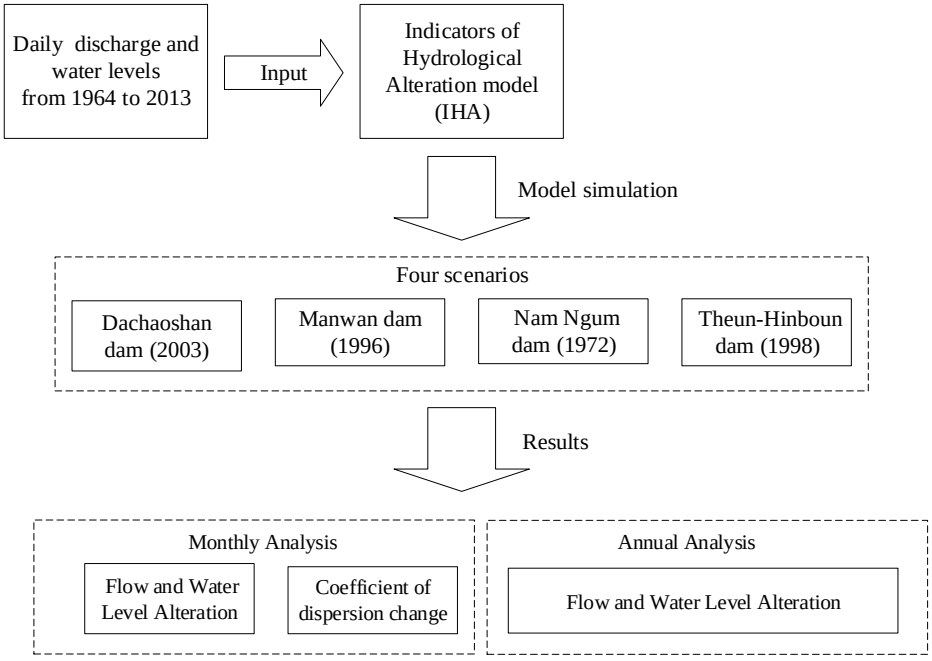


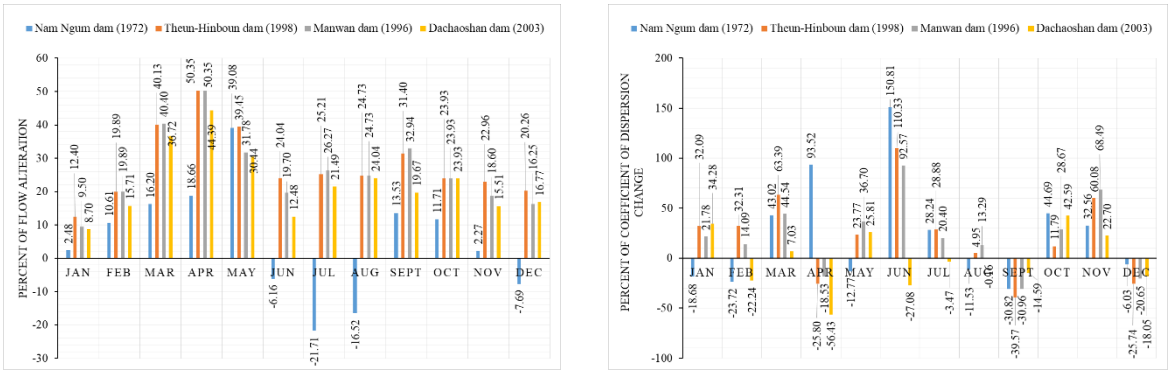
Fig. 2 Study diagram

RESULTS AND DISCUSSION

Monthly Flow and Water Level Analysis

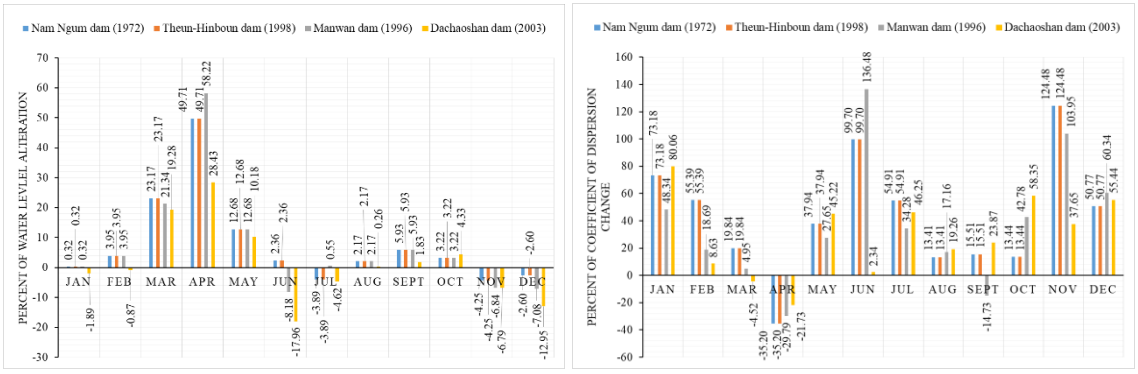
The analysis of mean monthly flow and mean monthly water level illustrated that under the dam construction and operation, most of the dam contribute to increasing the water flow and water level in every month except Nam Ngum Dam in which the flow and the water level are decreased in July, August, and December (Figs. 3 and 4). These might cause from the operation of Nam Ngum dam in Nam Ngum River, Laos PDR which diverse the water to Se Bang Fai River (opposite Nakhon Phanom province). The flow had increased more than 30 percent after the constructions in April and May. This alteration is different from other areas in Thailand which the flow is usually increase during dry season and decrease during wet season. The highest flow alteration is 50.35% in April resulted from the Theun-Hinboun Dam. The highest change of flow variation found in June with the 150.81% change in coefficient of dispersion (CD) resulted from Nam Ngum Dam (Fig. 3).

In terms of water level, the highest water level alterations is 58.22% in April which resulted from Manwan Dam, while Theun-Hinboun Dam contributed 49.71% of the change. The highest change of water level variation is still found in June with the 135.48% of CD change resulted from Nam Ngum Dam (Fig. 4). Moreover, it was found that during March to May and July, the monthly water level was also increased.



(a) Flow alteration (b) Change of coefficient of dispersion

Fig. 3 Monthly flow analysis



(a) Water level alteration (b) Change of coefficient of dispersion

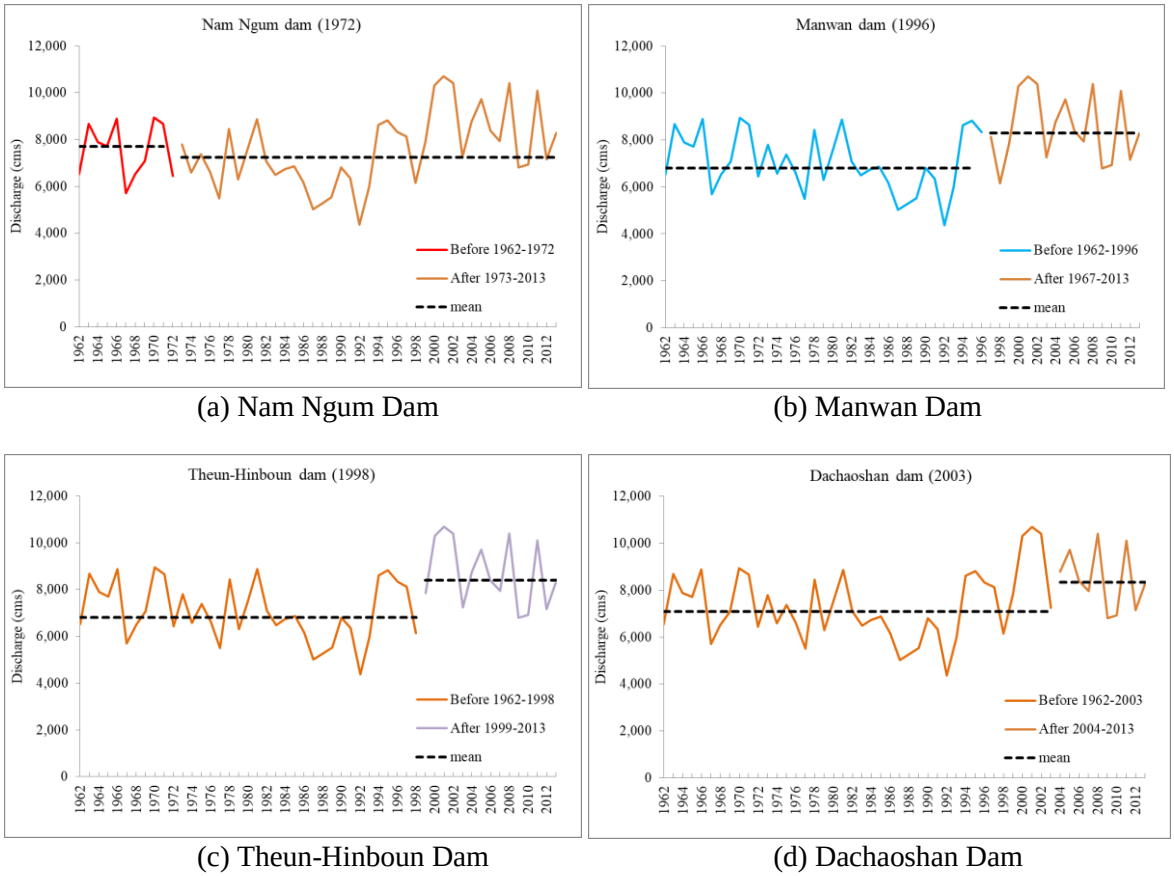
Fig. 4 Monthly water level analysis

However the characteristic of the average monthly flow graphs from Nakhon Phanom was increased every month and showed the differences when comparing to the stations from the upstream (see Piman, 2013; Lu et al, 2014; Rossi et al, 2009) which average monthly flow increased in dry-season and decreased in wet-season.

Annual Flow and Water Levels Analysis

The annual flow analysis indicated that the operation of dams had significantly increased mean annual flow in Mekong mainstream except Nam Ngum dam. Theun-Hinboun dam contributes the most effect to the flow. The mean annual discharge before and after dam operation is 6,810 and 8,390 m^3/s, respectively (Fig. 5). The annual flow after dam operation has 1,580 m^3/s increased.

While the annual water level analysis showed that the operation of dams just slightly increases the water level. The highest increment of water level is 0.04 m resulted from Nam Ngum Dam and Dachaochan Dam.



(a) Nam Ngum Dam (b) Manwan Dam

(c) Theun-Hinboun Dam (d) Dachaoshan Dam

Fig. 5 Annual flow analysis

CONCLUSION

A construction of the mega-dam structure in hydropower project usually results in huge hydrological effect regarding flow and water level. In Nakhon Phanom, the water level was highly increased as a result of the water releasing from hydropower projects from Nam Ngum, and Theun-Hinboun project in Laos.

The monthly flow and water level analysis indicated that most of the dams contribute to increase the flow and water level every month except Nam Ngum dam that the flow and the water level decreases in July, August, and December. The highest flow alteration is 50.35% found in April resulted from Theun-Hinboun Dam. The highest change of flow variation found in June was

150.81% change in coefficient of dispersion (CD) resulted from Nam Ngum Dam whereas the highest water level alteration is 58.22% found in April which resulted from Manwan Dam.

The annual flow and water level analysis indicated that the operation of dams significantly increased mean annual flow in Mekong mainstream except Nam Ngum Dam. Theun-Hinboun Dam influenced the water flow the most. The annual flow after dam operation was increased to 1,580 m^3/s. While the annual water level analysis showed that the dam operations have slightly effect to the increasing of water level. The highest increment of water level is 0.04 m. resulted from Nam Ngum Dam and Dachaochan Dam.

To handle with the occurrences, communities along Mekong River need to adapt themselves to the changes. Additionally, Thailand should be more actively collaborated with other countries especially for their assistance to supply the water when needed. Further studies need to be conducted regarding the hydrodynamic model to calculate the length of time from the releasing points and the preferred destinations.

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International Society of Environmental and Rural Development

Philosophy of ISERD:

Recently, in developing countries, subsistence agriculture is being converted to export-oriented mono-culture, and the amounts of agricultural chemicals applied to the farmland are increasing every year. The applied chemicals in farmland cause serious environmental problems downstream such as eutrophication, unusual growth of aquatic plants, decrease in dissolved oxygen and accumulation of bottom mud in water resources. Also, there seem to be many cases in which people apply agricultural chemicals without understanding its impact to health and food safety. Therefore, it is necessary to promote and enhance understanding of sustainable rural development among local stakeholders including farmers.

Sustainable rural development aims to meet human needs while preserving the natural environment. As it should cover not only social and economic development but also natural environment conservation, no single organization can achieve sufficiently the aspirations of sustainable rural development. Collaboration among international, governmental and non-governmental organizations, together with the academe and scientific sector, is indispensable.

The knowledge and intelligence accumulated in universities and research institutions are also expected to make the programs facilitated by the international, governmental and non-governmental organizations more adequately implemented and meaningful to societal development. However, these cases especially those implemented locally have been scattered without having been summarized well or recorded in annals academic or scientific societies.

So, the International Society of Environmental and Rural Development founded in 2010, aims to discuss and develop suitable and effective processes or strategies on sustainable rural development focusing on agricultural and environmental aspects in developing countries. The ultimate goals of the society are to contribute to sustainable rural development through social and economic development in harmony with the natural environment, and to support the potential or capacity building of local institutions and stakeholders in the rural area with academic background.

Purposes of ISERD:

The primary purposes of ISERD are to contribute to sustainable rural development through social and economic development in harmony with the natural environment and to support the potential or capacity building of local institutions and stakeholders in the rural area with academic background.

In order to enhance the realization of the primary purposes of ISERD, the secondary purposes are;

- to facilitate interaction among international, governmental, non-governmental organizations and local communities,
- to hold conferences or symposia on environmental and rural development,
- to edit the International Journal of Environmental and Rural Development,
- to confer some awards based on scientific achievement, research paper or poster presentation, and
- to encourage and develop local awareness concerning sustainable rural development.

Membership:

There shall be two categories of membership.

(a) Individual

(b) Organizational

An application for membership of ISERD shall be submitted to the secretariat of ISERD, where is located in the Research Center at Institute of Environmental Rehabilitation and Conservation (Japan) by writing or by other appropriate means.

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