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Food security and socio-economic impacts of soil salinization in the central dry zone of Myanmar: a case study

Aung Naing Oo, Kazuo Ando[1], Theingi Khaung and Moe Tin Khaing[2]
Department of Soil and Water Science, Yezin Agricultural University, Myanmar, [1]Center for Southeast Asian Studies (CSEAS), Kyoto University, Japan. [2]Department of Chemistry, Yadanarbon University, Myanmar,
email: dr.aungnaingoo@yau.edu.mm

Abstract: The study area, HteinKanGyi village in Myittha Township, Mandalay Division is located in the Central Dry Zone (CDZ) of Myanmar. The central Myanmar is known as Dry Zone because of its physical characteristics such as low annual precipitation, instable distribution pattern, significant high temperature and low relative humidity. In the study area, more than 700 acres of the land is salt-affected due to the water logging from the result of left main canal system of Kinda Dam. Soil salinity has been one of the most important issues for local farmers who live in this village. Decreasing soil productivity caused by salinization has led to social tension, unemployment and reducing incomes of all households. This study surveyed the impacts of soil salinity on the crop production and to describe the food security and social and economic conditions in the HteinKanGyi village, Myittha Township. All respondents have more or less acreage of salt affected soil. Some people had no cultivated rice fields because of severe affected by salinity, and thereby families survive mainly as seasonal agricultural laborers. General socio-economic characteristics of the studied village are high population density, low agricultural productivity, low technological base, low producer prices, high costs and diminished margins, limited access to institutional credit, high degree of indebtedness, large percentage of landlessness, high incidence of seasonal migration, shortage of labor supply on large holdings and limited alternative income sources. This finding could suggest that development extension agencies should provide farmers with financial and technical assistance to make available salt tolerant rice varieties, knowledge and improved technologies in order to increase food sufficiency.
Key words: Food security, socio-economic, salinity, dry zone, Myanmar.

Introduction

Soil salinization has become a serious problem all over the world and around 20% of the world's cultivated land are affected (Sumner, 2000). In Myanmar, soil salinization was found in coastal and inland regions. Coastal salinity was affected by seawater intrusion/ infiltration during flood resulting salt accumulation in the top soil in the summer season. It was commonly happened in Ayeyarwady, Yangon, Yakhaing and Taninthari regions. Inland salinity is commonly seen in dry zone areas of the central Myanmar such as Mandalay, Magway and Sagaing regions. Among the three regions, salinity areas were mostly observed in 16 townships of Mandalay region with total areas of 6,357 ha in 2013-2014. Meikhtila district has the largest salt affected area of 3,045 ha followed by Myingyan (1,530 ha) and Kyaukse (1,125 ha)Districts. In the township level, the largest salt affected areas were found in Nahtogyi, Myittha and Wuntwin Townships with the areas of 940 ha, 617 ha and 437 ha, respectively (Swe and Ando, 2017). According to Swe and Ando (2017), salinity is becoming a prominent abiotic problem declining rice production in central dry zone where little attention was paid in the past. They opined that with irrigation for several years continuously, alkali/saline soils have been developed in certain areas. The excessive applications of irrigation water have raised the ground water level sufficiently to increase concentration of salts through evaporation. It is related principally to the presence of sodium carbonate and sodium bicarbonate in these particular areas. Inland salinity or irrigation salinity is due to over-watering, seepage from irrigation channel, impaired natural drainage and high water table. From the low land rice in these salt affected areas, high rate of evaporation and evapotranspiration of rice crop increase the capillary transport of water and solutes from the groundwater to the root zone. When there is a condition of no or negligible leaching of these salts, the soils will be affected with salinity within a few years. In addition, due to the poor drainage facilities in the irrigation areas not only the agricultural lands have suffered but also agricultural production has suffered from the twin hazard of water logging (hypoxia) and salinity. It has been happened for more than two decades in HteinKanGyi and thus causing threat to the local farmers' survival. The lands which are severely affected by water logging and salinity have gone out of production as an abandoned field because it has been caused to the agricultural production of lands.

In Myanmar, development of agriculture is vital to any rural development promotion effort. Broad-based and economically efficient rural growth can significantly help to reduce rural poverty and enhance food sufficiency by bringing about sustainable increase in crop productivity and reducing risks and vulnerability for the poorest population.

Soil salinity has been accelerated by human activities such as deforestation, irrigation, salt-making and construction of roads and reservoirs (Mitsuchi *et al*., 1986). In Myanmar, especially in the dry zone, declining soil productivity caused by saline intrusionhas led to the farmers in terms of social tension, unemployment and reducing incomes of all social groups. Increasing soil salinization affects many farmers in the dry zone with small land holdings. Soil salinization must be seen as also a human problem rather than one concerned solely with the damage of ecosystems. While people are the main agents for salinization, they are also its victim.

Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (WFS, 1996). The entire livelihood system of farmers in the central of Myanmar is farm-based. Farmers continue to make their living from manual trade and agricultural production. Rice, ground nut, sesame, lablab bean and pigeonpea are the main crops grown under rainfed conditions by practicing traditional cultivation system, and rice is the staple crop of most farm households in the studied area. Due to water logging and soil salinization affected by irrigation canal of Kinda dam, low productivity has brought poverty leading to the lowest per capita income in the village. Their dependency on agriculture and lack of knowledge on management might have caused problems of salinization which has a severe effect on soil fertility and crop productivity. Therefore, it requires an examination in order to get a solution to this problem for a better livelihood of future generations. However, no research has been undertaken on an evaluation of the livelihood system in salt-affected areas of this region.Yet rice sufficiency is the key to survival in Myanmar as rice forms the greatest portion of daily food consumption for subsistence farmers.

The objectives of this study were (i) to assess the influences of soil salinity on the rice production systems, and (ii) to describe the food sufficiency and social and economic conditions in the salt-affected areas of HteinKanGyi village.

Materials and Methods

This study aims to understand farmers' knowledge, practices and related problems and constraints in the crop production system and their food security status and social and economic conditions undersalt-affected areas of HteinKanGyi village in Myittha Township, Mandalay Division, Myanmar.

Site selection: A study area was selected in the central dry zone of Myanmar, representing the tropical climate zone. This study site was purposely selected because they have different salinity levels. Soil salinization continues to affect the farmers' livelihoods. This study was conducted in villages at HteinKanGyi village in Myittha Township, Mandalay Division, Myanmar from October to December, 2016.

Research tools: Research methods used in this study include a small questionnaire, semi-structured interviews, and direct observation. The small questionnaire was used in collecting quantitative data. Semi-structured interviews were used in collecting qualitative data and separate guidelines for key informants and household informants were used. This was because holding a well-prepared interview guide in hand, semi-structured interviews are more likely to cover all sub-topics of interest, and thereby reducing the potential risk of missing data. Direct observations were made in order to validate information given by informants (IFAD, 2002).

Data collection: The interview and information collection process was used as follows: (i) key informant interview and group interview in village level (ii) household level in-depth interview and (iii) observations. A simple random sampling method was applied to select sites and draw a representative sample of household heads for the study. The total sample size of households was drawn using simple random sampling technique, in view of that the sample of this study consisted of (30) households with facing salinity problems. The simple size was determined by Yamane (1967).

Data analysis: Qualitative data was supported by documents and materials relating to the topics covered by the study and the quantitative component of the study. Field notes were converted into detailed notes each day in the field soon after completing all interview sessions of the day. When the entire data collection process was completed, descriptive methods were used in data analysis. Quantitative data was analyzed by applying descriptive statistics (mean, percentage, etc.) with the help of Microsoft Excel.

Results and Discussion

Village profile: The geographical topography of Myanmar is divided into three parts such as western hills region, central valley region and eastern hills region. The study village, HteinKanGyi, is situated in Myittha Township, Mandalay, the central valley region and falls in the dry zone with tropical climate. It is situated 90 kilometers away from Mandalay city and 25 kilometers from Myittha Township. This village is located in the areas which are severely affected by water logging and salinity.

The characteristics of the households in the studied villages are shown in Table 1. There are 2232 people in this village and living in 587 households. 43 % of the total household are farmers and the rest are landless. Most of farmers have only lowland and a few has both lowland and upland. The total area of the study village is 4000 acres with the cultivated area of 2875 acre for lowland rice and 700 acre for upland crops. In lowland area, more than 700 acres of the land is salt-affected due to the water logging from the result of left main canal system of Kinda Dam. Most farmers grow rice on their salt-affected land while some grow green gram, pigeon pea and sesame in upland. Because of high salinity in this study site, some farmers abandoned their rice field after the five to six years of the completion of Kinda dam according to the group discussion. Because of the spread of salt-affected areas in this village, the current productivity of arable land areas is very limited. Major soil types found in this village are sandy soil, loamy sand, sandy loam soil.

Table 1. Characteristics of the study households in HteinKanGyi, Myittha Township

Characteristics	HteinKanGyi
Total households	587 (2232 populations)
No. of agricultural households	250
Salt-affected households	70
Sample households	30
Average age of respondents (year)	55 (36 ; 72)
Education (%) Primary school	60
Secondary school	40
Average household size (person)	4.1 (2 ; 6)
Average labors (person)	2.4 (1 ; 5)
Average number of dependents (person)	1.6 (0 ; 5)
Salt-affected area (ac)	722
Abandoned land (ac)	200

Parentheses show minimum and maximum.

According to group discussion, there is a minimum temperature range from 10˚C to 20˚C in December, January and February to a maximum of 43˚C in March, April and May. The hottest month is May and the coldest month is January. Temperature gradually rises during the period between mid-March to mid-May, which is the pre-monsoon period, during which low pressure is created. The average annual humidity is 66 %, butit drops to 42 % in hottest months (April and May), whereas it shoots up to 80 % in wettest months.

Rainfall is also controlled by the monsoon circulation system. But rainfalls in the dry zone areas are sometimes come by tropical storms. Precipitation in early monsoon is favorable for crops in the village, if late, the crop yield is not certain for that year. All villages are located in semi-arid area so the farmers have adapted to climatic constraints. Based on their traditional knowledge, some farmers forecast on intensity of rainfall and grow different cropping patterns. Some farmers record the daily rainfall and list annually so they can make a decision on selection of crop variety for that particular year. The farmers from the village mentioned that precipitation varies from year to year, and even though the frequency of rainfall might be higher than normal, the amount of precipitation received may not be enough for the crops.

Soil salinity and rice production in the studied village: Swe and Ando (2017) noticed that in central Myanmar irrigated rice was cultivated since the ancient Myanmar King era of 11thCentury. Since the capitals of the kingdom were situated in Upper Myanmar where the climate is semi-arid, the kings constructed irrigation structures, such as weirs, lakes and canals. King Anawrahta (1044-1077) constructed seven weirs along the Zawgyi and Panlaung rivers and developed Ledwin - eleven- districts to produce sufficient rice for his entire kingdom. Since then, the new irrigation works were constructed; maintained, and renovated by the successive kings, making the irrigated rice production successful in upper Myanmar. In those days, irrigation system was mainly with gravitational flow and only for the monsoon rice cultivation.

In this study, according to the survey, the total irrigated area of Kingda Dam was allocated for 195260 acres which covers four townships, namely Myittha, Kyaukse, Tada-Oo, and Wundwin Townships (Irrigation Department, MOAI). Water from the dam is diverted into two main canals (Left Canal and Right Canal). The left canal of Kinda Dam was 78 miles long with total diversion canals of (DY) 34 in numbers and the flow rate of 1,948 cu.ft/sec. Total irrigated areas of the left canal of Kinda Dam were 65748 ac, while the right canal with 38895 ac (Irrigation Department, MOAI). Tun *et al.* (2009) observed that after three years of Kinda Dam irrigation the salt-affected area was formed about 41 acres. The water logging area increased yearly and it reached 722 acres and the related salt affected area was approximately 2500 acres in 1994-95.

Rice is the major staple food in Myanmar. All of respondents from the studied village are farmers, whose main occupation is the cultivation of rice for household consumption.There are two varieties of rice grown in the village namely Manawthuka in rainfed and Shwemanaw in the dry season. Due to the salinization, limitation of water resources, low soil fertility, high cost of capital investment for land preparation such as sowing, seedling, equipment, chemical fertilizer, pesticide, transportation and high cost of labor, the rice productivity is quite low. This situation has made the farmers face the problem of food insecurity. The villagers mentioned that the expenses of agricultural inputs have increased every year, especially fertilizer and pesticide. Farmers mentioned that rice price is not stable, and in some years the fluctuation is also high.

Rice production practices: According to the group discussion farmers starts land preparation at the onset of the rainy season in this village. Ploughing and harrowing and leveling are done by cattle. For land preparation, the land is ploughed at least 2-3 times followed by harrowing and leveling. Urea, compound fertilizers and cattle manure are commonly used as inputs in their fields. According to the group discussion, there are two methods of rice growing; transplanting and broadcasting in the village. The transplanting method is the most common for the monsoon season crop. For transplanting method, rice seedling is grown in the nursery for 30 to 35 days according to the varieties. Then, the rice seedlings are transplanted into the prepared paddy field. With the broadcasting system, farmers are unable to solve the weed infestation problem effectively because weeding totally depends on the manual control system and the farm labor charge to get the effective control might amount 30% to 50% of the total production cost which is unaffordable. Usually, monsoon paddy grows forabout 140 days in the field, from early-June to November. In the dry season, farmers grow irrigated rice by the broadcasting system. Unfortunately, in the summer season of 2016, there was no water for irrigated rice growing due to low precipitation in 2015.

At the harvesting time, the farmers in the village harvested rice by using a sickle. They reported that the whole rice plants are harvested by hand and the rice straw are kept for the fodder of cattle. Threshing is undertaken by a foot operated thresher by some farmers. However, most farmers preferred to use mechanized threshers. They reported that they can reduce the labor input requirements and it can be used quickly and efficiently. However, some farmers also reported that there is a lower level of seed viability of seed processed using mechanical threshers when compared with traditional practices. Most farmers undertake the storage of their rice grain in a barn for the seed of next growing season. Storage in barn is generally regarded as being capable of providing easier control of rodents and other pests.

It was observed that rice yields pre acre of the studied village for the year 2015 were much lower than those for the year 2014. This yield decrease for most households was apparently due to a prolonged drought in 2015.

The main problem with rice production in the studied village is salinity in the fields. According to observation, rice plants are affected by iron (Fe) toxicity under rice field with high salinity. Farmers could not cure this toxicity due to lack of knowledge and investment and consequently, the yield are very low. Farmers mentioned that there is another problem with the rice production that occurs about the time of harvest; damage can occur due to rodents and birds. Also, unseasonable rainfall (i.e. late rains) at harvest time can cause grain damage due to fungal diseases.

Socio-economic conditions: All villagers are Buddhists and they strongly believe in Buddha's teachings. They value the ordination ceremony when their son or grandson becomes a novice monk. All of the temple donations are based on agricultural income.

According to the elder villager, in years before constructing the Kinda dam, their lands were favorable for high productivity of crops. At that time, their standard of living was better so they could use the surplus for donations. All of the families do their social, cultural and religious activities after harvesting their cultivated crops.

In social, cultural and religious activities, the old persons and village headman play an important role. Even though the village headman has full authority, he shows respects to the old, honorable persons and follows the guidelines and suggestions from them. For the religious activities, monks play very important role in the village. In some social and cultural problems, monks can give the final decision for the village. Seasonal religious festivals are held under the guidance of the monks and elder person.

Although the major crop grown in the village is rainfed rice, some farmers grow sesame, pigeon pea, lablab bean and greem gram. Domestic animals raised by most farm households in the village are cattle, goat, pig and chicken for home consumption and sale.

The village economy is based on agriculture in the studied village. Most households are farm households, and very few households do non-farm work like government officials, public health workers, agricultural input retailer or small shopkeeper. The major source of income for the farm households in studied village is the cultivation of crops and keeping domestic animals like cattle, pigs and chicken also make a contribution to household income. They also spend certain amount money on their children’s education, health, transportation, clothing, lightening, kitchenware, house maintenance, donation and personal use. In most cases, farm work is done using family labor, but hired labor is common during peak seasons like transplanting and harvesting of the crops.

House type is a relevant indicator for the economic status, especially the cash income of farm households in the village. Generally houses with corrugated iron sheet (CI) roofing and brick walls are owned by high income households. Slate-roofed houses with wooden walls are owned by middle income households, and thatch-roofed houses with bamboo walls by low income households. But some medium and low income households are roofed with CI with the wooden walls.

Table 2. Comparison of soil salinity level, average rice yield and average household’s income of the studied village in the year 2016

Salinity level	Average rice yield (ton/ha)	Household’s income (US$/year)	Source of income
High	1.35	770	Farm-based
Moderate	2.85	1077	Farm-based
Low	4.45	1540	Farm-based

Survey data (2016)

According to the group discussion, the average of rice yields among the sample household is very low about 2.5 ton/ha (50 basket/ac), as compared to the national average yield 4.07 ton/ha of (MOAI, 2015). This low yield might be due to the salinity, low soil fertility and sandy texture soil. The main source of household income in the village was farm-based. The study indicates that 80% of the total income in the studied village comes from the rice cultivation. Table 2 shows the comparison of soil salinity level, average rice yield and average household’s income in year 2015. Farmers who have paddy field with high salinity level got an average yield of 1.35 ton/ha and annual household’ income was US$ 770. In contrast, farmers who have paddy field with low salinity level got an average yield of 4.45 ton/ha and annual household’ income was US$ 1540. It was found that the annual average income per household among the study household is US$ 985. Thus, salinity intrusion is one of the major environmental factors pushing towards greatest vulnerability to the local communities.

Village food security: Myanmar produces more than enough food to meet domestic needs and is a major food exporter, abundant food supplies do not automatically translate into abundant food for the poorer groups who live in the dry zone areas. Based on group interview, there are different types of agricultural and non-agricultural activities in the village practiced by the farmers in order to improve food security of their families. Generally, there are ten different agricultural activities (rice, pigeon pea, raising animals, etc.) and four non-agricultural activities (retail shop, daily labor migration to city, etc.) but not all households get involved in those activities.

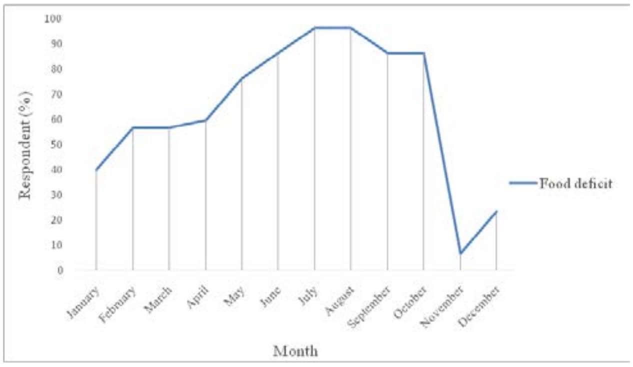

Fig. 1. Percentage of respondents facing food deficit during the year 2015

Seasonality plays a vital role in food security. There was a persistent food scarcity during the growing of crops and the pre-harvest period, when farmers have to invest a lot of money in such time. Most households in this study face food deficit more or less throughout the year (Fig. 1). The food deficit remains high from July to end of October (87-96 %), whereas it is the lowest in November and December (7-23 %) due to harvesting period for rice and growth of vegetables. There was also food shortage from February to May (57-77 %) due to lack of job in the dry season. This is due to no irrigation water in 2015 as most of the lands were not cultivated and food items are not easily available. They thus have to generate resources by selling food grains and cash crops, or by borrowing. Farmers have to tighten their grip on consumption during this time. They have to cook less compared to other times. Sometimes the men in the household temporarily migrate to the city for earning, leaving their family members at home. The food deficit is less during the month December–January due to harvesting period for rice and growth of vegetables.

Coping strategies: It was found that all farm households in the village were rice insufficient in 2015 due to salinity and prolong drought period. In order to survive throughout the year, rice insufficient households involved in various activities in quest for food or cash for food. Coping strategies are many and various in kind that only some selected, major activities are described in this report. In reality, many activates called "coping strategies food insufficiency" in this study are routine activities for some food sufficient households in generating their supplementary incomes. These activities can be briefly categorized as (1) farm-based strategies; (2) non-farm strategies; and (3) forest-based strategies.

Farm-based strategies are those activities directly related to cash crops or alternative food crops, and domestic animals. These include legume cultivation, and rising of domestic animals like cattle, goats, pigs, and chicken, etc. Non-farm strategies in this study mean such activities done for cash by selling or directly utilizing one's labor. Non-farm strategies include waged labor, migrated labor, and retailing. Forest-based strategies are those non-formal activities usually done by landless and small households during most difficult situations in time of hunger. They include mushroom and bamboo shoot collecting in the forest, firewood collecting. Although the study area is under forest conservation some landless and small farmers used to cut branches of big trees and it is still a simple coping strategy for food insufficiency in a shortest period of time.

Labor migration also increasingly becomes a major coping strategy for food insufficiency in the village. Twenty percent of farm households have migrated to the city as seasonal labor to other farm where watermelon was grown. The most common destination migrants from the village is Mandalay. Among those who migrate to the city, males remit more money to their homes than females do. Male migrants usually do hard works of higher wage rate, but their remittance is not regular.

In the studied village, most survey households are not entirely self-sufficient and need to integrate into the labor market as employers and laborers. As such, food insufficient households in the village also perform various non-farm activities as their survival strategies. For landless and marginal farm household with salinity problem in the village, labor migration is at first another strategy for coping with food insufficiency. The people from the farm household migrate in search of higher wage as it happens in the city or other agricultural farm.

Conclusion and suggestion

Salinity intrusion caused by irrigation canal from Kinda dam is leading to negative impacts on rice production and consequently to the food insecurity and livelihood of the studied village.

The studied village face enormous widespread soil salinity as a consequence of soil and water resource degradation. Also, rising water tables resulting from irrigation have caused water logging problems. The collected information shows that despite difficulties, farmers are continuing their efforts for the management of salinity to produce rice. In order to alleviate salinity in their rice field, they apply organic fertilizer and farmyard manure such as cattle manure. However, the average of rice yields among the sample household is very low about 2.5 ton/ha (50 basket/ac). In addition to salinity effect, periodic drought, the heavy reliance on monsoon, lack of financial capital, low inputs uses are the major constraints for the farmers in the village.

This finding could suggest that farmers are advised to use farmyard manure and green manure in order to reduce salinity, correct application of fertilizers, the timely use of fertilizer, better weeding, timely harvesting and proper threshing and winnowing. Since rice is the main source of livelihood system, extension agencies should provide farmers with financial and technical assistance to make available salt tolerant rice varieties, knowledge and improved technologies in order to increase food sufficiency.

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