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Modern Farming Technologies: Impact on Farm Productivity and Food Security in the Rice Terraces of the Cordillera Region, Northern Philippines

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Author's contribution

This whole work was carried out by author RTN.

Original Research Article

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ABSTRACT

The study assessed the impact of modern farming technologies on the productivity and food security in the rice terraces. The study covered four rice terraces clusters located in four provinces in the Cordillera region in the northern central part of the Philippines. The sites covered were: Haliap, Asipulo, Ifugao, Bagumbayan, Tabuk City in the province of Kalinga, Tanglagan, Calanasan, Apayao and Natonin, Mt. Province. The study is a part of a bigger project conducted for 24 months from January 2011 to December 2013. The study employed the Case Study method using 10 key informants supported by interviews, workshops and Focus Group Discussion. The results showed that one of the study sites still adhered to the traditional system of farming while three had already shifted to modern farming technologies. The three modern farming technologies adopted by farmers are: use of modern rice varieties as a substitute to the traditional varieties, use of fertilizers and pesticides and the use of hand tractors. Modern rice varieties improved rice production by 70% from the current yield of traditional rice varieties. Increase in yield created a fit between cash and subsistence wherein added produce improved food security and the surplus is sold to the local market for cash. However, the contemporary increase in yield is still not enough to cater to income and food security. The inevitable use of commercial inorganic fertilizers associated with modern rice varieties altered soil quality in the rice paddies. Soil is obviously sick with declining pH range. Although farmers have been using pesticides in the terraces, soil and water are still free from pesticide residues.

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1. INTRODUCTION

The Philippine Cordilleras is home to one of the widest and oldest rice terraces throughout the Asian region. Some of these rice terraces clusters were declared by the United Nation Educational, Scientific and Cultural Organization (UNESCO) as world heritage sites by virtue of their cultural, economic and environmental values to humanity. Modern society today is reaping the benefits of what generations of people in the Cordilleras have built.

The rice terraces are important part of the local and national economy of the Philippines. They ensure the food security of almost 80% of the local population who are dependent on them for survival [1]. They also contain agro-biodiversity and associated resources that underpin the goods and services they provide to the local community and to society as a whole [2]. Rice terraces also protect watershed and pump prime the growth of the tourism industry.

Historically, the rice terraces flourished as an organic production system. The integration of the region to the economy of the lowland areas in the 1970s brought in so much intercultural and economic exchanges that arbitrarily changed the lifestyles and economy of the people. New farming practices and technologies escalated in the rice terraces parallel with traditional agricultural practices. For almost 50 years, 70% of the farming households may have tried either one or two of these new farming practices or technologies. In some parts of the region, farmers have already shifted to modern farming practices but in some areas traditional farming practices still continue to prevail. In some other parts of the region, farmers are blending both traditional and modern farming practices. Farmers argued that the productivity of traditional rice varieties had been declining over the years and that they have no other recourse but to find ways to increase yield by shifting to high yielding rice varieties. The series of changes that have occurred in the rice terraces captured the attention of policy makers, putting the rice terraces in the forefront of public policy debate over the last few years. Is the adoption of modern farming technologies/practices a boon to productivity and food security in the rice terraces? This is the basic question that this current study sought to provide an answer.

2. MATERIALS AND METHODS

This study was part of a bigger project that was conducted for 24 months from January 2011- December 2013 covering four rice terraces clusters located in four provinces in the Cordillera region in the northern part of the Philippines. The four rice terraces clusters are found in Asipulo, Ifugao, Tanglagan Apayao, Bagumbayan, Kalinga and Natonin, Mt. Province, respectively. The collection of data followed a three step inquiry process. The first step consisted of a workshop with 10 key informants to get information pertaining to farm characteristics. The second step inquiry was the collection of data on modern farming technologies adopted by farmers and their impact on farm productivity and food security. The second step interview was aided by a semi-structured questionnaire administered on a face to face basis.

The third step consisted of the collection of soil and water samples in each study site for routine and pesticide residue analysis. The study adopted the qualitative research approach

using the case study method. After the tabulation of the data, the researcher returned to each study site for the validation of data through a Focus Group Discussion (FGD) with at least 15-20 farmers and barangay leaders. Toward the end of the study, a farmers' forum was organized attended by farmers and other stakeholders from the local and national government agencies, non-government organizations and academia to disseminate the output of the research project.

The Vulnerability Assessment Tool for Various Agro-ecosystems (VAST-AGRO tool [3] was used to determine the sensitivity of income of farmers to climate factors. The VAST-AGRO tool is an excel based assessment tool developed by the agricultural systems cluster of the College of Agriculture of the University of the Philippines in Los Banos, Laguna, Philippines.

3. RESULTS AND DISCUSSION

3.1 Profile of the Rice Terraces

The rice terraces assume different elevations along the mountain slopes from the top to the bottom of mountains. Using their relative position along the mountain slopes, the rice terraces can be classified into three agroecological zones: low, medium and high elevation terraces. Low elevation terraces are those found in Tanglagan, Apayao and Bagumbayan, Kalinga with a top elevation 300-500 masl. Medium elevation terraces are those found at the middle and lower slopes in Natonin and Asipulo that are within 600-1000 masl while high elevation terraces are also found in these two areas with elevation exceeding 1000 masl. Elevation influenced to a large extent the adoption of modern farming technologies. Lower elevation terraces were the first to shift to modern farming systems. The adoption of modern farming technologies escalated over the last 40 years. Three of the selected study sites shifted to modern farming system while one still adheres to the traditional ways of farming handed down from one generation to another. The physical profile of the four study site is shown in Table 1.

Table 1. Physical Profiles of the four study sites

Study Sites	Top Elevation (MASL)	Status of the Rice Terraces
Asipulo,Ifugao	1200	Shifted to high yielding rice varieties in 1990
Tanglagan, Apayao	300	Shifted to high yielding rice varieties in 1980
Bagumbayan, Tabuk City, Kalinga	500	Shifted to high yielding rice varieties in 1980
Natonin, Mt. Province	1500	Traditional rice varieties

3.2 Modern Farming Technologies in the Rice Terraces

Prior to the 1980's, the rice terraces persisted organically with traditional rice varieties. The transition to modern rice cultivars came only in the early 1980's although there were earlier attempts to do so without much success. The transition came as a response to the declining productivity of traditional rice varieties and intense food insecurity situation in the rice terraces. According to farmers, declining productivity can be attributed to declining soil fertility and the low tillering capacity of traditional rice cultivars. Farmers mentioned that

traditional rice varieties can only produce an average of five tillers which is low compared to modern rice cultivars. The modern farming technologies adopted by farmers are: use of high yielding rice varieties, use of fertilizers and pesticides and use of hand tractors replacing human and animal labor.

3.2.1 Use of modern rice cultivars

The study sites in Bagumbayan and Tanglagan were the first to shift to modern rice varieties followed by Asipulo in Ifugao province. The study site in Natonin, Mt. Province (is still very much traditional) adhering to the cultivation of traditional rice varieties. The adoption of modern rice varieties increased rice production by 80% ensuring enough food supply to the families of rice terraces farmers. However, there are certain trade-off between the cultivation of modern rice cultivars and traditional rice varieties. Modern varieties are perpetuating the continuing loss of the traditional rice varieties that have endured for many years. As shown in Table 2, some farmers would revert back occasionally to the cultivation of traditional rice varieties especially the glutinous ones for making rice wines. Rice wines are conventions for drinking during the performance of ritual sacrifices and maintaining the cultural heritage of the local people.

Table 2. Rice varieties cultivated by farmers

Varieties Cultivated	Asipulo, Ifugao	Natonin, Mt. Province	Bagumbayan, Tabuk City, Kalinga	Tanglagan, Apayao
Traditional	0	10	0	10
Modern	10	0	10	30
others	3	0	3	6
Total	13	10	31	46

**that revert back to the traditional rice varieties occasionally*

3.2.2 Use of pesticides, herbicides and commercial fertilizers

The use of synthetic inputs was alien to the rice terraces prior to the 1980's. The last 40 years were the most crucial period in the history of rice cultivation in the terraces. It was during this period that farmers saw the emergence of new pest and diseases forcing them to try commercial pesticides. One of the most notable pest that affected the rice terraces in the 1990 are the giant earthworms creating large burrows by their movements spilling water and causing terraces dikes and walls to crumble. The crumbling of dikes and walls had much to do with the physical degradation of the rice terraces for many years (Gomez and Pacardo 2009). Declining soil fertility also led farmers to try commercial inorganic fertilizers which are readily available in the market. The adoption of modern rice cultivars arbitrarily changed the old organic system into inorganic systems with the associated use of pesticides, herbicides and commercial fertilizers. Over the years, farmers are continually under extreme pressure to change their farming system. The use of fertilizers and pesticides in the four study sites is shown in Table 3.

The use of modern rice varieties is both a bane and a boon to rice cultivation in the terraces. Farmers use fertilizers and pesticides to remedy nutritional deficiencies in soil and protect crops from pest and diseases. However, inorganic fertilizers had caused changes in soil properties leading to declining pH while pesticides may have affected the population of aquatic biodiversity.

Table 3. Use of pesticides and commercial fertilizers

Use of Commercial Fertilizer and Pesticides	Asipulo, Ifugao	Natonin, Mt. Province	Bagumbayan, Tabuk City	Tanglagan Apayao	Total
Yes	10	3	9	9	31
No	0	7	1	1	9
Total	10	10	10	10	40

3.2.3 Use of hand tractors

Cultivating the rice terraces used to be a tedious manual job. Mud puddling is done by hand and feet with the aid of a shovel. The rice terraces used to be inundated with water making the soil soft and pliable easy for hand working. However, frequent droughts made the soil hard and difficult to cultivate thus farmers had to learn to use either the carabao or hand tractor. The use of hand tractor replaced manual labor reducing by 75% the number of man-hours spent in the cultivation of the rice terraces. The distribution of key informants on the adoption of hand tractor is shown in Table 4.

Table 4. Use of hand tractor

Use of hand tractors	Asipulo, Ifugao	Natonin, Mt. Province	Bagumbayan, Tabuk City	Tanglagan, Apayao	Total
Yes	10	0	10	10	30
No	0	10	0	0	10
Total	10	10	10	10	40

4. MODERN FARMING TECHNOLOGIES, PRODUCTIVITY AND FOOD SECURITY

Modern farming technologies brought so much relief to the rice terraces farmers. The adoption of high yielding rice varieties more than doubled rice production from the current yield of traditional rice varieties. Modern rice varieties created a perfect fit between cash and subsistence [4]. Rice is produced firstly to satisfy the food requirement of farming families and the excess is sold to the local market for cash. The added increases in rice production created a more secure food situation where farmers need not depend on lowland rice anymore. The food security situation is reflected on the answer of key informants on whether the food supply situation in the rice terraces is adequate or not as indicated in Figs. 1 and 2.

Farmers use pesticides to protect crops from pest and diseases and fertilizers to remedy nutrient deficiencies. These are direct intervention measures which are instrumental in harnessing the yield of crops. However, it is apparent that the continued use of commercial fertilizers influenced the pH level of paddy soils in the three study sites that have already shifted to modern farming. Paddy soils in Bagumbayan and Tanglagan exhibit strong acidity while soils in Asipulo exhibit alkalinity. The more traditional site in Natonin exhibits a more neutral soil with higher phosphorous and organic carbon and organic matter content. There is no doubt that the differences in soil pH are the effects of commercial fertilizers. The soil quality status of paddy soils in the four study sites is shown in Table 5(a).

Fig. 1 Key informants responses on the food supply situation in the rice terraces whether adequate or inadequate (based on traditional rice varieties)

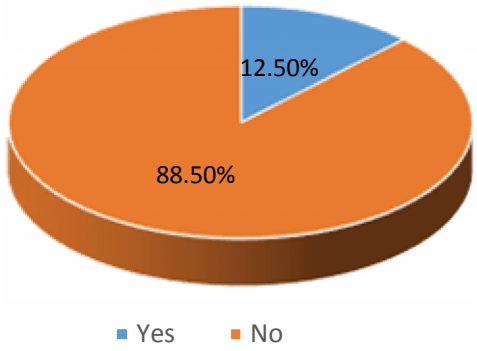

Fig. 2 Key informants responses on the food supply situation in the rice terraces whether adequate or inadequate (based on high yielding rice varieties)

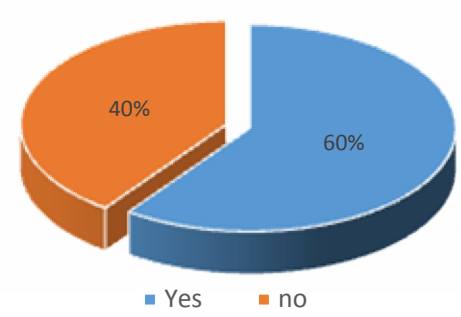

Table 5(a). Soil quality status of paddy soils in the four study sites

Study Site	pH	Total N (%)	P (ppm)	K (me/100g. soil)	OC (%)	OM (%)	CEC (NH4OAC)
Bagumbayan, Tabuk City, Kalinga	5.0	0.09	ND(Bray 2)	0.03	1.19	2.05	13.3
Tanglagan, Apayao	5.0	0.03	0.17(Bray 2)	0.1	2.54	4.37	29.4
Natonin, Mt. Province	5.5	0.09	158.1(Bray 2)	0.1	3.84	6.60	46.8
Asipulo, Ifugao	7.5	0.05	32.7 (Olsen)	0.4	2.84	4.13	63.5

Grab water samples were also taken for pesticide residue analysis. The results showed that soil and water quality in the three study sites that have shifted to modern farming systems is still clean and not affected by pesticide residues. The result of pesticide residue analysis is shown in Table 5(b).

Table 5(b). Pesticide residue content of soil in the four study sites

Study Sites	Nature of Pesticide	Pesticide Residue (mg/kg or ppm)*
Bagumbayan	Organochlorine, Pyrethroids,	<LOQ
Tanglagan	Organophosphates and	<LOQ
Haliap	carbamates.	<LOQ
Natonin		<LOQ

**Residue detected below the limit of quantification (LOQ). The LOQ for organophosphates, Organochlorines and pyrethroids is .005 mg./kg. Results obtained by gas-liquid chromatography*

The use of hand tractors brought many benefits to farmers. It reduced labor bottlenecks and freed plenty of man-hours spent in tending the rice terraces which the farmers can spend in doing other tasks. Hand tractors also found application in eliminating giant earthworms and golden apple snail with their rotating cylinders during field preparation. After plowing, farmers drain water from the paddies for a few days to allow giant earthworms to move inside the dry paddy beds. Water is re-applied quickly and harrowing is done with the rotating disk of the hand tractor. Giant earthworms and golden apple snail are crushed and killed in the process.

Higher productivity in the rice terraces results to better food security. However, food security is not only the function of productivity but also directly linked to the availability of additional sources of income. Families with additional sources of income are more food secure than those who depend purely on the rice terraces. The data in Table 6 indicates that income derived from non-climate sensitive sources (such as those in the employment and buy and sell business) is much higher than income derived from climate sensitive sources. This would mean that the few household members who are engaged in non-climate sensitive occupation earned much more income than the majority who are engaged in rice terracing and other climate sensitive occupation. Better food security can be achieved when farmers are engaged in agriculture and other non-agricultural sources of income. Harvest from the rice terraces satisfy the food requirement of families while earnings from non-agricultural sources meet the other financial need of families. The distribution of households according to income sources is shown in Table 7.

Table 6. Pesticide residue content of water in the four study sites

Study Sites	Nature of Pesticide	Pesticide Residue (mg/kg or ppm)
Bagumbayan	Organochlorine, Pyrethroids,	*ND
Tanglagan	Organophosphates and	ND
Haliap	carbamates.	ND
Natonin		ND

** Residue detected below the Limit of Determination (LOD). The LOD for organophosphate is 0 .02 mg./kg and 0.005 mg/kg for organochlorine and pyrethroids. Results obtained by gas-liquid chromatography*

Table 7. Distribution of households according to income sources

Sources of Income	Asipulo, Ifugao	Natonin, Mt. Province	Bagumbayan, Tabuk City	Tanglagan, Apayao	Total
Agriculture	**75**	**21**	**41**	**80**	**217**
Agriculture + non-climate sensitive sources	17	29	58	10	114
• % income from sensitive sources	40	87	30	70	155
• % income from non-sensitive sources	60	13	70	30	245
Non-climate sensitive sources	8	50	1.0	10	69
Total	100	100	100	100	400

5. CONCLUSION AND RECOMMENDATION

Modern farming technologies are some of the major drivers of change in the rice terraces. The adoption of modern rice varieties substantially increases the level of production in the rice terraces. It has improved the food security situation enabling farmers to create surplus for the market. However, surplus produce is still considered meager compared to lowland standards. Contemporary increases in yield are not enough to provide better income and food security to farming families. At the core of this issue is the very limited space for the expansion of agriculture and the lack of capital for agricultural intensification. The rice terraces offer vast opportunities for income generation. For the rice terraces clusters adhering to traditional rice varieties, there is a need to open up a niche market for heirloom rice to be integrated in the local, national and export market. This will provide an economic incentive for farmers to continue with their sustainable traditional farming systems. On the other hand, fish and duck production are two ventures that farmers can do to gain more income. Since ducks feed on golden apple snail, they have an added advantage in controlling the pest.

The data shows that farmers with more diverse sources of income are better food secure. In this regard upfront investments are necessary to improve agricultural production and create opportunities for income generation. Investments may include loans, grants and payment of environmental services. Farmers who are capable of capturing the financial value of goods and services derived from the rice terraces are in a better position to do long-tern conservation of the rice terraces.

The use of commercial inorganic fertilizer altered the quality of paddy soils in the rice terraces. Paddy soils under high yielding rice varieties are obviously sick with declining pH range compared to the more traditional site in Natonin, Mt. Province that has a more neutral soil. In this regard, it may be necessary for farmers to moderate the use of commercial fertilizers to control the decline in soil pH. It may also be necessary for farmers to apply lime to neutralize soil acidity prior to cropping.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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