ＳＤＧs 人材育成特別コース

ＳＤＧs プロジェクト実習成果報告書

令和元年度

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ＳＤＧｓ人材育成特別コース
令和元年度 ＳＤＧｓプロジェクト実習 成果報告書

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SDGs fieldwork in rural Vietnam and Japan

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1．全体の概要

「SDGs プロジェクト実習」の一環として、ベトナムと日本の農村部を対象に国内および国際実習を行った。参加学生は社会基盤環境学専攻・農村環境創成学講座のの立石　翼君と MAI Thi Khanh Van さんの２名であった。国際実習は担当教員と２名の学生が現地研究者の協力を得ながら共同で行い、海外学際共同研究の醍醐味を学生自ら体験できるよう様々な工夫を行った。国内実習は担当教員と MAI Thi Khanh Van さんのみが参加し、岡山県鏡野町を対象に中山間地域における観光開発と地域の活性化をテーマに行った。

なお、国際実習および国内実習の前後に、学内実習として準備会、予備発表会等を行った。

2．国際実習の日程と主な内容

調査期間は 2019 年 8 月 27 日（火）から 9 月 1 日（日）の 6 日間であり、主に中部ベトナムのフエ省、クァンチ省およびクァンビン省の農村地域を訪れて聞き取り調査を行った。なお、具体的な日程と主な内容は以下のとおりである。

8 月 27 日（火）：フエ市内集合。フエ農林大学の Quy 博士と日程等の確認
8 月 28 日（水）～29 日（木）：クァンチ省カウニ村にて、ベトナムの伝統的な農村社会構造（地縁組織、血縁組織それぞれの成り立ちとその関係）と地域開発に関する調査実習
8 月 30（金）：フエ省フォンヒエン村にて農地の再集積に関する調査実習
8 月 31 日（土）～9 月 1 日（日）：クァンビン省ソンチャク村にて観光開発と住民生業の変化、地域内格差に関する調査実習

3．国内実習の日程と主な内容

調査期間は 2019 年 10 月 24 日（木）から 26 日（土）の 3 日間であり、岡山県鏡野町を対象に中山間地域における観光開発と地域の活性化に関する調査実習を行った。

4．全体を通して

今回の実習は全学で推し進めている SDGs を共通言語として、ベトナムと日本の農村地域を対象にそれぞれの地域が抱えている問題と潜在力を総合的に理解する力を養うことを目的として行った。とりわけ、クァンチ省カウニ村とフエ省フォンヒエン村における実習では SDGs の 9 番目（産業と技術革新の基盤をつくろう）と 11 番目の目標（住み続けられるまちづくりを）を、クァンビン省ソンチャク村では 8 番目（働きがいも経済成長も）と 12 番目（つくる責任つかう責任）の目標を、さらに岡山県鏡野町での国内実習では SDGs の 12 番目の目標を、それぞれ念頭

に置きながら調査実習を行った。また、これらの過程で 2 名の学生がそれぞれの専門を活かしながら調査結果をまとめ上げるプロセスは極めて教育的効果が高く、今後さらに拡大させていきたい。

写真 1．　クァンチ省カウニ村における調査実習の様子

写真 2.　クァンビン省ソンチャク村での調査実習中の食事

2

II. Overseas fieldtrips (Vietnam)

2.1. Cau Nhi Village

48501155 Tsubasa Tateishi

2.1.1. Introduction

Clan system, a social unit, has been important and necessary for farming society in Vietnam since the past. It is related with production activity, which is related with development of farming villages. On this research, we focused on the function and structure of clan system in a farming village in Vietnam.

Figure 1. Location of Cau Nhi Village

2.1.2. Fundamental information of Cau Nhi Village

Cau Nhi Village in Hai Tan Commune is located on the northwest of Hue City, the center of Vietnam. It takes 1 hour from Hue City by car. Cau Nhi Village was founded in 1417. There are historical and traditional buildings in the village, thus it was registered as the first Cultural Village of Quang Tri Province. 550 households live in 8 hamlets of the village. There are no industrial estates around the village, thus the villagers are almost full-time farmers.

Table 1. Number of family clans in Cau Nhi Village

Original family clans since founding		Disappeared	4
		Exist now	8
	Family clans that came later		18

2.1.3. Methodology

We conducted interview to 7 original family clans written on the Table 2 and asked some questions like the below.

- Careers of each interviewee
- Number of households of each family clan
- Branches of each family clan
- Anniversary days of each family clan and the village
- Role of family clans in the village council

Table 2. Timetable of interview in Cau Nhi Village

Date	Time	Interviewee (Family clan)	
28th August 2019	AM	Mr. Le Chi Ca (Le)	Mr. Tran Dang Thoi (Tran)
	PM	Mr. Nguyen Van Cam (Nguyen)	Mr. Bui Xuan Kha (Bui)
29th August 2019	AM	Mr. Pham Huu Hoa (Pham)	Mr. Hoang Tan Lap (Hoang)
	PM	Mr. Dao Ba Hong (Dao)	

2.1.4. Findings

- Communication of policies: Government → Local authority → Clan leaders → Villagers
- Family clans have their own anniversary days, facilities and organizations as well as those of the village like the Table 3. As for the village council, all 26 family clans belong to it. However, 4 original family clans: Bui, Hoang, Nguyen and Pham have priorities in making decisions.

Table 3. Comparison between family clan and village

	Family clan	Village
Anniversary days	Death days of some ancestors	Praying days
Facilities	Ancestral houses	Communal house Worship hall
Organizations	Executive committee	Cultural village executive board Village steering committee Hamlet executive committee Village council Cooperatives

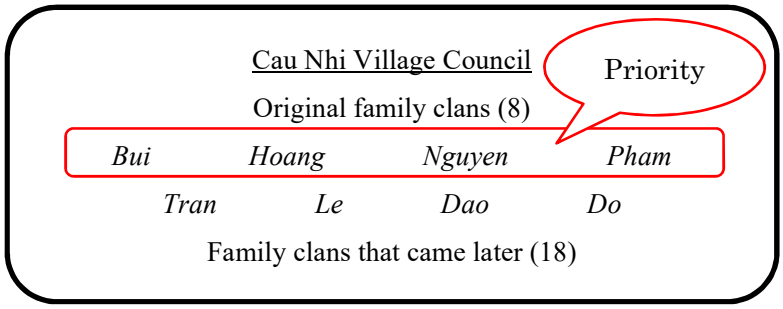

Figure 2. Cau Nhi Village Council

Figure 3. Family clan tree

- Clan system is divided into some branches. People have close relationship with other members at least in their own branches.

2.1.5. Our view

- Family clans that have priority in the village council are likely to influence the development of farming villages.
- Ties of clan system seem strong as well as those of local community or stronger than them.
- Regarding comparison between Vietnam and Japan, both clan system and local community establish their own anniversary days, facilities and organizations that is peculiar to Vietnam. On the other hand, only the latter is true of Japan.

2.2. Phong Hien Commune

48501155 Tsubasa Tateishi

2.2.1. Introduction

The fieldwork in Phong Hien Commune was to understand the land consolidation and its effect.

2.2.2. Fundamental information of Phong Hien Commune

Phong Hien Commune is located on the northwest of Hue City, the center of Vietnam. It takes 30 minutes from Hue City by car. Phong Hien Commune have agricultural land areas with 2,400 ha: paddy fields (16%), farmland for annual crops (13%) and others (71%). The average area of farmland is 0.5 ha/household. In the commune, farmers grow crops for 2 times per year. Between 2003 and 2004 and in 2017, the land consolidation was conducted.

Figure 4. Location of Phong Hien Commune

2.2.3. Methodology

We conducted interview about land consolidation, for instance, condition of farmland before and after land consolidation, how to divide farmland after land consolidation and production system in land consolidation areas.

Table 4. Timetable of interview in Phong Hien Commune

Date	Time	Activities
30th August 2019	AM	Interview to vice chairman of Phong Hien CPC
		Interview to director of An Lo Cooperative
		Interview to an organic farmer
		Visit to a land consolidation area

Figure 5. Interview in Phong Hien CPC

Figure 6. Interview to an organic farmer

Figure 7. Visit to a land consolidation area

2.2.4. Findings

- Farms after land consolidation were graded and divided by lottery among farmers.
- Phong Hien Commune has its own production process of land consolidation areas like the Figure 8.

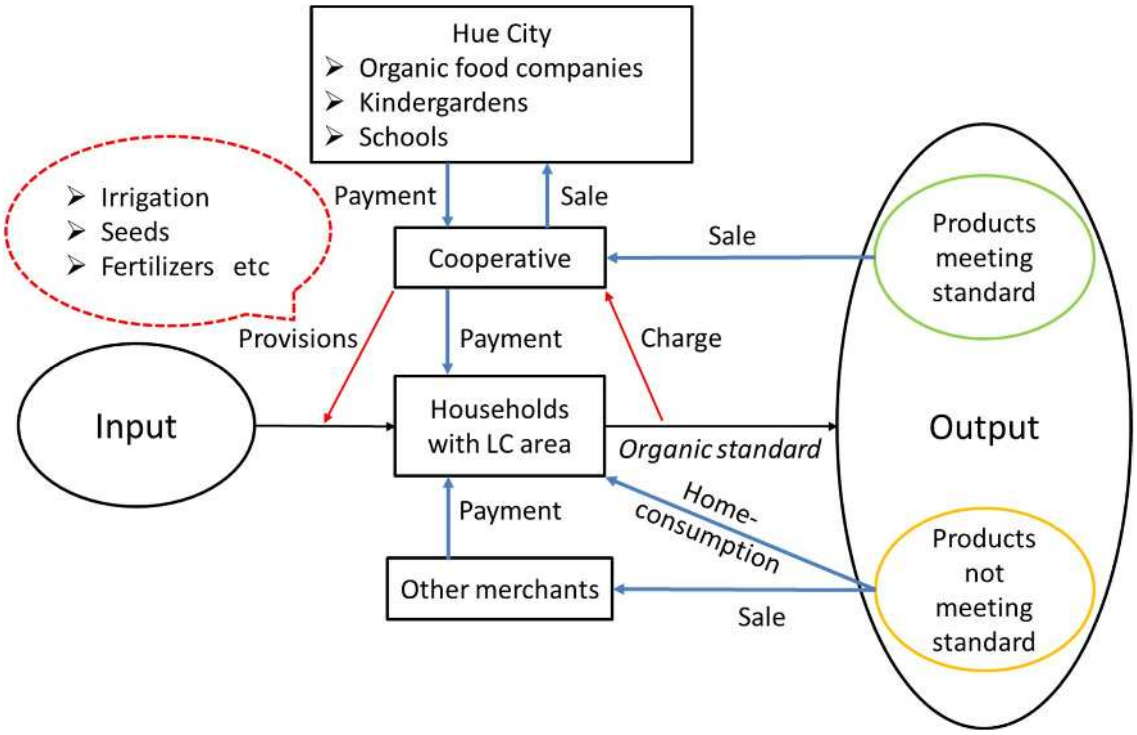

Figure 8. Production process of land consolidation areas in Phong Hien Commune

2.2.5. Our view

After the land consolidation, situations of farmers became not only better but also worse than before like the below. This difference might be a bigger and bigger problem to affect their incomes.

- As for higher graded land, the enhancement of productivity can be expected. And organic farming is successful, thus it may lead to the creation of added value.
- As for lower graded land, farmers suffer from inconvenient cultivation.

↓

Phong Hien Commune and the cooperative should settle measures to support farmers who have lower graded land or correct unfairness.

Regarding production process, the cooperative assists farmers by provisions and mediates sale of products that meet organic standard. That makes the agricultural production process much easier for farmers.

2.3. Son Trach commune

48430167 MAI Thi Khanh Van

2.3.1. Location

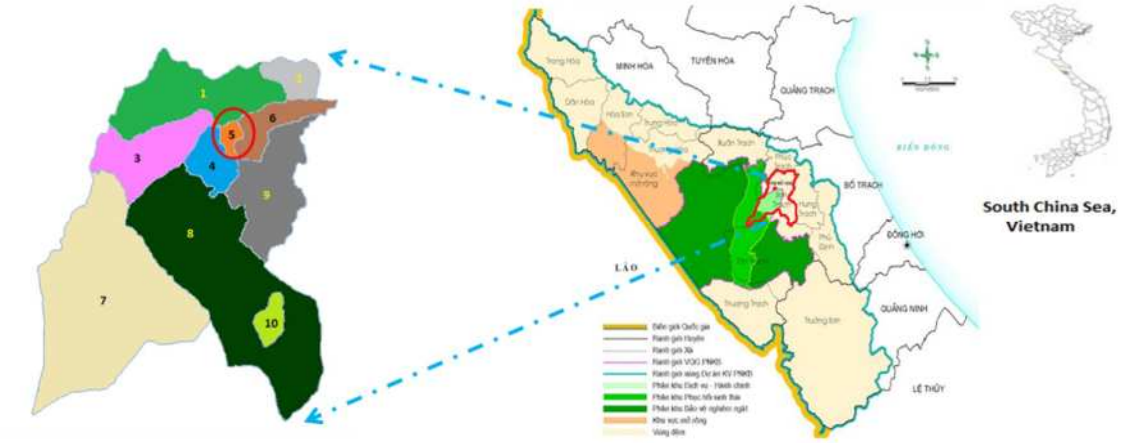

Figure 9. Map of Son Trach commune

Source : Ziegler et al. (2017[1]) & Son Trach CPC (2019[2])

Son Trach commune located in buffer zone of Phong Nha Ke Bang National Park (PNKB NP), Quang Binh province. The acreage of this commune is 10,138.71ha with the population is 3,060 households / 12,475 people. From figure 9, there is the list of villages in Son Trach commune: 1) Xuan Son; 2) Gia Tinh; 3) Na ; 4) Ha Loi; 5) Xuan Tien; 6) Cu Lac 1; 7) Tram Me; 8) Phong Nha; 9) Cu Lac 2; 10) Rao Con.

2.3.2. Timetable of fieldtrip and Methodology

Table 5. Timetable of interview in Son Trach Commune

Date	***Activities***
31st August 2019	*Visiting Paradise cave and interviewing local employees*
	Interviewing the leader of Xuan Tien village
1st September 2019	*Visiting Mooc spring and interviewing local employees*
	Interviewing the owner of local restaurant and staffs in local hotel

In two days at Son Trach commune, we met the local tourism employees and local residents, (Table 5) and interviewed them about: *Socio-economic background*; *Status of tourism development*; *Changes to local livelihoods induced by tourism; Issues and concerns and suggestions for the future.*

[1] Ziegler, T., Hendrix, R., Vu, N. T., Vogt, M., Forster, B., & Dang, N. K. (2007). The diversity of a snake community in a karst forest ecosystem in the central Truong Son, Vietnam, with an identification key. *Zootaxa*, *1493*(21), 1-40.

[2] Son Trach Commune People's Committee (2019). Census map

2.3.3. Findings

Figure 10 showed the increase over the years of the number of tourists and the number of tourism destinations. Tourism activities here have existed for a long time and flourished from 2013 to the present.

Due to the tourism development, the local livelihoods also changed from agriculture-based lives to tourism-based income activities. (Table 6)

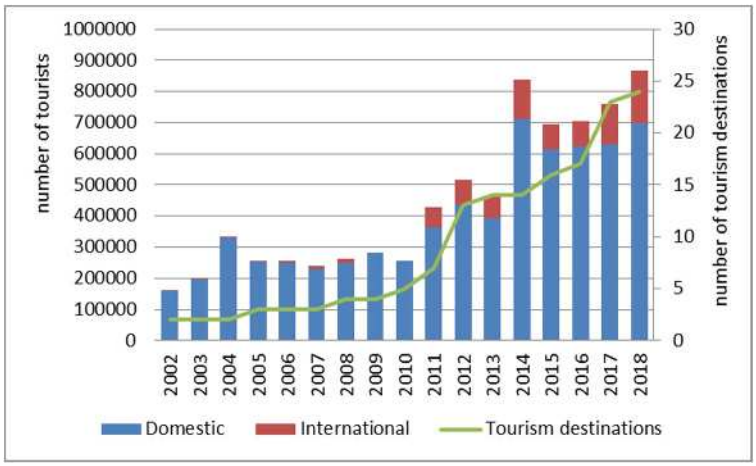

Figure 10. Status of tourism development in PNKB NP

Source: People's committee of Quang Binh province (2010)[3]; Nguyen T.T.H. (2018)[4]; PNKB NP Management Board (2019)[5]

Table 6. Changes in livelihoods of local people

Time	Agriculture	Forestry	Tourism
1975 - 1997	- paddy field	- illegal forest logging (wood and non-wood products)	
1997 - 2013	- paddy field - cattle raising - aquaculture	- illegal forest logging (wood and non-wood products)	- tour boat - employees for tourism companies
2013 - now	- aquaculture	- acacia planting - illegal forest logging (non-wood products)	- tour boat - employees - owners (hotel, motel, restaurant, ...) - photographer

Source: Field survey in 2019

2.3.4. Our view

- The local livelihoods in center of Son Trach commune were greatly affected by tourism. Tourism and tourism-related activities became main income-generating activities.

- However, because tourism was majorly dependent on nature, local people had to find alternative jobs during unfavorable weather period each year. Local government has been endeavoring to design more types of tourism activities, adapted to the local real situation.

[3] *People's committee of Quang Binh province (2010).* Sustainable Tourism Development Plan 2010 to 2020 PNKB NP Region. As part of the Nature Conservation and Sustainable Management of Natural Resources in the PNKB NP Region Project

[4] Nguyen, T.T.H. (2018). Participation and the Role of Stakeholders in Tourism Development in the World Natural Heritage Area - Case study of Phong Nha - Ke Bang (Chapter 8). In "Monograph SCG-ASEAN Initiative Conference 2018". Institute of Asian Students,Chulalongkorn University.

[5] *PNKB NP Management Board (2019). Number of tourists and total revenue from 2009 - 2019 in PNKB NP*

III. Domestic fieldtrip (Japan)

3.1. Kagamino town

48430167 MAI Thi Khanh Van

3.1.1. Location

Figure 11. Map of Kagamino town

Source: Tourism association of Kagamino town (2019)[6]

Kagamino town located in Tomata District, Okayama Prefecture, Japan. The acreage of this town is 419.68 km^2 with the population is 12,245 people.

3.1.2. Timetable of fieldtrip and Methodology

In three days in Kagamino town,we met the local tourism employees and local residents, (Table 7) and interviewed them about: Socio-economic background; Status of tourism development; Local issues in tourism; Plan for developing tourism and solving with issues.

Table 7. Timetable of interview in Kagamino town

Time	Interviewee
October 24th	Staffs of Kagamino town office
	Senior manager of Industry Tourism Division, Kagamino town office
	Maganer of Okutsu lake general information center
October 25th	Employee of Furusato Shiitake village - Shiitake tour
	General manager of Okutsu lake general information center
	Staffs of Tourism Research Association
October 26th	Host of Tomisanso Hotel
	Manager of Utatane-no-Sato Ippuku-Tei Restaurant
	Host of Satoyama restaurant Aelu

6 Tourism association of Kagamino town (2019) http://www.kanko-kagamino.jp/access/

Dated: December 28th 2019

3.1.3. Findings

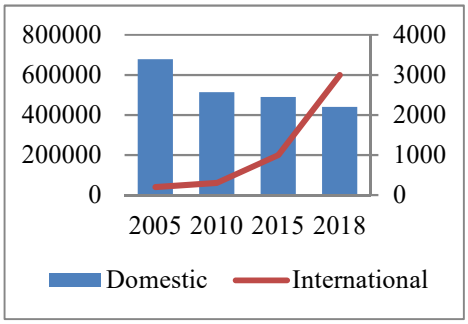

Figure 12. Number of visitors visited Kagamino town

Source: Field survey in 2019

Table 8. Development process of tourist activities in Kagamino town

Period of time	1940 - 1989	After 1989 - now
Main type of tourism	big group tourism (company scale)	individual tourism small group tourism (family scale)
Activities	enjoying hot spring (onsen)	trekking; walking to sightseeing; taking photos

Source: Field survey in 2019

Table 8 showed the change in main type and activities of tourism that took place before and after 1989. Next, the data in Figure 12 also demonstrated the change in types of tourist to Kagamino town. While the number of domestic tourists has decreased, the rapid increase of international visitors has been a promising sign. The role of tourism in this town's economy was undeniable. In the changing process of tourism, the creating new tourist destinations have provided employment opportunities for many local residents. (Table 9)

Table 9. Number of labors in tourism sector of Kagamino town

Types of tourism destinations	Number of destinations	Number of labors	
		Total	Female
The scenery and experience	7	113	43
Hot spring and Lodging	11	57	30
Local specialty products/souvenirs	5	40	29
Restaurants	8	25	19
Experience history and culture	4	5	2
Total	35	240 *(100%)*	123 *(51.25%)*

Source: Field survey in 2019

3.1.4. Our view

Tourism in Kagamino town has a lots of potential for development, especially for rural tourism and nature-based tourism. However, the decline in number of tourists in recent years makes hardly to maintain and develop tourist businesses. Another problem is that the small scale of the business and the fact that most of the workers are part-time workers constitute the unprofessional business, arduous to compete with other localities to attract tourists. In order to improve the situation, the local government focuses on creating new types of tourism, suitable to the needs of tourists. These efforts are proving its success, especially with attracting international visitors.

Essay through SDGs Project Research

48501155 Tsubasa Tateishi

SDGs Project Research was introduced in the course “Introduction to Social Environment.” By the time I knew SDGs Project Research, I had been some foreign countries for the training course to study English or traveling. However, I had never participated in the program for academic research then, thus I found a good chance to do so. The project that I enrolled in was going to be conducted in Vietnam. I had never been to Vietnam, so I had just a little background knowledge about Vietnam. I took the course “Sustainability of Rural System” which was taught by Prof. Kim and read a book about agriculture and farming villages in Vietnam during the period of rapid economic growth to acquire fundamental information about that.

On 27th August 2019, I arrived at Hue City. In the evening, I ate pho for the first time. It was quite delicious and gave me the energy to participate in the research motivationally. I participated in the research from 28th August to 1st September. The first study area was Cau Nhi Village. In the village, our project team visited houses of each interviewee. I thought if I was traveling individually, I would not have the chance to visit houses of Vietnamese ordinary citizens and face to portraits of Mr. Ho Chi Minh in each house. Regarding the main subject, a lot of Vietnamese proper nouns and lack of background knowledge disturbed me in my understanding about the interview. Although I got information which was not enough, I could compare the differences of community between in Vietnam and in Japan because I had grown up in a farming town in Japan. I thought ties of family clans in Vietnamese farming villages were wider and more firmly than those in Japanese ones. I found this kind of differences between two countries, which was my harvest. As for the second study area: Phong Hien Commune, I got to know the farming system in land consolidation areas. Not only that, I saw the plot-to-plot irrigation at the paddy field our project team visited, which was rare to see if we were in Japan. Regarding the third study area: Son Trach Commune, the difference between domestic travelers’ taste and foreign one was impressive.

Through this project research, I could understand the sense to research in foreign study area. It was the first time to participate in this kind of project, so I could also understand my situation without enough knowledge and technique. I wish I could have a chance to work abroad after graduation from master course, thus I need more effort to polish my grounding to active abroad.

For the ending of this essay, I want to appreciate to Prof. Kim, Ms. Mai Thi Khanh Van and other participants in the project research in Vietnam. Especially Prof. Kim gave me the supplementary explanation clearly during the research and Ms. Mai Thi Khanh Van gave me a lot of information and advice to prepare for the debriefing session and colloquium. Thank you so much for their helpful support to me.

Essay through SDGs Project Research

48430167 MAI Thi Khanh Van

The first time when my supervisor - Prof. Kim suggested that I should join SDGs Project Research, I had no idea about its purposes. Next time, I learned regarding it and started to plan my field trips. The research sites located in both Vietnam and Japan. I have learned that there are the differences between villages in Vietnam and Japan. However, my personal view was not established until I came to each of these places.

The first field trips of SDGs Project Research started in late August, 2019 in Cau Nhi village. The first visit took only a few hours, and my impression of this village was only the surprising modern of a rural area in the central of Vietnam. Coming back this time, I studied more, and I found the cause of that development. It came from the deep connection between members of a clan family and each family clans in the village. That made Cau Nhi be easier to implement effectively the policies issued by the Vietnamese government.

The second site was Phong Hien commune. Although the theme still related to the rural development, I learned about a completely different issue on this trip - land consolidation. At that time, I not only gained at the knowledge in the new field, but also surprised by the understanding each other between the neighbors.

The third one - Son Trach commune was also the study site of my master's thesis. Because of coming here many times, I became the guide on that trip. From the questions of my supervisor and the rest of the members, I was capable to consider familiar issues from a new perspective. This provided me the opportunity to more considerably improve my thesis.

The last trip was Kagamino town in late October 2019. Although I spent a lot of time preparing, I still worried. My Japanese has been not good enough to conduct interviews. However, both my supervisor and co-supervisor translated to me in these interviews, helping me break down the language barrier. The information I have collected during the 3 days in this town was extremely diverse and fascinating. In addition, the other members on the trip selected various issues. That allowed me an opportunity to know more about Kagamino. I undoubtedly experienced a memorable time in this town.

While preparing a report and remembering what happened, I realized how lucky I was to participate in this program. The knowledge and memories I have received, the ideas and plans that I am working on, all started from SDGs Research Project.

Because of every great thing, I would like to thank all the members who joined me on field trips in Vietnam and Japan. After that, I truly appreciate Mr. Tsubasa Tateishi, my project partner. We spent many times discussing ideas, preparing reports and presenting presentations together. This program helped me to have a good friend. At the end, from the bottom of my heart, my deepest appreciation goes to Prof. Kim. Whether in Vietnam or Japan, talking with him and answering his questions allowed me to investigate the issues in many alternative ways. Thanks to the guidance of my supervisor, all journeys ended well.

Hopefully, in the future, on new trips, I will have the opportunities to collect more wonderful experiences. At the same time, I will be able to create back the meaningful things, appropriating to the content of SDGs.

Farm Practices and Soil Environment Survey in Ifugao, the Philippines towards Sustainable Rice Terrace Farming

フィリピン・イフガオの棚田の営農と土壌環境の調査

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1. はじめに

フィリピン・ルソン島にある棚田群は，世界遺産であるコルディリェーラの棚田群を含み，フィリピンの生産基盤のひとつであると共にイフガオ族の伝統水稲耕作文化として非常に貴重な存在である．その一方で，経済的に大きな発展をとげるフィリピンにあって，若い労働力は山を下り，都市部へと移動してしまう問題がある．今回対象とする地域には 2000ha の棚田があり，そのうち 600ha が崩壊の危機にある．コルディリエーラについては 2001 年に危機遺産登録され，2012 年に危機遺産解除となっているが，棚田崩壊の危機が去ったわけではなく遺産の自然科学的危機は依然として進行している．つまり，危機遺産指定の解除は，棚田を巡る社会学的，文化的条件からやや安易になされており，自然科学的に危機が去ったことが証明された結果ではない．従って，今，現地調査を行い，その課題と解決策を模索することは将来に向けた環境保全となる．

棚田は傾斜地に水をためて営農を行うと言うことで，文化的な遺産と言うだけでなく，自然の物質循環の中で，斜面のままであれば表面流の発生と有機物の流亡が発生するところを，水源涵養と有機物の保全に変え，自然環境の一部を担っている．今回調査するフィリピン・バナウェーの棚田では，事前調査によって，亀裂発生防止のために年間を通じて湛水状態を維持することがわかっている．一方で灌漑・排水路が系統立っておらず，下水が混入する状況で有機物が多い棚田が認められ，一部では，浸透抑制はされても棚田の構造基盤となる硬盤は発達していない棚田が認められた．つまり硬盤形成ではなく目詰まりによる浸透抑制が行われており，それによって湛水を維持している棚田が存在すると推測された．

今回は，このような状況にある棚田ではどのような営農が行われており，土壌環境としてどのような状態にあるのか，その解決策はどのようなものであるのかを模索することを目的に調査・分析を行った．なお，調査・分析そのものの内容については学生の報告を参照されたい．

2. 実習の概要

国内に於ける事前準備として，調査手法，分析手法の学習を行った．まず，日本棚田百選に選ばれている岡山県久米郡美咲町の棚田で調査演習を行った．日本の棚田も同様

に人口減による管理不全が報告されており，棚田の保全については課題を抱えている．土壌サンプリングを行い，土壌物理性として，透水・保水実験，粒度分析を行い，土壌化学性として，ICP 発光分析，全炭素・全窒素分析を行った．特にリン・窒素については抽出方法について検討し，現状を最もよくあらわす分析手法を模索した．

次いで，フィリピン現地については教員が事前に訪問し，概要がわかっている棚田について，学生が主に訪問・調査することで実習を行った．調査に対しては，フィリピン大学ロスバニョス校に留学し，土壌科学を専門とする研究室に在籍し，必要に応じて調査に出るという体制を取った．当該大学には指導教員と学生で事前に訪問し，研究施設の概要，受け入れ体制を把握した上でその留学を行っている．

調査後の試料の分析や考察については，Skype を活用してリアルタイムで議論をし，調査計画，現地調査，土壌試料分析計画，実試料分析，考察と進めた．

3. 主な成果

これまでの調査から，棚田の浸透性は概ね適切に保たれていること，それは耕盤という水田が水をためるために必要とする構造の発達の有無にかかわらず維持されていることがわかっていた．水資源の保全としては良好であるが，耕盤による湛水の維持というよりは目詰まりによる湛水の維持が疑われていた．また，有機物が多い水田においては，栄養塩の洗脱と思われる肥料分の不足が発生しており，有機物の取り扱いに課題があるであろう事が推測されていた．

今回の調査により，科学的な分析に加えて，現地農家に対するインタビューも行ったため，彼等の棚田管理に対する意識が明らかになり，いくつか新たな考察項目が加わった．すなわち，多くの棚田で肥料が足りていないこと，肥料に対する知識の欠如，営農手法の改善に対する抵抗感，などが明らかになった．化学肥料は悪いものであるといった印象を持っており，適切な使用も見られないこと，逆に排水路に下水が混ざることによって下流部では有機物過多となる水田があることがわかってきた．有機物過多である棚田の場合，肥料成分としての効用より，栄養塩の洗脱が起こりやすくなり，これがこれまでの分析から観察されていた事柄であると考えられた．さらに，硫化水素の発生と思われる現地報告があり，この場合，根腐れの危険性があり，早めの対処が望まれる．

4. おわりに

傾斜地に作られた農地は，雨の多い東南アジアにおいては棚田というひとつの景観を形作っている．また自然の水循環という立場からも非常に重要な位置づけにある．今回の調査から，自然科学的な分析事項に併せて，農家のインタビューを行ったため，普段とは違った視点からの調査ができたと考えている．学生の現地留学と調査という，理想的な体制での調査・分析が実施でき実りの多い実習になった．今回の調査内容を踏まえて，農家や自治体に対する提案ができればそれが望ましい成果の形では無いかと考える．

Assessment of Soil Quality as Affected by Topography and Farming Practices in Banaue Rice Terraces, Ifugao Province

Division of Social Engineering and Environmental Management

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1. Introduction

1.1 Background history of the Ifugao Rice Terraces

The Ifugao Rice Terraces (IRT) is well known as the world cultural heritage site. The rice terraces were constructed manually, and they have more than 2000-year history (Acabado.S, 2015). As the world heritage, it includes five clusters; the Nagacadan terrace cluster in the municipality of Kiangan, the Hungduan terraces cluster, the central Mayoyao terraces cluster, the Bangaan terrace cluster in the municipality of Banaue that backdrops a typical Ifugao traditional village, and the Batad terrace cluster of the municipality of Banaue that is nestled in amphitheater-like semi-circular terraces with a village at its base (UNESCO, 2019).

However, the rice terraces face their change such as collapse, and soil degradation considered to be serious nowadays. On the background, social and other environmental changes, decrease of the farm population, shortage of the indigenous knowledge (IK), use of chemical products and climate change, greatly affect the rice terrace destruction (Sekiguchi, 2014).

In previous studies, which were mainly based on interviews from farmers, they assured the crisis of rice farming in IRT. Mainly in 2000s, some studies were conducted to raise the awareness of its vulnerability to social and environmental changes since the site was listed as endangered world cultural heritage by World Heritage Committee. In 2012, it was formally removed from the list. However, it did not mean that terraces degradation ends. UNESCO (2019) reported that storms and other climate change impacts affected greatly on the rice terraces as they are vulnerable to natural disaster.

Moreover, it should be noted that there is still limitation of scientific data, especially with regard to soil and water environment in IRT. Few studies assess and ensure the sustainability of IRT from agricultural and environmental aspects.

Soil quality and sustainable agriculture

Soil quality is the capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation. (NRCS Colorado, USDA, 2019)

Soil quality now occupies a pivotal position in this concept, alternative agriculture to the ultimate goal of sustainable agriculture, and many would agree that soil quality is the "key" to agricultural sustainability as shown in Figure.1. Further research is needed to quantify the indicators or attributes of soil quality into indexes that can accurately and reliably characterize the relative state of soil quality as affected by management practices and environmental stresses. (J.F.Parr, 1992)

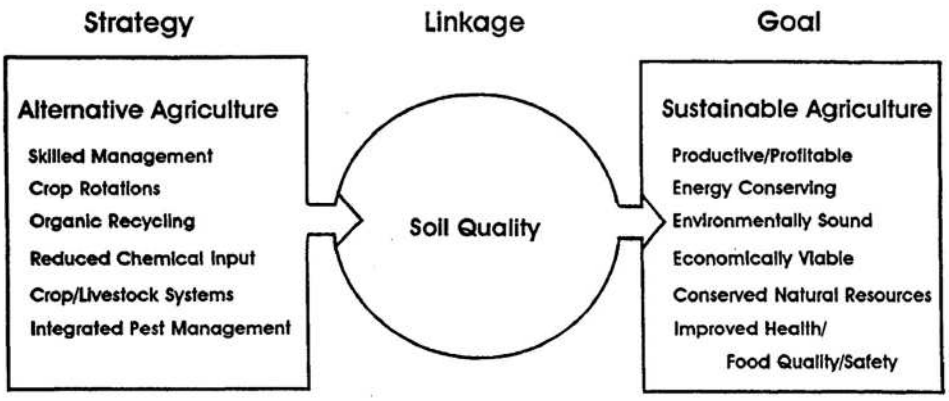

Figure.1 A conceptual diagram that illustrates how they attributes of soil quality provide a link between the strategy of alternative agriculture and ultimate goalof sustainable agriculture.

Soil and water environment are hardly recognized since few changes are visible. Sustainable agriculture and agricultural management should be encouraged all over the world, to achieve the Sustainable Development Goals (United Nations, 2015)

1.2 Objectives

In Banaue Rice Terraces as a pivotal part of IRT, the scientific data is limited as well as other areas in IRT. Therefore, the assessment should be more specific to utilize the information by farmers. Soil quality and affected factors were examined and discussed in this paper.

The objectives of my study are to assess the soil quality and to clarify the effects of the farming practices and topography on the soil quality in Banaue Rice Terraces

Specific objectives are:

- **to assess the soil quality**
- **to determine the effects of the farming practices and topography on the soil quality ***
- **to identify the farmer's knowledge in soil and land management**
- **to propose better farming and land management**

in Banaue Rice Terraces, Ifugao

2. Methodology

2.1 Study area

Bangaan and Batad, Banaue, Ifugao Province shown in Figure.2 were selected as study areas considered the worse soil condition and the terraces collapse that was shown in previous paragraph . One researcher revealed that the destruction of the rice terraces dikes in certain area in Banaue was nine times larger than those in Kiangan.

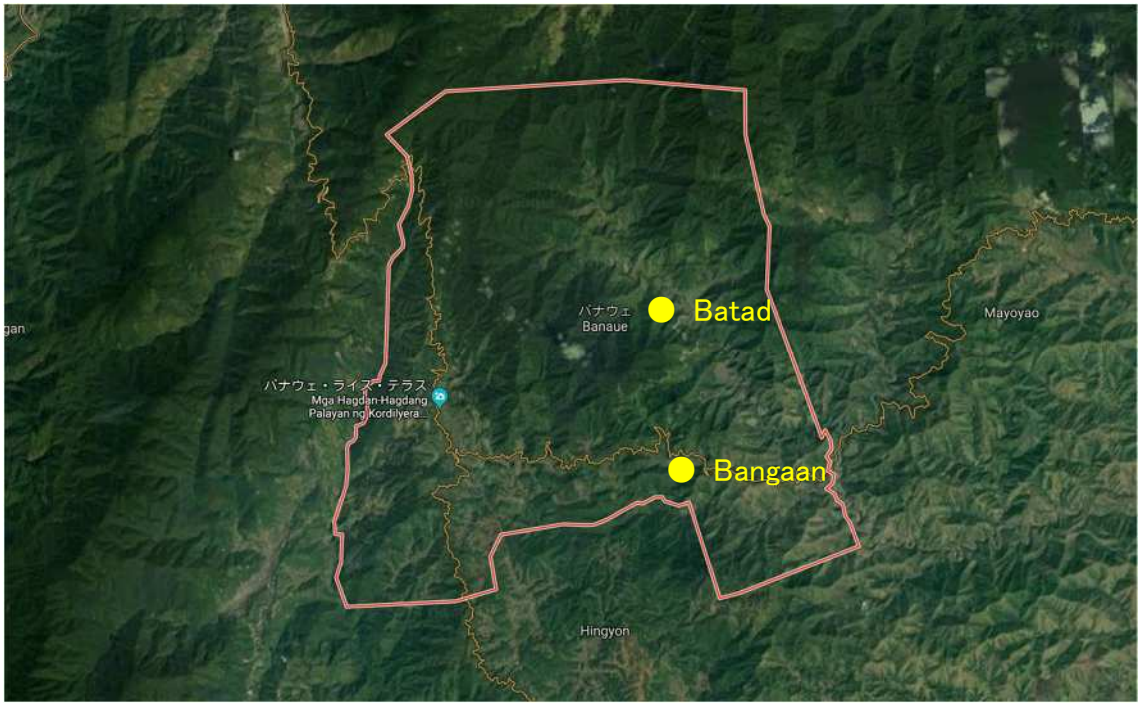

Figure.2 Map of Banaue (cited from Google Map)

Outline of field survey

Survey was done following the schedule on Table.1 and Table.2 Table.3 and Table.4 show sampling schedules.

Table.1 Schedule of survey in Bangaan

Date and time	Activity
October 1	Interview with questionnaire, field investigation
October 2	soil sampling, field investigation
October 3	Soil sampling, field investigation, and interview
October 4	Soil sampling, field investigation and interview
October 5	Soil sampling, field investigation and interview
December 27	Additional interview

Table.2 Schedule of survey in Batad

Date and time	Activities
October 28	Interview, and field investigation
October 29	Soil sampling, and field investigation
October 30	Soil sampling, field investigation, and interview,
October 31	Soil sampling, field investigation, and interview
December 26	Additional interview

Table.3 Schedule of soil sampling in Bangaan

Date and time	Sampling site (owner name_ number of one's fields)
October 2	Bato_01, Bato_02, James_01, Bato_03, Virginia_01, Virginia_02
October 3	Conchita_01, Leticia_01, Lucas_01, Leticia_02, Ester_01
October 4	Virginia_03, Christina_01
October 5	Jose_01, Maribel_01
October 26	Bato_04, Pio_01

Table.4 Schedule of soil sampling in Batad

Date and time	Sampling site (owner name_ number of one's fields)
October 29	Joseph_01, Madelyn_01, Ana2_01, Elizabeth_01, Tessie_01, Collapse_01(Tessie), Abandoned_01
October 30	Rodolfo_01, Moises_01, Ana1_01, Moises_02, Linda_01, Moises_03, Hilda_01
October 31	Ana1_02, Collapse_02, Nancy_01, Abandoned_02

All field survey was approved by municipal office of Banaue and barangay captain of Bangaan and barangay office of Batad.

2.2 Interview

In order to collect necessary data, Interview to the farmers was conducted before and during the soil sampling. Oral and written interview were done.

17 farmers were interviewed in each Barangay, Bangaan and Batad.

Gathering for interview was in October1 in Bangaan and October 28 in Batad as shown in Figure.3

Figure.3 Interview to the farmers in Bangaan

Additional interview was done at the same venue or at famers houses after the gathering Paper questionnaire includes original questions in English, distributed to each farmer individually.

The questionnaire has 5 sections as follows:

1. General farm household characteristics
2. Products description
3. Crop cultivation
4. Characteristic and practices unique to the area
5. Supply chain and facilities

Some farmers could fill up the questionnaire in English, sometimes using their dialect and pictures while others who could not understand English or do not know how to write in English was supported by a translator who can use both their dialect and English. He wrote the answer on the questionnaires instead of them.

In oral interview, concept of soil and soil management were also mentioned.

2.3 Soil sampling and field investigation

17 fields were selected in Bangaan and 16 fields in Batad considering with the difference in farming practices and elevation and location shown as Figure.4 and Table5 in Bangaan, and Figure.5 and Table.6 in Batad, respectively.

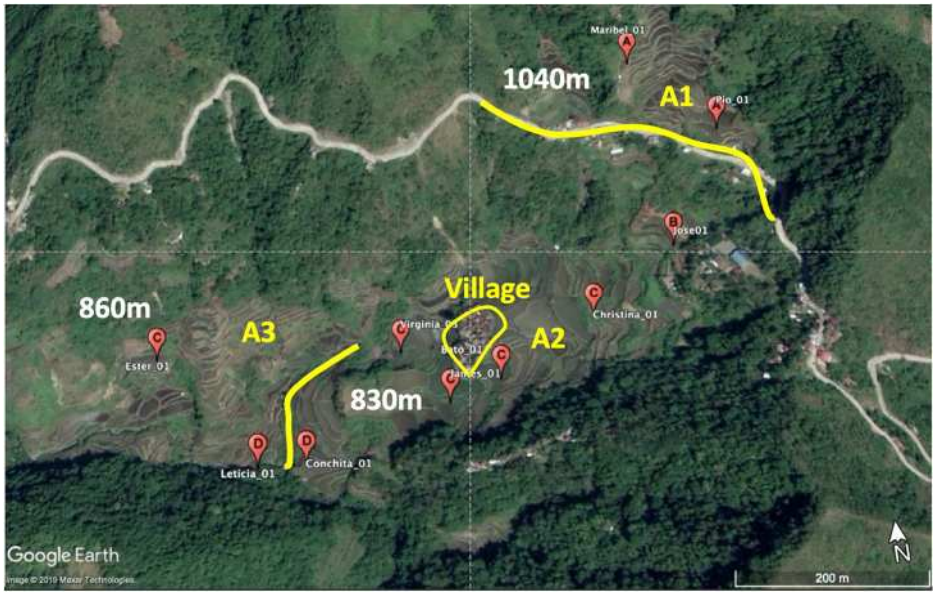

Figure.4 sampling sites in Bangaan, Banaue

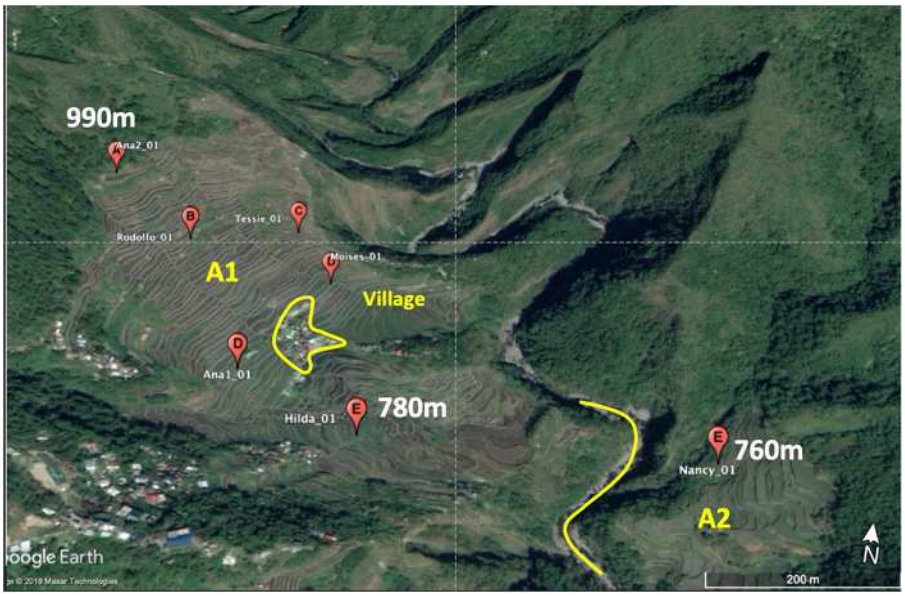

Figure.5 sampling sites in Batad, Banaue

(cited from Google Earth Pro version7.3.2.5776)

Table.5 Elevation of each sampling site in Bangaan

Group	Elevation (m)		Sampling site
A	950 above	1039	Maribel_01
		1010	Pio_01
B	900 – 949	940	Jose_01
C	850 – 899	891	Christina_01
		886	Bato_03
		874	Verginia_02
		873	Verginia_01
		870	Bato_02
		867	Leticia_02
		865	Bato_01
		859	Ester_01
		855	James_01
		851	Verginia_03
D	800 – 849	847	Bato_04
		840	Lucas_01
		833	Leticia_01
		828	Conchita_01

Table.6 Elevation of each sampling site in Bangaan

Group	Elevation (m)		Sampling site
A	950 above	987	Ana2_01
		972	Joseph_01
B	900-949	935	Elizabeth_01
		923	Madelyn_01
		900	Rodolfo_01
C	850-899	868	Tessie_01
D	800-849	828	Moises_01
		822	Ana1_01
		802	Moises_02
E	750-799	794	Linda_01
		785	Hilda_01
		774	Moises_03
		772	Ana1_02
		759	Nancy_01

Sampling procedure

Soil was taken from three depths: 0 to 10cm, 10 to 20cm depths, using shovel and trowel. two points were chosen in each field. When the field is small enough, one point in the center was a representative. Soil was mixed in the plastic bag after the soil sampling.

In addition to soil sampling, information about irrigation facilities, soil condition, other land use condition was recorded.

2.4 Analysis

The soil brought back were kept air-dried for 7 days to 10 days in soil chemistry laboratory, pounded and sieved at 2mm.

Following items shown in Table 7 were measured.

Table 7 List of analysis item and used methods

Analysis	Methods
Moisture content	
Soil pH	(1:1=soil:water)
Organic Matter	Walkley and Black Method
Total Nitrogen	Kjekdahl method
Available Phosphorus contents	Bray No.2 method
Exchangeable K, Ca, Mg	Quick methods
Available micronutrient (Cu, Zn, Mn, Fe)	DTPA extraction, ICP-OAS
Cation Exchange Capacity (CEC)	Ammonium acetate methods

3. Results and Discussion

3.1 Interview

Farmers profiles was shown in Table 8. Part of farmers response was shown in Table9. In Bangaan, the interview was announced by Barangay Captain, in Batad, announced by Barangay officer in advance and on the morning of the day through radio in the area.

Table 8 Farmers profile

	Bangaan (n=17)	Batad (n=17)
Average farming experience (years)	36.1	37.8
female respondents (%)	64.7	82.4
number of family member (person)	3	2.2
non-farm income (%)	52.9	52.9

Table 9 Farmers response about field and farming practices (selected basic question)

	Bangaan (n=17)	Batad (n=17)
Irrigation (%)	70.1	94.1
Rainfed (%)	29.4	17.6
Stone wall (%)	100	100
Machine use (%)	52.9	29.4
Commercial fertilizer use (%)	5.9	11.7
Pesticide use (%)	35.3	35.3
Herbicide use (%)	0	11.8
Sign before collapse (%)	35.3	58.8
Double cropping (%)	5.9	5.9

Farmers Characteristic

Women tended to join interview since their husband worked in the fields. In Batad, some farmers have more than 20 fields, and they also play an major role in an organization or their traditional role such as “tonaong” who leads the rice planting in the area. Those who have many fields hire many labors to maintain all fields and they can afford to do that since they have rice to sell or give to the labor instead of money.

Water management

There are 5 irrigation ways in Bangaan and Batad according to the interview.

1. irrigation from river
2. water from mountain
3. water from spring outside/ inside their fields
4. water from upper fields
5. rainfed

As shown in Table.11, both areas have irrigation. The irrigation from a river in Bangaan was established few years ago.

In both areas, everyone prefers to keep the water however, upper area in Bangaan which no irrigation maintained and rely on rainfed and water from the mountain, often experience shortage of water and cracking soil.

According to previous research, in November or December, farmers distribute water to each rice terraces, harrow and puddle the field in Ifugao (IFSU,2011). However, interview revealed that people in Batad and Bangaan seldom drain the water and always keep water flowing from up to downstream preventing cracking on the soil surface. In Batad, some of them drain the water only for plowing period while A few those who in Bangaan that have fields in specific area (just below the village) drain the water before planting because

the soil is too soft and rice cannot be grown if they don't drain the water Sowing starts simultaneously and the seedling are transplanted in December or January.

Stone works

There are two types of the rice terraces in Ifugao, the stonewalled and unstonewalled. Prior to the introduction of mortar and plasters, stone wall is purely made of stones. Nowadays, the farmers make the wall with not only the stones, but with mortar that used for fillers or on the top layer that is expected to be footpath. (IFSU, 2011)

In Bangaan and Batad, almost all the rice fields have stone wall. Some fields which experienced collapse before, the owner had difficulty to bring needed stones, the wall would be incomplete.

Only one farmer in Bangaan and two farmers in Batad use commercial fertilizer. The farmer in Bangaan mentioned that she does not have enough time to take care the rice, so she thinks better to use chemical to grow rice easily.

Also, it is noted that farmers who have fields not in main portion of the area have different practices. It seems the indigenous knowledge comes from different person or not inherited well.

Rice variety

The rice variety grown in two areas are shown in Figure.6 and Figure.7.

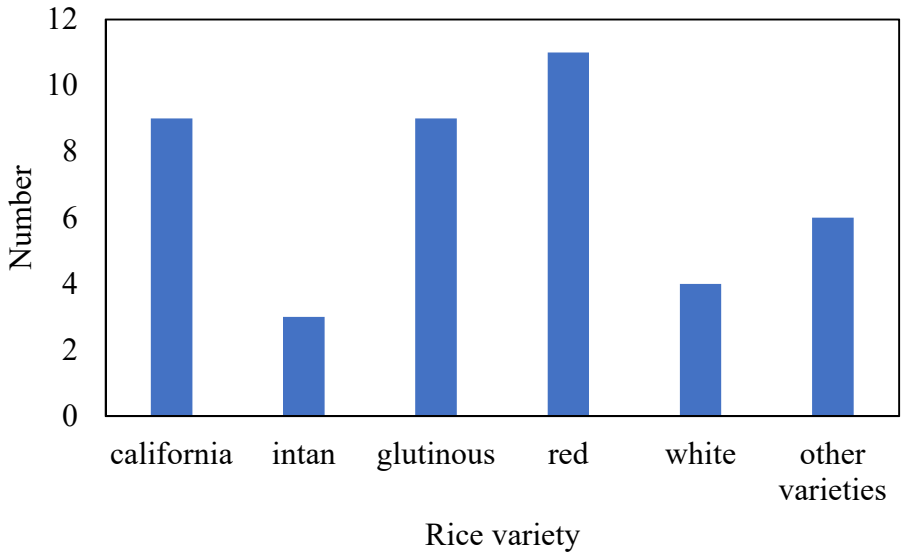

Figure6 Rice variety in Bangaan

“California rice” is commercial rice as they recognized.

“Intan rice” seems also commercial rice originated in India, that is included in “other varieties”. As well as Intan rice, there is one farmer who produces C4 rice developed by IRRI.

“Tinawon” as general term referring to their native rice varieties which are produced once a year, included in “white rice” in this paper.

“Chayaot” and “bino’gong/ binuhgon/ binuhgpa” included in “sticky rice”, “minnang/ minaangan rice” were included in “red rice”, respectively.

The characteristics of “ninhgon”, “sipor”, “mayoyao rice”, “inten red rice”, and “inten white rice” included in “other varieties” were not well identified.

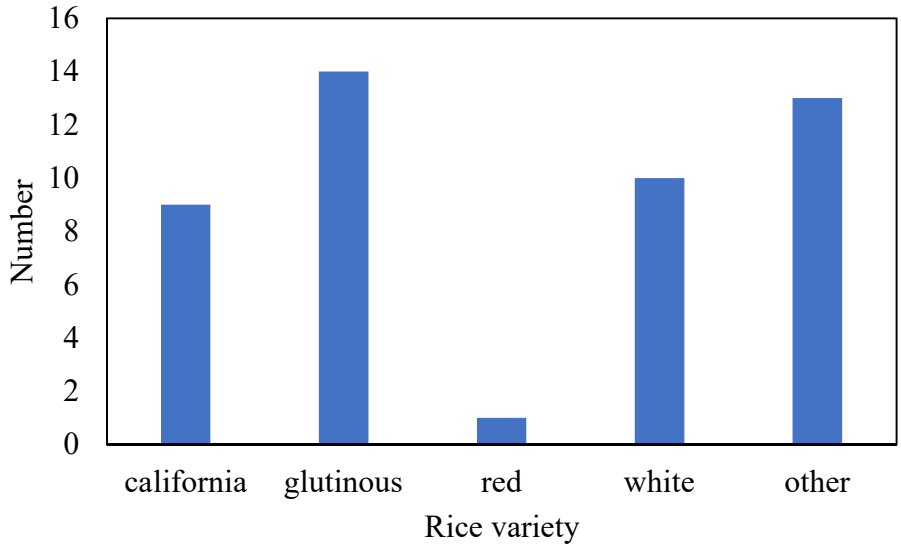

Figure7 Rice variety in Batad

“California rice” seems only one commercial variety produced in Batad.

“Tinalbok/ tinalbo”, ”pinkitan/pawikan”, “inguna”, ”dayakot”, and “tinwon” are included in “white rice”,

“binugon/ inugon”, “chaga’od”, “dikket/dicket/diket”, and ”buyabuy/ pujapuy /puyapuy” are categorized in “sticky rice”.

“Ingngoppot” is native “red rice”.

They have other varieties “linawang”, “injula”, “tukayan”, “imbu-u”, ”latong”, and “migapas”. Migaspas was brought from Viscaya and Isabela, stunted variety to be tolerant to extreme weather.

The main reason why they plant heirloom rice is the accessibility of rice seeds. Traditionally farmers plant the rice variety and still inherit them.

A part of their testimony is consistent with previous research noted as below.

According to previous research conducted by IFSU (2011), heirloom rice is preferred by farmers because of the characteristics: aroma, taste, resistance to pests, disease, and extreme weather condition, and less fertilizer requirement.

So, it has short height, low yield, and long maturity. Also, the cost, accessibility to irrigation, and its value as inheritance from ancestor that encourage unity are the reason why they grow the heirloom rice.

On the other hands, in order to meet increasing food demands, it's inevitable to cultivate commercial rice that has high yields and short maturity that enables the farmers to cultivate the rice twice a year. (Sekiguchi, 2014)

Cropping calendar

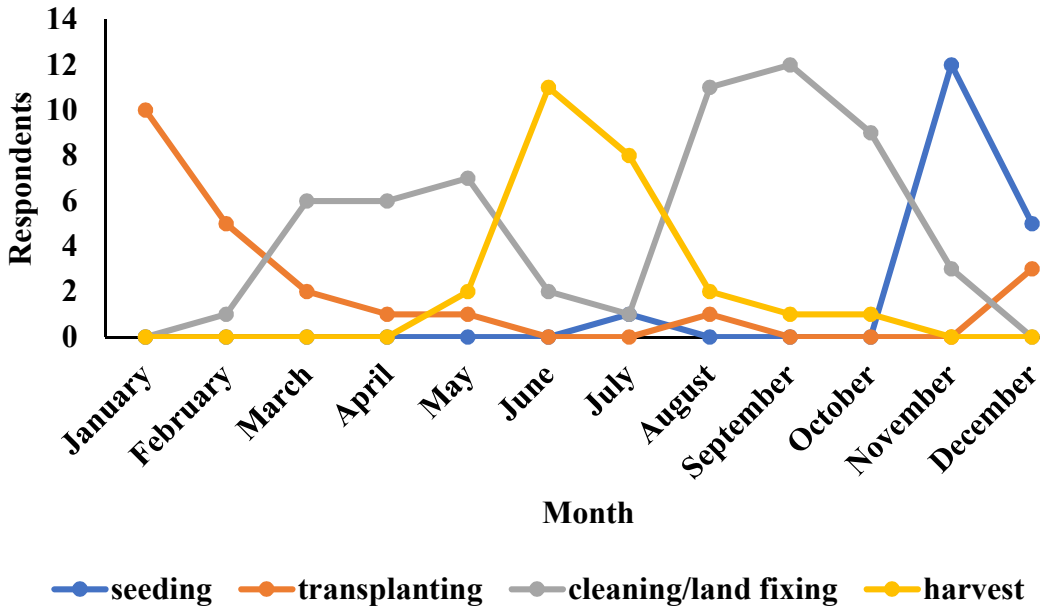

Figure 8 Cropping calendar in Bangaam (n=17)

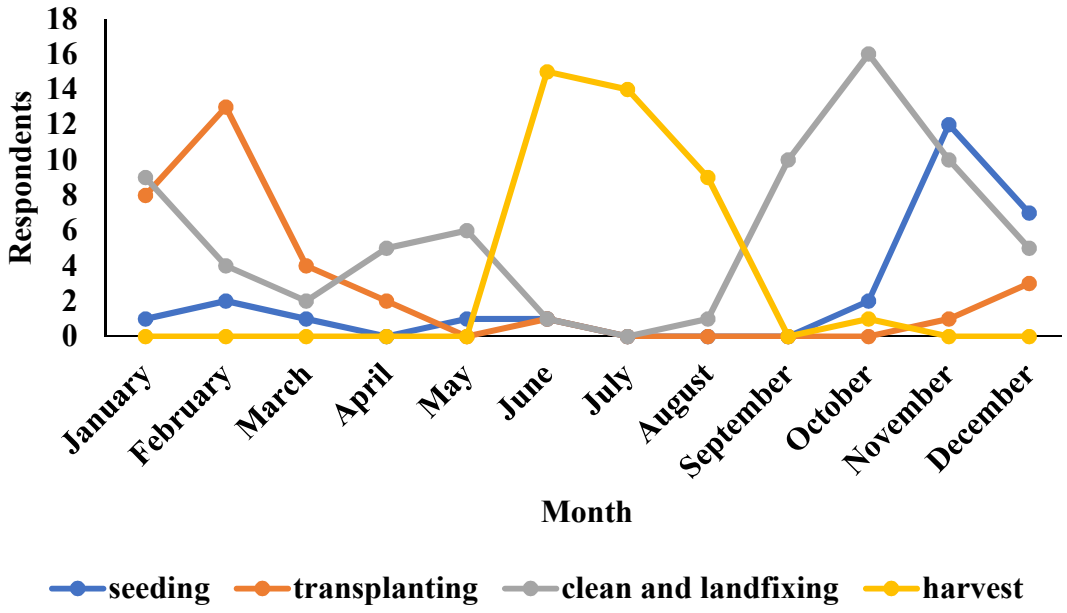

Figure 9 Cropping calendar in Batad (n=17)

As shown in Fig.8 and 9 there is a similar trend of both cropping schedule in Bangaan and Batad.

There is a slight difference in transplanting season. It peaks in February in Bangaan while in January in Bangaan. Besides transplanting, harvesting period also varies widely since more varieties of rice are produced in Batad. Most of the farmers in Bangaan and Batad grow rice only once in a year. It's somewhat correspondent with previous study; some farmers cultivate rice twice a year, however, once is still dominant because of the selection of rice variety, water capacity (IFSU,2011).

Farmers in Batad pointed that few decades ago, they could plant rice twice in a year, but now due to climate change, double cropping is impossible. More details should be examined.

After the rice harvest, the rice straws are left in the fields. Farmers bury them into the soil and make them rotten as fertilizer for the next cultivation. Some farmers mentioned that they burn the rice straw if it's dried.

Pests and pest control

Bangaan

1. rat (dongo/dango ,gehing for smaller,cho'oh for bigger)

   Present throughout the year, especially the ripeness period. They often burrow the hole from inside to the stone wall, which can be water path. In planting season, they also eat the young rice plants and the damaged plants would be dead.

   Control: Farmers make feed mixed with poison and put it on the path way or their nests. Rice, camote, weeds, or golden kohol are used as their feed.

2. maya bird (red bird, pujang/fujang)

   They eat rice fruits.

   Control: Farmers hang something on the line to make noise keeping the birds away. Scarecrows also can be substitutes for the farmers monitoring birds.

3. white bird (terob)

   They eat rice fruits.

   Control: Farmers hang something (called idro) on the line to make noise keeping the birds away. Scarecrows also can be substitutes for the farmers monitoring birds.

4. earthworm (kiwit)

   Present throughout a year in the moist soil, appear if the soil gets dried. The length is from 5 to 30 cm. They eat rice and dig the hole into deeper soil (bottom) that make water comes out from the fields and cause terrace collapse.

   Control: Electric apparatus is effective for earthworm (according to one farmer).

5. eel (o'lang)

   Active during night time.They eat rice and dig the hole as well as earthworm.

   Conrtol: Kill with knife during at night.

6. cricket

   They seems damage the rice. Some farmers argue that it also dig some hole in the rice fields.

7. fly (change) :

   Evrey year appear in ripneness period.The number increase rapidly for few weeks,

8. golden kohol (biskol)

   Eat young rice plants.

   Control: Drain the water from the fields

For those pests, some farmers use insecticides, Cymbush (Cypermethrin 25%) and karate (2.5g/L Lambda-cyhalothrin) which is a synthetic pyrethroid. Also, changing rice planting season is effective to avoid flies like change.

Some farmers also mentioned that animal variety including pests are changing from what they used to be.

Batad

1. rat (pu-at /mahulatan)

   Present from February to May (ripeness period).They burrow the holes.

   Control: Same as in Bangaan, put the poisoned feed (called at-tib/binin) to the stone wall (their nests).

2. maya birds (red birds, pujang(fujang) billit tukeng)

   Present in ripeness period. They eat rice.

   Control: Use lanet to keep them away.

3. white birds (terob)
4. earthworm (kiwit)

   They burrow the hole in the rice fields that caused terrace collapse.

   Control: Kill manually when farmers drain the water to plow the soil/
5. long earthworm (o'lang)

   1-foot-length earthworm. They distinguish regular earth worm and longer earth worm. In Bangaan, O'lang is considered as an eel, however, People in Batad insisted that o'lang is big earthworm not an eel.
6. fly (chango)

   insects that eat rice. Some farmers insist it is present every ripeness period while other say throughout a year.
7. Golden kohol (biskol)

   Present from February to March. It damages rice panicle.

   Control: Use insecticides or pick up manually.
8. ground breath cricket (gwelet/ kol'le/ kul'la)

   Present throughout a year, especially February and Murch.Dig holes in the soil.
9. white butterfly
10. fly (pho-ew)

    Like butterfly.
11. bag or fly (bu-aw/ puchien,bucheng)
12. worm (bigis/ peeke/ peleckel)

    Present throughout a year especially February, March, May.

Some farmers spray insecticides, Cymbush (Cypermethrin 25%), Karate (2.5g/L Lambda-cyhalothrin), and Solomon (Beta-Cyfluthrin + Imidacloprid 300 OD (8.49 + 19.81 % w/w)).

Perception of climate

Interesting to note that, Farmers in Bangaan regard summer as March and April, while those who in Batad regard it as during September to November.

Statistically, lowest temperature is recorded in January and highest recorded in May generally (world weather online, 2019))

Soil character

Cracking

During the field trip, the situation water went into the big crack（can be called rill）was observed (groupB, Jose_01), farmers argued that is a cause of terrace collapse.

Dark soil

In both areas, Dark colored soil was observed below the village.

In Bangaan, some farmers argued that soil below the village are different from others; rice cannot be grown due to the softness of soil. They drain the water before planting and also, they experienced their skin turned red and many leeches living there and biting farmers.

In Batad, one farmer mentioned the soil beside the village is easily cracking. white those below the village are soft, black and the terraces are very deep.

They have some fields but they did not change their farming practices between each field. The size of the field, direction, rice variety, and altitude are not significantly different from other fields, so that water quality might affect the soil. In both areas that kind of soil was observed only below the village, so it's considered that wasted water from the village containing a lot of organic material and Phosphorous derived from detergent and soap they use come into downstream and cause the soil too fertile and make it suitable for leeches to live.

Azolla and Blue green algae

Roger.A.P (1986) mentioned that Azolla and Blue green algae are seen on the surface water in Banaue Rice Terraces. Azolla is a genus of seven species of aquatic ferns in the family Salviniaceae while Blue-green algae is a type of bacteria called cyanobacteria. Both have ability of nitrogen fixation but azolla is more available as a fertilizer. Blue green algae is often considered as a problem caused by eutrophication and takes more oxygen for other plants and animals in the water.

According to interview and field observation, Azolla was observed in Bangaan and Batad and Blue green algae was observed in Batad.

Some farmers remove them and others leave them in the fields.

Why some farmers remove them is because it sticks with rice plants and prevent growing rice plants.

Perception of soil fertility

The farmers judge fertile fields by the amount of fertilizer, yields, accessibility of irrigation, but not the actual soil condition.

One answered that brown soil in the upper mountain is an example of a fertile soil, while the other answered, black soil in the lower.

From this, it is said that they do not share a common knowledge, nor do they have a concrete idea about soil quality.

Also, most of them assumed that any commercial fertilizer and pesticides do harm to soil physical properties.

Soil sampling and analysis

Characteristics of analyzed soil were shown in Table 10 and 11.

Table 10 Analyzed soil samples in Bangaan with their characters

Group	Elevation (m)	Sampling site	Character
A	950 above	Maribel_01	DL-1, CF
		Pio_01	DL-1, OF
B	900-949	Jose_01	OF
C	850-899	Christina_01	OF
		Bato_01	OF
		Ester_01	DL-2, OF
		James_01	OF, DC
		Verginia_03	OF, BS
D	800 - 849	Leticia_01	DL-2, OF
		Conchita_01	OF

Table 11 Analyzed soil samples in Batad with their characters

Elevation(m)		Sampling site	Character
A	950 above	Ana2_01	OF
B	900-949	Rodolfo_01	OF
C	850-899	Tessie_01	OF
D	800-849	Moises_01	CF
		Ana1_01	OF
E	750-799	Hilda_01	OF, BS
		Nancy_01	DL-1, OF

OF: Organic fertilizer CF: Chemical fertilizer BS: Black color soil DC: Double cropping DL: Different location considered a watershed surrounding a village as a center. (same number refers to same watershed that separated by river or road) Results of soil analysis

were shown in Table 12 to Table 17. In discussion, coefficient of determination (R^2) to discuss correlation. C/N ratio was cariculated as OM contains 58% of organic carbon.

Table12 Soil PH, Organic matter, Total Nitrogen in Bangaan

Group	sample site	sample depth (cm)	pH	OM (%)	TN (%)	C/N ratio
A	Maribel_01	0-10	4.5	3.03	0.11	10.58
A	Maribel_01	10-20	4.8	1.37	0.10	10.20
A	Pio_01	0-10	5.0	3.50	0.18	10.74
A	Pio_01	10-20	5.1	3.27	0.16	6.62
B	Jose_01	0-10	5.6	2.91	0.15	19.26
B	Jose_01	10-20	5.7	0.44	0.06	14.59
C	Christina_01	0-10	5.5	2.90	0.16	14.97
C	Christina_01	10-20	5.4	1.12	0.10	14.53
C	Bato_01	0-10	5	3.25	0.18	11.06
C	Bato_01	10-20	5.2	2.98	0.17	10.87
C	Ester_01	0-10	5.5	7.38	0.29	11.40
C	Ester_01	10-20	5.5	6.89	0.27	4.28
C	James_01	0-10	6.2	3.82	0.20	12.34
C	James_01	10-20	5.8	3.45	0.18	12.35
C	Verginia_03	0-10	5.2	8.31	0.42	16.09
C	Verginia_03	10-20	5	7.54	0.34	8.08
D	Leticia_01	0-10	5.6	5.44	0.26	11.45
D	Leticia_01	10-20	5.4	4.31	0.20	12.86
D	Conchita_01	0-10	5.5	6.14	0.18	11.59
D	Conchita_01	10-20	6.1	5.42	0.22	12.24

Table 13 Soil PH, Organic matter, Total Nitrogen in Batad

Group	sample site	sample depth (cm)	pH	OM (%)	TN (%)	C/N ratio
A	Ana2_01	0-10	5.4	4.08	0.20	11.82
A	Ana2_01	10-20	5.5	2.11	0.08	14.47
B	Rodolfo_01	0-10	5.3	2.79	0.13	12.44
B	Rodolfo_01	10-20	5.5	1.88	0.12	9.29
C	Tessie_01	0-10	5.6	3.90	0.14	16.56
C	Tessie_01	10-20	5.6	2.43	0.14	10.44
D	Moises_01	0-10	5.8	3.72	0.17	12.84
D	Moises_01	10-20	6.0	1.52	0.11	7.70
D	Ana1_01	0-10	5.8	5.44	0.21	14.83
D	Ana1_01	10-20	5.4	2.11	0.14	8.90
E	Hilda_01	0-10	5.8	6.34	0.41	8.91
E	Hilda_01	10-20	6.0	8.01	0.35	13.10
E	Nancy_01	0-10	5.4	2.01	0.17	6.76
E	Nancy_01	10-20	5.3	0.85	0.08	6.32

As shown in Table12 and 13, pH of the fields with chemical fertilizer (Maribel_01 is lower than organic one in Bangaan. However, no significant difference was observed in Batad (Moises_01).

OM showed similar trends as TN (Figure 10 and 11) that is consistent with the results of Wang (2011). However, unlike the previous study, elevation and these two elements are negatively correlated ($R^2 = 0.3$ in both). This shows that the source of OM and TN are the same, leaching occurred and they were accumulated at lower.

Black color soil (Verginia_03 in Bangaan and Hilda_01 in Batad) have twice or three times as much as OM and TN than other fields at the same elevation. It's probably because

the effects of wasted water from the village.

In different location, one field in Bangaan (Ester_01) have more OM. It might be because the field is closest to the mountain and the humus from the mountain easily come and accumulate into the field.

Compared with different elevation, same watershed, and organic fertilizer application in Bangaan, (Jose_01, Chiristina_01, Bato_01, James_01, Conchita_01), organic matter content and average total Nitrogen are relatively higher at higher elevation, while there is no significant difference in Batad.

Average pH was lower in Bangaan (5.4) than that in Batad (5.6) and generally categorized

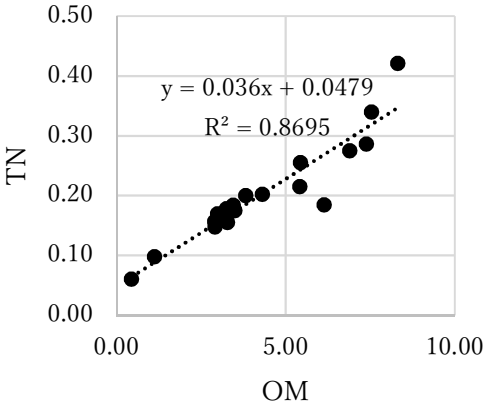

Figure 10 OM-TN in Bangaan

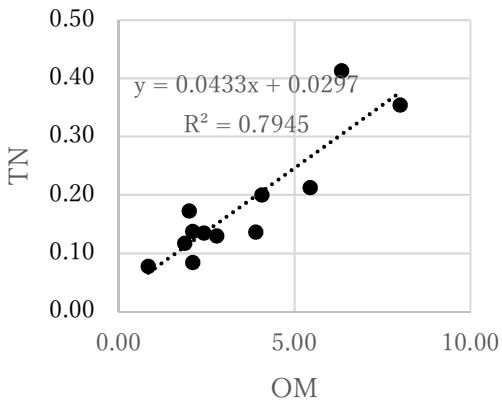

Figure 11 OM-TN in Batad

Table14 Soil macro nutrients, CEC, and Base saturated percentage in Bangaan

Group	sample site	sample depth (cm)	AP (mg/kg)	Ca (cmol/kg)	Mg (cmol/kg)	K (mg/kg)	CEC (cmol/kg)	Base saturation (%)
A	Maribel_01	0-10	4.63	14.50	6.87	2.19	29.28	80.46
A	Maribel_01	10-20	3.00	14.25	5.01	1.68	29.83	70.21
A	Pio_01	0-10	4.93	18.12	13.02	3.70	41.30	84.36
A	Pio_01	10-20	4.28	17.23	15.27	2.69	35.02	100.49
B	Jose_01	0-10	12.02	24.61	11.78	2.19	40.84	94.47
B	Jose_01	10-20	7.53	23.95	15.58	3.20	43.34	98.59
C	Christina_01	0-10	5.02	21.54	10.89	2.69	35.51	98.94
C	Christina_01	10-20	3.42	20.97	14.46	4.21	36.30	109.19
C	Bato_01	0-10	5.15	22.47	15.80	5.22	37.13	117.14
C	Bato_01	10-20	5.07	22.50	13.86	3.20	41.95	94.30
C	Ester_01	0-10	21.95	19.35	11.18	2.19	44.88	72.90
C	Ester_01	10-20	18.56	21.62	11.81	1.68	41.92	83.78
C	James_01	0-10	21.81	23.89	14.66	18.86	40.37	142.20
C	James_01	10-20	16.44	22.87	15.97	14.81	41.35	129.77
C	Verginia_03	0-10	19.51	18.97	13.35	3.20	32.13	110.52
C	Verginia_03	10-20	20.81	20.99	9.79	2.19	35.46	92.99
D	Leticia_01	0-10	14.14	21.09	8.62	5.72	36.40	97.36
D	Leticia_01	10-20	11.92	20.56	9.34	1.68	35.74	88.37
D	Conchita_01	0-10	14.31	21.01	11.32	2.69	39.23	89.26
D	Conchita_01	10-20	10.62	24.09	10.58	2.19	28.01	131.62

Table15 Soil macro nutrients, CEC, and Base saturated percentage in Bangaan

Group	sample site	sample depth (cm)	AP (mg/kg)	Ca (cmol/kg)	Mg (cmol/kg)	K (mg/kg)	CEC (cmol/kg)	Base saturation (%)
A	Ana2_01	0-10	20.87	17.03	3.81	12.79	27.95	120.37
A	Ana2_01	10-20	16.79	14.22	2.12	13.30	20.78	142.62
B	Rodolfo_01	0-10	10.37	15.03	3.39	2.69	25.81	81.79
B	Rodolfo_01	10-20	10.37	14.80	5.43	2.69	25.64	89.40
C	Tessie_01	0-10	10.72	16.58	4.77	4.21	26.37	96.94
C	Tessie_01	10-20	6.74	14.72	4.67	1.68	27.22	77.40
D	Moises_01	0-10	13.48	16.39	7.06	8.25	28.50	111.22
D	Moises_01	10-20	10.72	14.54	5.96	2.69	25.23	91.91
D	Ana1_01	0-10	18.94	17.25	7.55	10.77	29.77	119.50
D	Ana1_01	10-20	15.33	18.08	5.74	4.71	27.96	102.05
E	Hilda_01	0-10	10.88	17.35	5.98	4.21	37.45	73.53
E	Hilda_01	10-20	13.09	16.28	6.34	1.68	30.41	79.89
E	Nancy_01	0-10	6.01	16.05	6.56	7.24	28.25	105.65
E	Nancy_01	10-20	5.96	15.20	4.33	3.20	26.95	84.34

As shown in Table 14 and 15, topsoil (0 -10cm) are richer in macro nutrient in general. Macro nutrients in the fields with chemical fertilizer are relatively lower than organic farming even they have higher CEC. (Maribel_01 and Pio_01 in Bangaan, Moises_01 and Tessie_01 in Batad).

Field with double cropping in Bangaan (James_01) have relatively larger amount of nutrient compared to one cropping field (Christina_01 and Bato_01). However, the owner, James complained that the rice yield is not good at second harvest, so more data are needed to identify the nutrient change in whole year.

Fields in different watershed in both areas have certain difference from other fields, however no consistent trend with them.

Elevation do not affect the trend of macro nutrient on soil in both areas.

Compared with average value, Mg, Ca, and CEC value were higher in Bangaan. CEC contributes to store more Ca and Mg in Bangaan, mainly decided by parent smaterial.

Based on previous studies shown in Appx.1 (Sigari, A.T, 2005), most fields in both areas contain larger nutrient than the standard level in the Philippines.

P-deficiency is 34.8%, and 7.14%, Bangaan and Batad repectively. Upper terraces in Bangaan have less Available P than those of lower, probably upper one was washed away with soil particle and accumulate them at lower.

K-deficiency is 78.3% and 71.4%, Bangaan and Batad respectively, is almost same as previous study (Sigari,2003) and high rate. Some There is no trend in K flow in the areas, so the reason should be identified.

Table 16 Soil micronutrients in Bangaan

Group	sample site	sample depth (cm)	Fe (mg/L)	Mn (mg/L)	Cu (mg/L)	Ni (mg/L)
A	Maribel_01	0-10	403.98	42.64	39.31	1.35
A	Maribel_01	10-20	395.47	74.10	68.95	1.55
A	Pio_01	0-10	272.75	79.70	74.03	3.02
A	Pio_01	10-20	317.17	120.52	113.81	3.03
B	Jose_01	0-10	144.41	12.76	12.78	0.15
B	Jose_01	10-20	150.04	21.17	20.28	0.25
C	Christina_01	0-10	168.46	5.93	6.76	0.42
C	Christina_01	10-20	120.23	9.37	9.86	0.70
C	Bato_01	0-10	275.30	32.86	31.08	0.83
C	Bato_01	10-20	274.73	32.49	30.70	0.86
C	Ester_01	0-10	165.19	9.38	9.75	0.87
C	Ester_01	10-20	148.86	8.57	9.00	1.26
C	James_01	0-10	119.42	17.91	17.37	0.98
C	James_01	10-20	81.74	21.25	20.09	1.02
C	Verginia_03	0-10	192.04	20.60	19.65	0.06
C	Verginia_03	10-20	235.89	34.03	31.62	0.03
D	Leticia_01	0-10	144.88	18.92	18.20	0.93
D	Leticia_01	10-20	225.54	26.13	24.61	0.84
D	Conchita_01	0-10	131.456	13.887	13.9125	1.05
D	Conchita_01	10-20	133.2205	4.7685	5.7765	1.12

Table17 Soil micronutrients in Batad

Group	sample site	sample depth (cm)	Fe (mg/L)	Mn (mg/L)	Cu (mg/L)	Ni (mg/L)
A	Ana2_01	0-10	249.48	44.79	41.41	0.55
A	Ana2_01	10-20	324.64	90.75	84.52	0.25
B	Rodolfo_01	0-10	319.58	54.94	50.68	0.29
B	Rodolfo_01	10-20	275.09	56.23	51.64	0.43
C	Tessie_01	0-10	274.46	74.40	69.13	0.48
C	Tessie_01	10-20	337.52	71.91	66.37	0.26
D	Moises_01	0-10	57.23	7.11	7.62	0.46
D	Moises_01	10-20	95.16	8.26	8.54	0.03
D	Ana1_01	0-10	91.16	2.91	3.97	0.20
D	Ana1_01	10-20	101.02	3.78	4.72	0.15
E	Hilda_01	0-10	283.27	55.20	50.85	0.30
E	Hilda_01	10-20	220.51	96.64	90.28	0.29
E	Nancy_01	0-10	364.58	28.16	26.07	0.90
E	Nancy_01	10-20	441.48	29.58	27.24	1.19

As shown in Table 16 and 17, General trend that subsoil (10 -20) have more micronutrient than topsoil (0-10) was observed in both areas. Elevation does not affect the micronutrient trend so much.

Zn content was also very low in both areas so that ICP could not measure the Zn amount (resulted in less than 0mg/L).

Some fields in different watershed/location showed different contents if seen each element (e.g. Maribel _01 and Pio_01 which in fferent location in Bangaan, have more Fe than other fields.)

Also, farming practices or irrigation water quality might affect the micronutrient (e.g. In Verginia_03 in Bangaan, there is few Ni compared to others.)

Excess Cu content can be a pollutant if it's constantly high, so needed to figure out the source of Cu for proper and possible management. (Appx.1)

There is no specific trend in each element based on elevation, location and farming practices. However, these results probably illustrate that Parents material mainly affect the micronutrient contents. also Fe is strongly correlated with pH because pH contribute to these metal elements mobile (Figure 12)

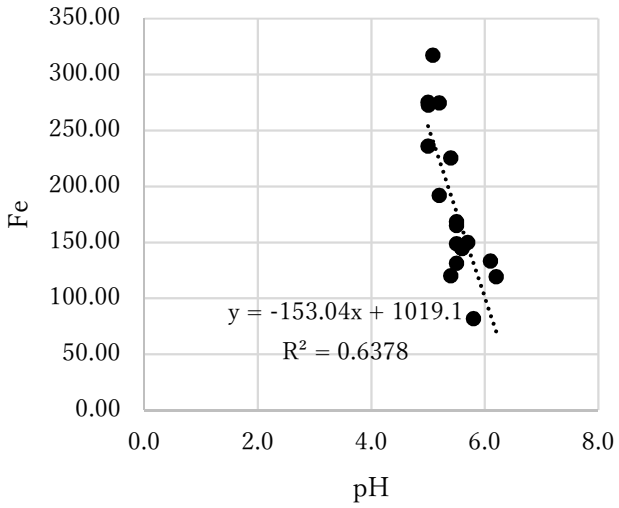

Figure 12 pH-Fe in Bangaan

4. Conclusion and recommendation

This study aimed at figuring out the soil quality in Banaue and how affected by environment and human activities. Even the number of data was not sufficient, the analysis had potential to figure out the soil quality at local scale and how they can improve their farming based on scientific data.

it was confirmed that chemical fertilizer affects the soil pH in Bangaan while double cropping does not affect the soil properties. Also, it is found that different watershed has different soil quality, but there is a trend of accumulation of OM, N and P in lower fields. They increased as the elevation decreased significantly.

Most fields are applied only weeds, sunflowers and rice straw as fertilizer, however, the nutrient is not enough especially N and K that has high deficient rate. K and N should be added more. For example, mixing Azolla and Blue green algae with soil is a way to increase soil nutrient. Also, in order to decompose the rice straw before the seedlings need nutrient, it is recommended to drain some water and keep the rice straw buried into the soil so that it decompose easily and make Nitrogen available to the plants.

Some farmers left the rice straw on the fields and clean them before sowing. It might cause immediate reduction of soil and less nutrient supply to seedlings.

Each area has unique black color soil below villages and the soil was rich in OM and TN. H_2S might be produced that damage rice growth. In Bangaan the black soil was distributed in small area so if waste water made the soil fertile, proper management of wasted water can be addtitional fertilizer of the area and also the soil can be a buffer for contaminated water from households. The temporary solution for this is also to drain the water sometimes.

Lastly, farming plan should be improved reflecting the trend of the present soil quality.

From the results obtained, certain tendencies were found such as; movement of soil nutrients downstream, effect of chemical fertilizer on the soil quality, and nutrient

deficiency of a large portion of the area. Based on these results, farmers can know which fields to prioritize.

In this way, from soil environment's perspective, farming in the rice terraces are gonna be more productive and sustainable.

Future task

To develop sustainable farming, more data gathering is strongly recommended to assess the environment properly for crop production and conserve the land.

Interview was not enough to figure out yields and amount of organic fertilizer application. Soil fertility would change easily during the fallow period influenced by fertilization practices during plant seeding and growth periods in the plains (Li 1992). Further data gathering, field survey during specific period such as planting season, harvest season, typhoon season are necessary.

References

Acabado.S, 2015 Antiquity, Archaeological Processes, and highkand Adaptation The Ifugao Rice Terraces

CUI Baoshan, 2010: Temporal and spatial distributions of soil nutrients in Hani terraced paddy fields, Southwestern China, nternational Society for Environmental Information Sciences 2010 Annual Conference (ISEIS), Procedia Environmental Sciences 2 (2010) 1032–1042

farmguru: Insecticides/Pesticides, Syngenta Insecticide Cymbush – https://www.store.farmguru.in/products/agro-chemicals-crop-protection-insecticidespesticides/syngenta/syngenta-insecticide-cymbush/pid-11552122.aspx

Gomez,A.R, et al., 2005 Survey of the Damage in the Ifugao Rice Terraces and Its Environmental Dynamics, The Philippine agricultural scientist , vol88, No.1, 133-137

IFSU, 2011; Ifugao Indigineous Knowledge (IK) Workbook

J.F. Parr, R.I et al, 1992 :Soil quality: Attributes and relationship to alternative and sustainable agriculture, America Journal of alternative agriculture, Volume 7, Numbers 1 and 2,

IRRI, Science of C4rice (http://photosynthome.irri.org/C4rice/index.php/19-about/57-science-of-c4-rice , https://c4rice.com/the-project-2/)

Ngidlo,T.R (2014) Modern Farming Technologies: Impact on Farm Productivity and Food Security in the Rice Terraces of the Cordillera Region, Northern Philippines American Journal of Experimental Agriculture, ISSN: 2231-0606,Vol.: 4, Issue.: 8 , 913-921

NRCS Colorado, USDA, 2019 https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/co/home/?cid=nrcs144p2_063020 (Visit October 15, 2019)

Roger.A.P ,1986, NlTROGEN-FIXlNG'PHOTOTROPHS IN THE IFUGA0 RICE

TERRACES (PHILIPPINES) Phil Agri 69, 599-609

science india, https://www.cropscience.bayer.in/en/Products-H/Brands/Crop-Protection/Insecticide-Solomon.aspx (Insecticide-Solomon - Crop Science Indiacrop)

Sekiguchi Hirotaka, 2014:世界遺産を守る民の知識 フィリピン・イフガオの棚田と地域の学び

Sigari. A.T. et al., 2005: Soil Fertility Limitations of Ifugao Rice Terraces , Crop science 28(1) 39-48, Crop Science Society of the Philipines.

UNESCO, Rice Terraces of the Philippine Cordilleras (https://whc.unesco.org/en/list/722/) Visit on September 3

United Nations,2015: A/RES/70/1 - Transforming our world: the 2030 Agenda for Sustainable Development

Wang.Q ,2011: Soil Nutrient Distribution in Two Typical Paddy Terrace Wetlands Along an Elevation Gradient During the Fallow Period, J. Mt. Sci. (2011) 8: 476-483 DOI: 10.1007/s11629-011-1122-y

world weather online: Banaue weather https://www.worldweatheronline.com/banaue-weather-averages/ifugao/ph.aspx

持続可能な営農を目的とした
フィリピン・イフガオの棚田における営農と土壌環境の調査

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1.調査背景

フィリピン・イフガオの棚田は世界遺産としても有名で 2000 年以上の歴史を持つとされている。しかしながら昨今，棚田の崩壊や，土壌劣化が深刻化していると考えられている。社会科学的アプローチを中心に行われてきた棚田の保全だが，土壌の観点からそれに言及した先行研究は少ない。そこで今回は，土壌の質をキーワードに現地での営農と土壌の環境について詳細に調査し整理した。また，調査結果をもとに持続可能な営農について提言することを目指した。

土壌の質とは，「特定の種類の土壌が自然または管理された生態系の境界内で機能する能力で，植物と動物の生産性を維持し，水と大気の質を維持または向上させ、人間の健康と居住をサポートする能力のことを指す。(NRCS Colorado、USDA、2019)

土壌の質は現在、持続可能な農業の達成において極めて重要な位置を占めている。図 1 に示すように、土壌の質が農業の持続可能性の「鍵」である。土壌の質の指標または属性を、パラメータを選択して正確に評価する研究が今までにも数多く行われてきている。(J.F.Parr, 1992)

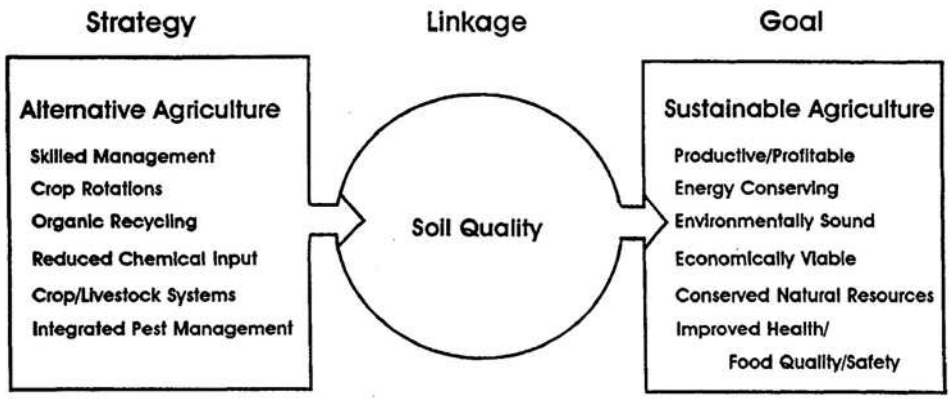

図.1 土壌の質が代替農業の戦略と持続可能な農業の橋渡しをする概念図

よって，以下の目的で今回の調査を実施した。

・Batad、Batad における土壌の化学物理性の評価

・どのような（営農要因・環境要因）が Bangaan、Batad における土壌の化学物理性に影響を及ぼしているのかの考察

・Bangaan、Batad の棚田における営農、営農管理方法の提案

2. 調査地概要と調査方法

調査地は，フィリピンにあるイフガオ州のバナウェ市，Bangaan と Batad で調査を行った。

これらの調査地の特徴は主に以下の 3 つである。

・有機農業が多い。

・村の土地利用が類似している（上流から森林，棚田，居住区，棚田）

・集落が棚田群内に存在しているため生活排水の影響が考えられる。

2.1 調査に用いたアンケートとインタビュー

インタビューには、筆者自作のアンケートを用いた。このアンケートは（1）農家の基本情報、（2）作物の基本情報、（3）営農に関する情報、（4）農地の特徴と、地域特有の取組に関する情報（5）サプライチェーンと設備の 5 つの大項目で構成され、質問に応じて、選択式の回答欄と自由記述欄を設けている。また，追加で土壌に対する認識やその他現地で気になったことについてグループディスカッションと個別の口頭インタビューを行なっている。

2.2 現地踏査、土壌サンプリング

図 2 に Bangaan の土壌サンプリング地点，図 3 に Batad の土壌サンプリング地点を示す。

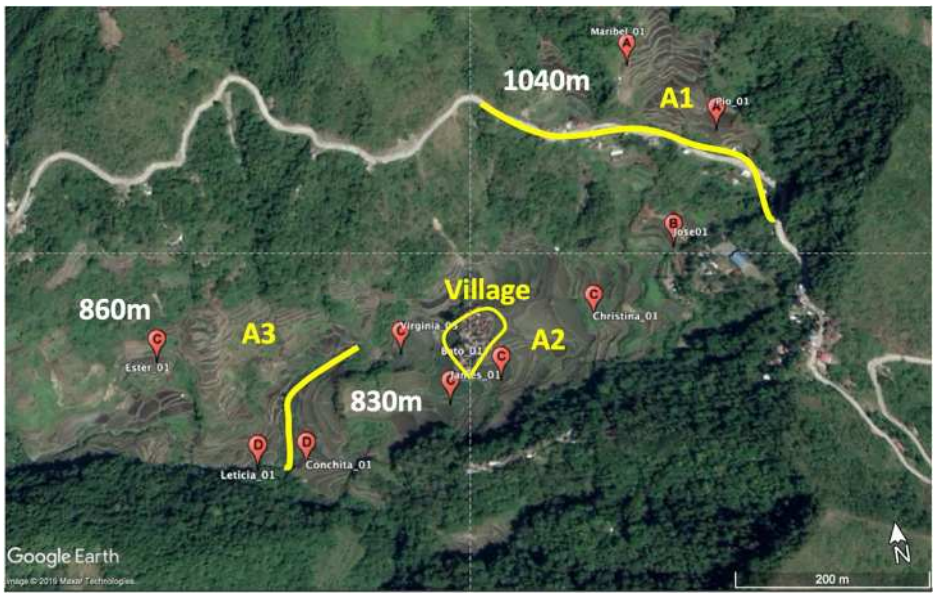

図 2　Bangaan の土壌サンプリング地点

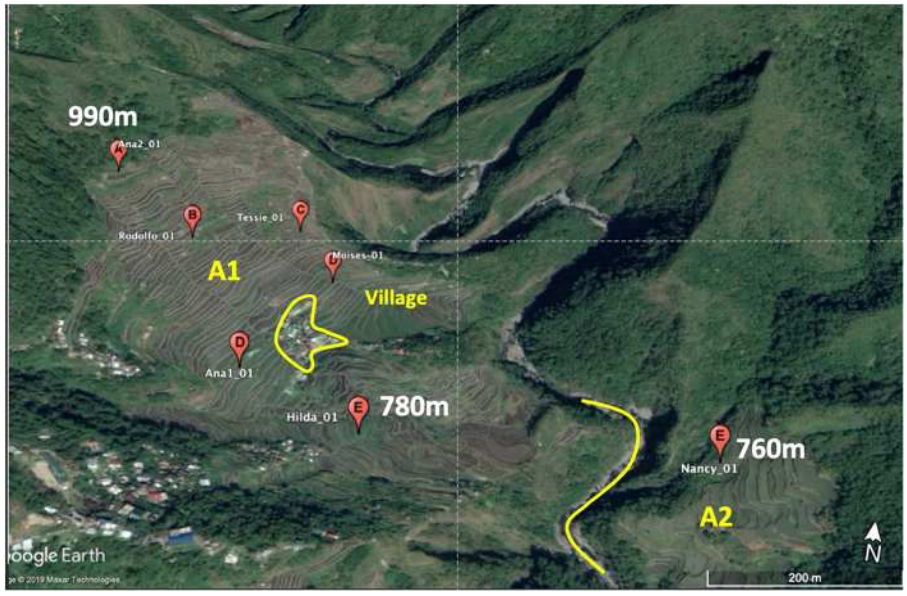

図 3　Batad の土壌サンプリング地点

サンプリングのほか、灌漑設備の見学や、土壌の様子、サンプリングを実施しなかった他の圃場の様子についても観察を行った。調査中に村内で会った農家の方からもお話を伺い、営農・営農管理・農地管理・灌漑設備・地形、営農以外の土地利用に関する追加の情報を得た。

土壌は、2 深度（表層～10cm、10～20cm）に分けてサンプリングを実施した。0～20cm が稲の根群域で作土層と考えられているためである。
また、圃場内の不均一性を平均化するため、各圃場では基本的に 2 地点から土壌を採取し、混ぜ合わせたのちに 1 試料とした。

2.3 土壌分析

土壌分析は表 1 に示す項目を実施した。

表 1 土壌分析項目と用いた手法

Analysis	Methods
含水比	
土壌 pH	(1:1=土：水)
有機物	Walkley and Black 法
全窒素	Kjekdahl 法
可給態 P	Bray No.2 法
交換態 K, Ca, Mg	Quick 法
可給態 Cu, Zn, Mn, Fe	DTPA 抽出 ICP-OAS
陽イオン交換容量(CEC)	Ammonium acetate 法

3. 調査結果と考察

表 2，3 に，各土壌の特徴を示す。

表 2 Bangaan の土壌情報

Group	Elevation (m)	Sampling site	Character
A	950 above	Maribel_01	DL-1, CF

		Pio_01	DL-1, OF
B	900-949	Jose_01	OF
C	850-899	Christina_01	OF
		Bato_01	OF
		Ester_01	DL-2, OF
		James_01	OF, DC
		Verginia_03	OF, BS
D	800 - 849	Leticia_01	DL-2, OF
		Conchita_01	OF

表 3 Batad の土壌情報

Elevation(m)		Sampling site	Character
A	950 above	Ana2_01	OF
B	900-949	Rodolfo_01	OF
C	850-899	Tessie_01	OF
D	800-849	Moises_01	CF
		Ana1_01	OF
E	750-799	Hilda_01	OF, BS
		Nancy_01	DL-1, OF

OF: Organic fertilizer CF: Chemical fertilizer BS: Black color soil DC: Double cropping DL: Different location considered a watershed surrounding a village as a center. (same number refers to same watershed that separated by river or road)

次に，ｐH，OM，ＴN，ＣＮ比を示す。ＣＮ比に用いた有機炭素量は有機物の 58％と仮定して計算した。(Sparks,1996)

表 4　土壌の基本特性 （ Bangaan）

Group	sample site	sample depth (cm)	pH	OM (%)	TN (%)	C/N ratio
A	Maribel_01	0-10	4.5	3.03	0.11	10.58
A	Maribel_01	10-20	4.8	1.37	0.10	10.20
A	Pio_01	0-10	5.0	3.50	0.18	10.74
A	Pio_01	10-20	5.1	3.27	0.16	6.62
B	Jose_01	0-10	5.6	2.91	0.15	19.26
B	Jose_01	10-20	5.7	0.44	0.06	14.59
C	Christina_01	0-10	5.5	2.90	0.16	14.97
C	Christina_01	10-20	5.4	1.12	0.10	14.53
C	Bato_01	0-10	5	3.25	0.18	11.06
C	Bato_01	10-20	5.2	2.98	0.17	10.87
C	Ester_01	0-10	5.5	7.38	0.29	11.40
C	Ester_01	10-20	5.5	6.89	0.27	4.28
C	James_01	0-10	6.2	3.82	0.20	12.34
C	James_01	10-20	5.8	3.45	0.18	12.35
C	Verginia_03	0-10	5.2	8.31	0.42	16.09
C	Verginia_03	10-20	5	7.54	0.34	8.08
D	Leticia_01	0-10	5.6	5.44	0.26	11.45
D	Leticia_01	10-20	5.4	4.31	0.20	12.86
D	Conchita_01	0-10	5.5	6.14	0.18	11.59
D	Conchita_01	10-20	6.1	5.42	0.22	12.24

表 5 土壌の基本特性（Batad）

Group	sample site	sample depth (cm)	pH	OM (%)	TN (%)	C/N ratio
A	Ana2_01	0-10	5.4	4.08	0.20	11.82
A	Ana2_01	10-20	5.5	2.11	0.08	14.47
B	Rodolfo_01	0-10	5.3	2.79	0.13	12.44
B	Rodolfo_01	10-20	5.5	1.88	0.12	9.29
C	Tessie_01	0-10	5.6	3.90	0.14	16.56
C	Tessie_01	10-20	5.6	2.43	0.14	10.44
D	Moises_01	0-10	5.8	3.72	0.17	12.84
D	Moises_01	10-20	6.0	1.52	0.11	7.70
D	Ana1_01	0-10	5.8	5.44	0.21	14.83
D	Ana1_01	10-20	5.4	2.11	0.14	8.90
E	Hilda_01	0-10	5.8	6.34	0.41	8.91
E	Hilda_01	10-20	6.0	8.01	0.35	13.10
E	Nancy_01	0-10	5.4	2.01	0.17	6.76
E	Nancy_01	10-20	5.3	0.85	0.08	6.32

表 6 土壌に含まれる元素（Bangaan）

Group	sample site	sample depth (cm)	AP (mg/kg)	Ca (cmol/kg)	Mg (cmol/kg)	K (mg/kg)	CEC (cmol/kg)	Base saturation (%)
A	Maribel_01	0-10	4.63	14.50	6.87	2.19	29.28	80.46
A	Maribel_01	10-20	3.00	14.25	5.01	1.68	29.83	70.21
A	Pio_01	0-10	4.93	18.12	13.02	3.70	41.30	84.36
A	Pio_01	10-20	4.28	17.23	15.27	2.69	35.02	100.49
B	Jose_01	0-10	12.02	24.61	11.78	2.19	40.84	94.47
B	Jose_01	10-20	7.53	23.95	15.58	3.20	43.34	98.59
C	Christina_01	0-10	5.02	21.54	10.89	2.69	35.51	98.94
C	Christina_01	10-20	3.42	20.97	14.46	4.21	36.30	109.19
C	Bato_01	0-10	5.15	22.47	15.80	5.22	37.13	117.14
C	Bato_01	10-20	5.07	22.50	13.86	3.20	41.95	94.30
C	Ester_01	0-10	21.95	19.35	11.18	2.19	44.88	72.90
C	Ester_01	10-20	18.56	21.62	11.81	1.68	41.92	83.78
C	James_01	0-10	21.81	23.89	14.66	18.86	40.37	142.20
C	James_01	10-20	16.44	22.87	15.97	14.81	41.35	129.77
C	Verginia_03	0-10	19.51	18.97	13.35	3.20	32.13	110.52
C	Verginia_03	10-20	20.81	20.99	9.79	2.19	35.46	92.99
D	Leticia_01	0-10	14.14	21.09	8.62	5.72	36.40	97.36
D	Leticia_01	10-20	11.92	20.56	9.34	1.68	35.74	88.37
D	Conchita_01	0-10	14.31	21.01	11.32	2.69	39.23	89.26
D	Conchita_01	10-20	10.62	24.09	10.58	2.19	28.01	131.62

表 7 土壌に含まれる元素（Batad）

Group	sample site	sample depth (cm)	AP (mg/kg)	Ca (cmol/kg)	Mg (cmol/kg)	K (mg/kg)	CEC (cmol/kg)	Base saturation (%)
A	Ana2_01	0-10	20.87	17.03	3.81	12.79	27.95	120.37
A	Ana2_01	10-20	16.79	14.22	2.12	13.30	20.78	142.62
B	Rodolfo_01	0-10	10.37	15.03	3.39	2.69	25.81	81.79
B	Rodolfo_01	10-20	10.37	14.80	5.43	2.69	25.64	89.40
C	Tessie_01	0-10	10.72	16.58	4.77	4.21	26.37	96.94
C	Tessie_01	10-20	6.74	14.72	4.67	1.68	27.22	77.40
D	Moises_01	0-10	13.48	16.39	7.06	8.25	28.50	111.22
D	Moises_01	10-20	10.72	14.54	5.96	2.69	25.23	91.91
D	Ana1_01	0-10	18.94	17.25	7.55	10.77	29.77	119.50
D	Ana1_01	10-20	15.33	18.08	5.74	4.71	27.96	102.05
E	Hilda_01	0-10	10.88	17.35	5.98	4.21	37.45	73.53
E	Hilda_01	10-20	13.09	16.28	6.34	1.68	30.41	79.89
E	Nancy_01	0-10	6.01	16.05	6.56	7.24	28.25	105.65
E	Nancy_01	10-20	5.96	15.20	4.33	3.20	26.95	84.34

表 8 土壌に含まれる微量元素（Bangaan）

Group	sample site	sample depth (cm)	Fe (mg/L)	Mn (mg/L)	Cu (mg/L)	Ni (mg/L)
A	Maribel_01	0-10	403.98	42.64	39.31	1.35
A	Maribel_01	10-20	395.47	74.10	68.95	1.55
A	Pio_01	0-10	272.75	79.70	74.03	3.02
A	Pio_01	10-20	317.17	120.52	113.81	3.03
B	Jose_01	0-10	144.41	12.76	12.78	0.15
B	Jose_01	10-20	150.04	21.17	20.28	0.25
C	Christina_01	0-10	168.46	5.93	6.76	0.42
C	Christina_01	10-20	120.23	9.37	9.86	0.70
C	Bato_01	0-10	275.30	32.86	31.08	0.83
C	Bato_01	10-20	274.73	32.49	30.70	0.86
C	Ester_01	0-10	165.19	9.38	9.75	0.87
C	Ester_01	10-20	148.86	8.57	9.00	1.26
C	James_01	0-10	119.42	17.91	17.37	0.98
C	James_01	10-20	81.74	21.25	20.09	1.02
C	Verginia_03	0-10	192.04	20.60	19.65	0.06
C	Verginia_03	10-20	235.89	34.03	31.62	0.03
D	Leticia_01	0-10	144.88	18.92	18.20	0.93
D	Leticia_01	10-20	225.54	26.13	24.61	0.84
D	Conchita_01	0-10	131.456	13.887	13.9125	1.05
D	Conchita_01	10-20	133.2205	4.7685	5.7765	1.12

表 9 土壌に含まれる微量元素（ Batad）

Group	sample site	sample depth (cm)	Fe (mg/L)	Mn (mg/L)	Cu (mg/L)	Ni (mg/L)
A	Ana2_01	0-10	249.48	44.79	41.41	0.55
A	Ana2_01	10-20	324.64	90.75	84.52	0.25
B	Rodolfo_01	0-10	319.58	54.94	50.68	0.29
B	Rodolfo_01	10-20	275.09	56.23	51.64	0.43
C	Tessie_01	0-10	274.46	74.40	69.13	0.48
C	Tessie_01	10-20	337.52	71.91	66.37	0.26
D	Moises_01	0-10	57.23	7.11	7.62	0.46
D	Moises_01	10-20	95.16	8.26	8.54	0.03
D	Ana1_01	0-10	91.16	2.91	3.97	0.20
D	Ana1_01	10-20	101.02	3.78	4.72	0.15
E	Hilda_01	0-10	283.27	55.20	50.85	0.30
E	Hilda_01	10-20	220.51	96.64	90.28	0.29
E	Nancy_01	0-10	364.58	28.16	26.07	0.90
E	Nancy_01	10-20	441.48	29.58	27.24	1.19

＊Ｚｎは 0 に近い値をとりＩＣＰでの測定が不可能だったので，1 月に再測定のためデータなし。

以下に，特筆すべき結果を整理する。

Bangaan では，OM が 8.70%，TN が 52.2%，P が 34.8%，K が 78.3%，CEC が 0%，Batad では OM が 14.29%，TN が 71.43%，P が 7.14%，K が 71.43%，CEC が 0 %割合で適正範囲外の値をとった。

ＣＥＣは全域で基準値を満たしており，土壌栄養を保持する能力が高いことがわかる。ＣＥＣ が高いのは粘土鉱物の組成とＯＭとＴN，そしてＰは流域ごとに見ると，下流ほど表層有機物が増加する傾向が見られた。Batad では特に傾向が

見られなかった。OM が８％を超えたのは，どちらの地域でも黒色の下流部の土壌であった。灌漑水の違いあるいは管理の頻度（圃場にいくまでが遠い）が関与していると考えられた。

次に， ｐＨについて見る。

湛水下では，酸性土壌におけるｐＨの上昇が起きる（Sigari，2003)。植物が取り込む炭酸水素イオンが，光合成のために二酸化炭素と水酸化物イオンに分解され，葉の上部より放出されることが原因の一つである。（臼井，2013）

また Roger（1984）は Banaue での研究で標高とｐＨには負の相関があることを明らかにしている。今回も標高とｐＨの負の相関は, Bangaan では多少見られた。決定係数は Bangaan で０.37，Batad で 0.07 であった。

また，Ngidlo（2014）などの主張した化学肥料の使用による土壌ｐＨ の低下は，今回も確認された。しかしながら，Gomez の主張よる伝統農法で P とＯM が有意に多いという傾向は，確認されず，OM の大小は農法よりも地域と標高による違いが顕著であった。

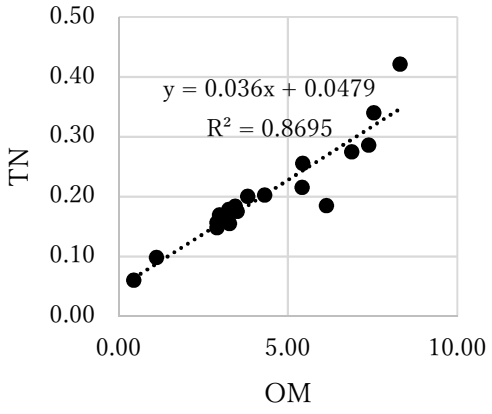

図 4 OM-TN （ Bangaan）

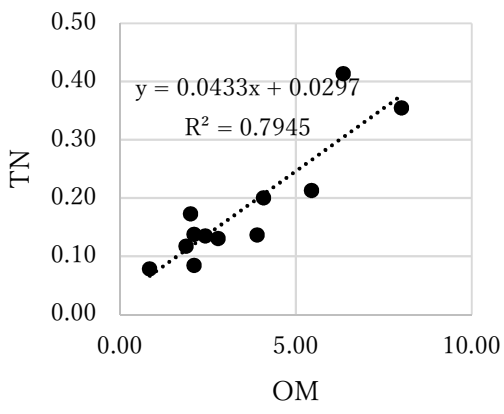

図 5 OM-TN （ Batad ）

インタビュー・現地調査での観察

インタビュー

アンケート結果については，今回特筆すべき内容以外を省略する。ここでは，グループディスカッションと，口頭でのインタビューで得られた知見について簡単に整理する。

土壌と営農の認識について調査を行ったところ，肥沃な土壌についての認識は農家によってまちまちであり，共有されていない，あるいは体系的な知識となっていないことが明らかになった。

また，化学肥料の利用については，土壌劣化，生物多様性の損失につながるという考え方が一般的であった。

一方で，収量が少なく自分たちの食べるコメも賄えていない現状があること，出稼ぎでマメな管理ができないことから化成肥料を使用している農家も 34 人中 3 名見られた。

現地調査での観察

特徴的な土壌としては、黒っぽい土壌が農村の直下部にどちらの地域でもみられた。特に Batad は最下流までに棚田が多く、広範囲で黒っぽい土壌が見られた。これは灌漑水に生活排水が混合している可能性が高く，土壌が排水に含まれる物質を吸着していると考えられる。また，このような土壌では，耕盤と考えられる水田の底（足がつくところ）が深いところにあり，ある圃場では，礫を敷き詰めていることもあった。（なぜ敷き詰めているのか聞く必要あり）下水施設が整っていない分，汚水に含まれる物質が土壌の栄養の供給源となっていることが考えられた。物質循環の視点で見ればサステイナブルともいえるが，それが原因で営農がしにくい，硫化水素の発生でイネ が育たないなどの問題になっているという問題もみられることから適切な管理を行うことにより，域内での物質循環をより効率的に営農に活用できる可能性がある。

その他，9 月，10 月の調査時には，代かきしている棚田もあれば，まだ収穫後のイネの株がそのままになっているところもあった。この作業のスピードは圃場と農家の家の距離に多少依存しているようであった。種まきの直前に代かきを行っても，イネ藁が急激に分解され過還元になったり，分解されずに苗に栄養が十分供給されないことがあったりするので，収穫後のイネ藁は迅速に処理する

必要がある。日本では，田から水を抜き，気温の高い秋のうちにイネわらのすき込みを行う。またコンバインを使うことでイネわらを細かく裁断することも可能である。Banaue でも，田植えに向かうに従って気温が低下するので，収穫直後に，イネわらのすき込みを行うのが望ましいと考えられる。また，どちらの地域でも,「土壌表面の乾燥を防ぐために湛水している, あるいは, 湛水したいが, 水がないのでできない」という課題を伺った。亀裂を防ぐために必要な水を供給する，あるいは，土壌の乾燥を防ぐ手段があるといい。尚，湛水を止めると雑草が繁茂する。田植えまでに雑草をきれいにしなければならないので手間はかかるが緑肥として施肥することが可能である。一方雑草の繁茂している圃場では亀裂が見られ, 湛水している土壌より大きな亀裂が入り, そこへ水が流れ込んでいるのが確認できた。雑草が繁茂していてもマルチの代用として土壌表面からの蒸発を防ぐことはならないようだ。

4. 結論と提言

今回は，営農と地形的要因を踏まえて Banaue の土壌の質について，どのような分布を示すか, そしてどのような課題が見られるかを明らかにしようとした。土壌の質は, 作物の生産性だけでなく, 環境保全機能など土壌が持つ機能がどの程度働いているのかを示すものであり，その中でも今回は土壌の化学性に焦点を当てて, 分析を行い先行研究との比較を中心に考察を行った。その結果データ数は少なかったものの，化学肥料の使用による土壌の性質変化に関しては概ね先行研究と同様の結果が得られたが，先行研究にない新たな傾向は見られなかった。

今回の 2 地域で特徴的だったのは，ＯＭが総じて多いことほとんどの土壌が酸性を示していること，ＮとＫが少ないこと，ＣEC が高いことが挙げられる。また OM，ＴＮ，Ｐは下流に行くに従い増加する傾向が見られたことから土粒子とともに移動している，あるいはリーチングが起きていると考えられた。

土壌栄養の飢餓を改善するためには，域内で未活用の資源を利用することも考えるべきであり，現地踏査の結果から Azolla と Blue green algae のすき込みは効果的であると考えられた。また，稲ワラはＣＮ比の高いこと，生活排水による影響か有機物が村直下の棚田で過剰であることが確認され，土壌が黒っぽくな

っていることから，排水を定期的に行うことで，可給態の窒素量を増やす，有機物量を適量にし，過還元を防ぐといった対策ができるだろう。今回分析したのは化学性のデータのみのため，土壌中での元素の動態，化学反応については勉強不足の部分が多く，研究方針によっては更なる文献調査が必要である。
さらに営農の記録と細かなサンプリングを行う必要が出てきた場合は，農家の協力を得るのが望ましい。

引用・参考文献

Acabado.S, 2015 Antiquity, Archaeological Processes, and highkand Adaptation The Ifugao Rice Terraces

CUI Baoshan, 2010: Temporal and spatial distributions of soil nutrients in Hani terraced paddy fields, Southwestern China, nternational Society for Environmental Information Sciences 2010 Annual Conference (ISEIS), Procedia Environmental Sciences 2 (2010) 1032–1042

farmguru: Insecticides/Pesticides, Syngenta Insecticide Cymbush – https://www.store.farmguru.in/products/agro-chemicals-crop-protection-insecticidespesticides/syngenta/syngenta-insecticide-cymbush/pid-11552122.aspx

Gomez,A.R, et al., 2005 Survey of the Damage in the Ifugao Rice Terraces and Its Environmental Dynamics, The Philippine agricultural scientist , vol88, No.1, 133-137

IFSU, 2011; Ifugao Indigineous Knowledge (IK) Workbook

J.F. Parr, R.I et al, 1992 :Soil quality: Attributes and relationship to alternative and sustainable agriculture, America Journal of alternative agriculture, Volume 7, Numbers 1 and 2,

IRRI, Science of C4rice (http://photosynthome.irri.org/C4rice/index.php/19-about/57-science-of-c4-rice , https://c4rice.com/the-project-2/)

Ngidlo,T.R (2014) Modern Farming Technologies: Impact on Farm Productivity and Food Security in the Rice Terraces of the Cordillera Region, Northern Philippines American Journal of Experimental Agriculture, ISSN: 2231-0606,Vol.: 4, Issue.: 8 , 913-921

NRCS Colorado, USDA, 2019 https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/co/home/?cid=nrcs144p2_063020 (Visit October 15, 2019)

Roger.A.P ,1986, NlTROGEN-FIXlNG'PHOTOTROPHS IN THE IFUGA0 RICE

TERRACES (PHILIPPINES) Phil Agri 69, 599-609

science india, https://www.cropscience.bayer.in/en/Products-H/Brands/Crop-Protection/Insecticide-Solomon.aspx (Insecticide-Solomon - Crop Science Indiacrop)

Sekiguchi Hirotaka, 2014:世界遺産を守る民の知識 フィリピン・イフガオの棚田と地域の学び

Sigari. A.T. et al., 2005: Soil Fertility Limitations of Ifugao Rice Terraces , Crop science 28(1) 39-48, Crop Science Society of the Philipines.

UNESCO, Rice Terraces of the Philippine Cordilleras (https://whc.unesco.org/en/list/722/) Visit on September 3

United Nations,2015: A/RES/70/1 - Transforming our world: the 2030 Agenda for Sustainable Development

Wang.Q ,2011: Soil Nutrient Distribution in Two Typical Paddy Terrace Wetlands Along an Elevation Gradient During the Fallow Period, J. Mt. Sci. (2011) 8: 476-483 DOI: 10.1007/s11629-011-1122-y

world weather online: Banaue weather https://www.worldweatheronline.com/banaue-weather-averages/ifugao/ph.aspx

感想

今回の調査を通じて，海外で研究に必要なプロセスを一通り体験することができた。

まずは問題の発見，そしてそれに取り組むための手段を模索した。次に，どのような情報が必要かを精査すること，そして必要な情報をいかに正確に効率的に取得するかということを計画し，実践的に学ぶことができた。また，現地でしかわからないことを整理しどのように分析や考察につなげていくかという筋道を立てていく発表や報告書作成までの過程も，大変であったが，やりがいもあった。

現地では，電気や水が途切れやすい不自由な生活，そして土壌サンプリングなどの力仕事もあり，身体的・精神的疲労も多く，自己管理と現地の方の協力を得ることは非常に重要だと感じた。実際，アンケートやインタビューなどは現地の方に通訳をしてもらいながらデータをとっており，労力はかかったが，その分貴重なデータが得られたと思う。

また，今回は自分が今まで行ったことのないアンケート調査や分析なども実施している。これにはフィリピン大学ロスバニョス校の先生，技官の方々に大変お世話になった。皆様がいなければ自分が今回データを得ることもできなかった。日本で発表を来てくださった方々の協力もありがたい。この授業を通してそういった手法であったり得られた結果を多くの方に見ていただけたりしたこと，そして専門分野の異なる各先生から有益な助言をいただけたことは非常に有益であったと思う。

今回の調査で改めて，国際研究を行う際にどのように研究を進めていくべきか，また，国境をこえて研究をすることで得られるものを実感することができた。この経験を，これから自分の修士研究を進めてまとめ上げていく上でも，卒業後の就職でも役立てていきたいと考えている。

ひとまずは今回の調査を生かして，自分の修士研究をさらにより良いものに，そして社会と現地のニーズにあったものになるようにこれからも研究に邁進していきたい。