

An aerial photograph of a flooded paddy field, showing numerous rectangular plots of water and green vegetation. In the upper right corner, a satellite is visible in orbit, with a blue structure representing the Earth's surface and a dark blue/black space background. The satellite is gold-colored with various instruments and a white spherical antenna.

# USE OF REMOTE SENSING TO ESTIMATE PADDY AREA AND PRODUCTION

A Handbook

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APRIL 2019



The logo for the Asian Development Bank (ADB), consisting of the letters 'ADB' in white on a dark blue square background.

# **USE OF REMOTE SENSING TO ESTIMATE PADDY AREA AND PRODUCTION**

## **A Handbook**

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APRIL 2019

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## Foreword

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Rice remains an important staple food worldwide and particularly in Asia and the Pacific. Based on data from the Food and Agriculture Organization of the United Nations, the top five rice-consuming economies in the world are from the Asia and Pacific region; comprising (in order of consumption) the People's Republic of China, India, Indonesia, Bangladesh, and Viet Nam. The region also accounts for nearly 90% of the world's total rice production.

Given the global importance of addressing food security within the context of the Sustainable Development Goals, government policies and interventions need to be based on timely and reliable agricultural statistics.

While traditional methods of data collection and management (such as administrative records and sample surveys) exist, they continue to be affected by measurement errors for a variety of reasons. The application of remote sensing technology—which employs more objective methods in generating statistics on paddy area and rice production—is a viable alternative, but is still in the nascent stages of adoption by government agencies working on official agricultural statistics.

The Asian Development Bank (ADB), as part of its efforts to build statistical capacity for national statistical offices (NSOs) and ministries of agriculture (MoAs), piloted the use of satellite data under Regional Capacity Development Technical Assistance 8369: Innovative Data Collection Methods for Agricultural and Rural Statistics. Under this technical assistance project, satellite data was used to estimate paddy area and rice production in Savannakhet, Lao People's Democratic Republic; Nueva Ecija, Philippines; Ang Thong, Thailand; and Thai Binh, Viet Nam.

This handbook is a step-by-step guide to all the tools and techniques developed as part of the technical assistance project. It is expected to encourage and assist NSOs and MoAs interested in piloting satellite-based techniques as an alternative to existing methods. The handbook also serves as a complement to a web-based online training course developed under this project and available at <http://cars.adbx.online/>.

The ADB project team is extremely grateful to the Center for Agricultural Statistics, Ministry of Agriculture and Forestry, Lao People's Democratic Republic; the Philippine Statistics Authority, Philippines; the Office of Agricultural Economics, Ministry of Agriculture and Cooperatives, Thailand; and the Center for Informatics and Statistics, Ministry of Agriculture and Rural Development, Viet Nam for their support and active participation in the project. In particular, we thank Lisa Grace Bersales, Savanh Hanephom, Ngo The Hien, Romeo Recide, Vivanh Souvannamethy, and Sommart Yingyuad for leading the implementation of the project in the pilot economies. We would also like to offer our sincere gratitude to Sengphachan Khounthikoummane, Aengsone Kouangbounhieng, Saksit Klumtok, Nelson Lagniton, Nguyen Hoai Nam, Mimi Sangsiriwattana, and Ermina Tepora for providing technical and logistical support in the conduct of all project activities. Their contribution to field work and survey data collection was vital to the success of the project.

We would like to thank all those who contributed to the production of this publication for their dedication, cooperation, and hard work—the consultants, particularly Chrysalyn Gocatek; the industry experts; ADB staff; the Japan Aerospace Exploration Agency; the Remote Sensing Technology Center of Japan; and other partners who collaborated closely during the technical assistance project. We also acknowledge the contribution of Paul Dent as the manuscript editor, and Rhommell Rico as the focal person for the publication’s cover design, layout, page design, and typesetting.

We hope this handbook will be instrumental in promoting remote sensing and in assisting NSOs and MoAs to use innovative technologies in producing quality and timely agricultural statistics.



**Yasuyuki Sawada**  
Chief Economist and Director General  
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Asian Development Bank



## Abbreviations

ADB	Asian Development Bank
AFSIS	Association of Southeast Asian Nations Food Security Information System
ALOS	Advanced Land Observation Satellite
AM	amplitude modulation
ASEAN	Association of Southeast Asian Nations
AUIG	Advanced Land Observation Satellite User Interface Gateway
CCE	crop cutting experiment
CRS	coordinate reference system
CSPRO	Census and Survey Processing System
CSV	comma-separated values
EA	enumeration area
ESA	European Space Agency
ENVISAT	Environmental Satellite
ETM+	Enhanced Thematic Mapper Plus
FAO	Food and Agriculture Organization of the United Nations
FM	frequency modulation
GADM	global administrative areas
GIS	geographic information system
GPS	global positioning system
GPX	global positioning system exchange format
HH	horizontal transmit and horizontal receive or horizontal-horizontal polarization
HHs	households
HV	horizontal transmit and vertical receive or horizontal-vertical polarization
INAHOR	INternational Asian Harvest mOnitoring system for Rice
INAHOR-AD	modified or advanced version of INternational Asian Harvest mOnitoring system for Rice
IR	infrared
IRRI	International Rice Research Institute
JAXA	Japan Aerospace Exploration Agency
JPL	Jet Propulsion Laboratory
KML	keyhole markup language
KMZ	keyhole markup language zipped
Lao PDR	Lao People's Democratic Republic
LTM	Landsat Thematic Mapper
MODIS	Moderate Resolution Imaging Spectroradiometer
MPZ	Miradi Project Zipped
NASA	National Aeronautics and Space Administration
OLI	Operational Land Imager
PALSAR	Phased Array type L-band Synthetic Aperture Radar
PRC	People's Republic of China
PSU	primary sampling unit
QGIS	quantum geographic information system
RPC	rice production calculator

SAR	synthetic aperture radar
ScanSar	scanning synthetic aperture radar
SDG	Sustainable Development Goals
SHEGA	Scientific and Handy Equipment for Gintong Ani
shp	shapefile
SNO	serial number
SSU	secondary sampling unit
UAV	unmanned aerial vehicles
UTM	universal transverse mercator
UN	United Nations
USU	ultimate sampling unit
UV	ultraviolet
VH	vertical transmit and horizontal receive or vertical-horizontal polarization
VV	vertical transmit and vertical receive or vertical-vertical polarization
WGS	World Geodetic System

### **Unit of Measure**

dB	decibel
GHz	gigahertz
Hz	hertz
kg	kilogram
km	kilometer
m	meter
m <sup>2</sup>	square meter
mm	millimeter
nm	nanometer
µm	micrometer

## Chapter 1: Introduction

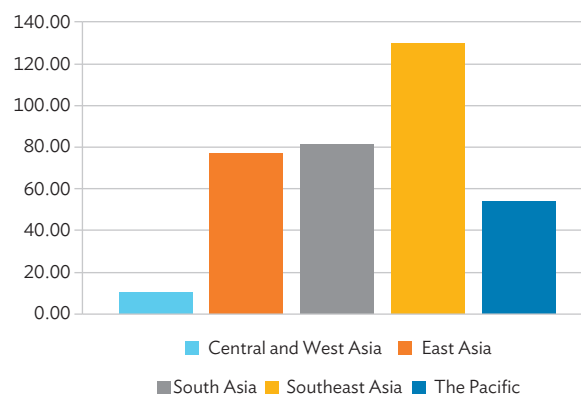
### 1.1 The Importance of Rice in Asia and the Pacific

Rice is the most commonly consumed staple food across the world. In Asia and the Pacific, the average annual per capita consumption of rice increased from 67.15 kilograms (kg) in 1961 to 80.69 kg in 2013 (FAO 2018). Annual rice consumption varies across the region, with Southeast Asia averaging at 129.56 kg per capita in 2013, followed by South Asia at 81.40 kg per capita, and East Asia at 76.92 kg per capita (Figure 1.1). The world's top national economies in terms of rice consumption are all from Asia and the Pacific: the People's Republic of China (PRC), India, Indonesia, Bangladesh, Viet Nam, the Philippines, Thailand, Myanmar, and Japan (FAO 2018).

Asia and the Pacific also accounts for almost 90% of the rice produced globally, with the PRC, India, and Indonesia contributing the greatest

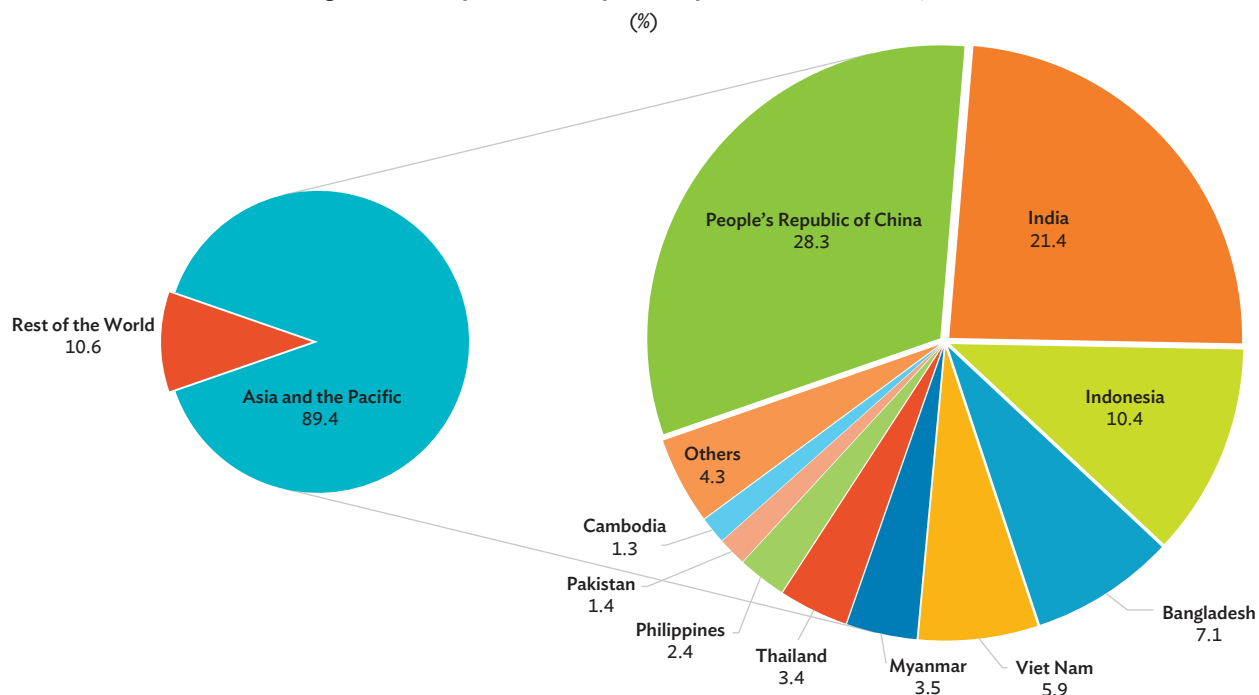
volumes (Figure 1.2). Moreover, four of the top five rice exporters in the world are from Asia and the Pacific, namely India, Thailand, Viet Nam, and Pakistan (IRRI 2018).

**Figure 1.1: Average Annual Rice Consumption by ADB Regions, 2013**  
(kg/capita)



ADB = Asian Development Bank, kg = kilogram.  
Source: Food and Agriculture Organization of the United Nations. FAOSTAT. <http://www.fao.org/faostat/en/#data> (accessed 8 November 2018).

**Figure 1.2: Paddy Production by Economy in Asia and the Pacific, 2016**



Source: Food and Agriculture Organization of the United Nations. FAOSTAT. <http://www.fao.org/faostat/en/#data> (accessed 8 November 2018).

The importance of rice to the Asia and Pacific region is even more emphasized in the context of climate change and its associated impacts, with production vulnerable to extreme weather events such as longer and more frequent drought spells interspersed with erratic patterns of violent storms, heavy rains, and flooding events. Given that a significant percentage of the world's population resides in Asia and the Pacific, and that the regional population continues to grow exponentially, achieving rice self-sufficiency is going to become ever-more challenging using existing inputs such as land, labor, fertilizers, pesticides, types of rice seeds etc. Addressing these challenges requires well-designed agricultural development plans at the national level. Such plans rely on high-quality and timely data being delivered in a cost-effective manner, so that governments can provide support directly to the most vulnerable areas and populations.

## **1.2 Agricultural and Rural Statistics for Food Security**

The 2018 United Nations (UN) Secretary-General Report on the Progress towards the Sustainable Development Goals indicated that, after years of decline, world hunger is on the rise again. The report shows that, from a rate of 10.60% of the world's population in 2015, global undernourishment increased to 11.00% in 2016. This translates to an increase of about 38 million undernourished people, from 777 million in 2015 to 815 million in 2016. It also means that nearly one in nine individuals on the planet does not have enough to eat (UN 2018). Therefore, it is imperative that addressing food security continues to be a central focus for policymakers worldwide.

Goal 2 of the Sustainable Development Goals (SDGs) specifically aims to “end hunger, achieve food security and improved nutrition, and promote sustainable agriculture” (UN 2018). Attaining SDG 2 will require better access to nutritious food for everyone and the extensive promotion of sustainable

agriculture, including improving the productivity, incomes, and agricultural practices of small-scale farmers. The goal can only be effectively monitored if timely, cost-effective, and high-quality data are available for generating agricultural and rural statistics.

## **1.3 Sources of Agricultural and Rural Statistics in Developing Economies**

Accurate and reliable agricultural and rural statistics are vital in formulating agricultural policies and programs, monitoring policies on food security, promoting economic growth, and allocating resources in the agriculture sector. Moreover, current statistics must be readily available to allow for evidence-based policymaking. There is a need for economies to incorporate sustainable data collection and management practices into their national statistical systems, allowing them to produce accurate and reliable agricultural and rural data to inform and guide policy analysis and decision-making. Presently, most national statistical agencies compile agricultural and rural statistics either through administrative reporting systems or household surveys and censuses.

### **1.3.1 Administrative Reporting Systems**

Many developing economies in Asia and the Pacific rely on administrative reporting systems in generating statistics on agricultural production and land use. The lack of financial resources to conduct agriculture surveys or censuses is one reason for opting to use data collected from local administrative authorities. There is also a need to further develop and strengthen statistical capacity in some economies before it is possible to implement large-scale agricultural censuses. Another pressing issue that needs to be addressed through continuous training and capacity development is the shortage of technical staff who have competent skills relevant to producing accurate agricultural statistics.

In an administrative reporting system, data are collected at the lower administrative levels, for instance, the village or municipal levels, and are then aggregated and forwarded up to the various administrative levels until national estimates are derived. The information is typically collected and compiled by agriculture personnel assigned in local villages or municipalities to assess crop and livestock production or identify land use. Data collection is usually done by observing harvests and interviewing key people—including village chiefs, farmers, and traders—in each locality.

The process of collecting data through administrative reports is less expensive, and can provide more timely estimates, than deriving statistics from censuses or surveys. However, information from these reports is prone to large measurement errors and can be considered subjective due to the nature of the data collection process. In addition to problems of accuracy, statistics derived from administrative reports are often found to be inconsistent with other sources of information.

A lack of validation procedures for agricultural estimates derived from administrative reports adds to the inconsistencies and, sometimes, the unreliability of the information. There have been cases where reports made by local administrative offices refer to planned or targeted figures, rather than being based on information collected from farmers or key people in the locality. In other instances, figures in administrative reports have been deliberately or inadvertently adjusted through human intervention, leading to incorrect information and flawed decision-making by local officials.

### 1.3.2 Probability Household Sample Surveys

Some of the more advanced economies across Asia and the Pacific regularly conduct household surveys to collect data on the agriculture sector. These surveys are usually done to gather information on specific commodity types, for example, livestock

production surveys or crop production surveys, and are often conducted periodically, e.g., monthly or quarterly. Since these surveys are conducted more frequently than censuses, more up-to-date information on farm productivity is made available. This can help governments in making short-term decisions about providing agricultural inputs to farmers or in making production forecasts. Other agriculture-related household surveys are conducted to monitor food demand and consumption, track household food security, evaluate production costs, or assess labor force participation in agriculture.

In the Philippines, regular monthly surveys conducted by the government include the Rice and Corn Stocks Survey, Commercial and Municipal Fishery Survey, and Farm Prices Survey. Regular quarterly surveys include production surveys on rice and corn, other crops, livestock, fisheries, and food consumption. The Philippines also conducts agricultural labor surveys semiannually. Costs and returns surveys for specific commodity types have also been conducted, albeit on an *ad hoc* basis. Economies that do not regularly conduct agriculture surveys usually gather information related to agricultural area, agricultural production, and landholdings as part of living standards surveys or household income and expenditures surveys, which are conducted every 3 to 5 years.

By implementing probability sample surveys to derive statistics on crop areas or crop and livestock production, the precision levels of the estimates can be measured. Results of surveys, when properly managed and executed, also provide more reliable information than data from administrative reports. However, there is also the possibility of under- or over-estimating results. For instance, a farmer may be asked about the total area cultivated by the farming household to produce rice, but he or she may respond with the household's total landholding (which could include areas dedicated to other crops, for raising livestock, or for purposes other than agricultural production). This can result in the



overestimation of rice-cultivated areas. On the other hand, underestimation of rice-cultivated areas may occur if respondents leave out areas that are given to share-croppers but still used for rice cultivation. Since such surveys are usually conducted after the cropping season, some farmers may have limited or imprecise recall of information. Household surveys also require data validation and data processing, so results may not always be available in a timely manner. This is critical if policies or decisions need to be made for the following cropping season, such as provision of seeds or other inputs that farmers may need.

### 1.3.3 Censuses of Agriculture

National censuses of agriculture are conducted to provide information that will help describe the structure and characteristics of agriculture in an economy. Based on the recommendations of the Food and Agriculture Organization of the United Nations (FAO), as indicated on the World Programme for the Census of Agriculture 2020, national economies should consider including 23 essential items<sup>1</sup> across 15 themes: (i) Identification and general characteristics, (ii) Land, (iii) Irrigation, (iv) Crops, (v) Livestock, (vi) Agricultural practices, (vii) Services for agriculture, (viii) Demographic and social characteristics, (ix) Work on the holding, (x) Intra-household distribution of managerial decisions and ownership on the holding, (xi) Household food security, (xii) Aquaculture, (xiii) Forestry, (xiv) Fisheries, and (xv) Environment/Green House Gas emissions. These data are collected directly from household or agricultural holdings, although data may also be collected at the community level.

Community level data may include information on geography, socioeconomic conditions, community infrastructure and services, and community development programs in agriculture.<sup>2</sup> Censuses of agriculture are usually conducted every 10 years, due to the intensive resource requirements of conducting a national census. However, some economies, such as India and Viet Nam, conduct agricultural censuses more frequently.

Implementing nationwide censuses is generally expensive and requires significant human resources. Thus, many developing economies depend on funding assistance from development agencies to be able to conduct agricultural censuses. In Bhutan, two previous agricultural censuses, conducted in 2000 and 2009, were both fully funded by the Danish International Development Agency. Likewise, agriculture censuses in Nepal have been either partially or fully funded by development organizations such as the Asian Development Bank (ADB), the FAO, and the United Nations Development Programme.

## 1.4 Using Remote Sensing for Agricultural and Rural Statistics

Recognizing the increasing demand for accurate, reliable, and more frequently measured data, national statistical agencies are becoming more interested in exploring technologically innovative and more efficient methods of collecting agricultural data. One of the methods that has gained traction in recent years is the application of remote sensing and satellite-based technologies.

1 The FAO recommended that the national economies include 23 essential items in their Census of Agriculture, namely: (i) identification and location of agricultural holding, (ii) legal status of agricultural holder or type of holder, (iii) sex of agricultural holder, (iv) age of agricultural holder, (v) main purpose of production of the holding, (vi) other economic activities of the household, (vii) total area of holding, (viii) area of holding according to land use types, (ix) area of holding according to land tenure types, (x) area of land actually irrigated: fully controlled and partially controlled irrigation, (xi) area of temporary crops harvested for each temporary crop type, (xii) area of productive and non-productive permanent crops in compact plantations for each permanent crop type, (xiii) number of permanent crop trees in scattered plantings for each tree crop, (xiv) use of each type of fertilizer, (xv) type of livestock system, (xvi) number of animals, (xvii) number of female breeding animals, (xviii) use of agricultural pesticides, (xix) household size by sex and age groups, (xx) whether working on the holding is the main activity, (xxi) working time on the holding, (xxii) number and working time of employees on the holding by sex, and (xxiii) presence of aquaculture on the holding.

2 World Programme for the Census of Agriculture 2020. <http://www.fao.org/world-census-agriculture/wcarounds/wca2020/en/>.

Apart from applications in crop area and production estimation, remotely sensed data can also be useful to determine paddy field conditions during the growing stages of the crop. The technology can also be used to gather other agro-meteorological information that affect rice yield, and to quickly assess crop damage during times of calamity (e.g., damage caused by flood or drought). For example, after typhoon Haiyan hit the Philippines in November 2013 and devastated the northeastern part of Leyte Province, satellite images were released by the International Rice Research Institute (IRRI) in collaboration with sarmap SA and the Department of Agriculture-Philippine Rice Research Institute. Rice area maps were constructed from satellite images before and after the typhoon, showing that about 1,800 hectares of standing rice crops in the province had been damaged by flooding. This critical information assisted authorities in making urgent decisions on how to provide aid to the province (IRRI 2013).

A number of studies related to the use of remote sensing in the agriculture sector have been conducted in individual economies across Asia and the Pacific. There have also been various broader initiatives implemented by the global community to improve and expand the use of remote sensing for agriculture. For example, research has been conducted in Viet Nam on the application of remote sensing technology to estimating rice yield in Thai Binh province, Viet Nam (Guan et al. 2018). In addition, through a number of initiatives in the Mekong Delta, the use of satellite imagery has been explored to derive statistics necessary to address issues on severe drought, flooding, hydrologic changes, coastal erosion, and loss of biodiversity. For its part, the Ministry of Agriculture and Rural Development in Viet Nam has been taking advantage of the technology by using satellite images to develop land use maps, which allow users to collect information on crop growth.

In Thailand, studies have been conducted on the application of satellite-based technology for rice area and production estimation. In 2011, the Geo-

Informatics and Space Technology Development Agency, in close collaboration with the Japan Aerospace Exploration Agency (JAXA) and Khon Kaen University (KKU) made a study on the use of remote sensing technology—specifically, synthetic aperture radar—for estimating rice crop area and forecasting rice production in Khon Kaen province. The KKU Model, a rice crop yield estimation model that relies on agro-meteorological satellite data, was used to estimate rice crop yield in the rainfed region of Khon Kaen province, as well as for rice crop monitoring in Suphan Buri province. Similar technology was applied in Roet province in 2012. The Office of Agricultural Economics in Thailand, likewise, has done some case studies on the application of remote sensing methods and objective yield surveys for rice yield estimation in the provinces of Sing Buri and Ang Thong.

With the objective of strengthening regional food security in Southeast Asia, the Association of Southeast Asian Nations (ASEAN) implemented the ASEAN Food Security Information System (AFSIS). The project included the development of a statistical system called the Agricultural Land Information System to estimate agricultural crop areas using optical satellite imagery available from Google Earth. A feasibility study to test the system was implemented in the Lao PDR and Cambodia in 2011 as well as in the Philippines in 2013 (AFSIS 2017).

On a larger scale, the Remote Sensing-Based Information and Insurance for Crops in Emerging Economies initiative was established by IRRI and its partners, and aims to reduce the vulnerability of rice smallholder farmers in low-income economies of Asia. The project employs satellite-based technology for mapping and estimating farm-level rice area and production for microinsurance purposes. It enables the production of rapid estimates of crop loss and damage, which can be used in food security programs and disaster response. The project is currently being implemented in Cambodia, India, the Philippines, Thailand, and Viet Nam, while implementation is on hold for Bangladesh and Indonesia (RIICE n.d.).

At the international level, the Group on Earth Observations Global Agricultural Monitoring Initiative was established to support agricultural development through remote sensing technology. The initiative was launched by the Group of Twenty (G20) Agriculture Ministers in June 2011 and aims to strengthen global agricultural monitoring by improving the use of remote sensing tools for crop production projections and weather forecasting. Recently, the initiative started collaborating with the Agricultural Market Information System, which is hosted by the FAO. With this collaboration, the two initiatives aim to enhance the use of satellite observations within current systems employed in area and yield estimation and to integrate earth observations into early-warning market indicators (GEOGLAM n.d.).

### **1.5 ADB's Technical Assistance on Using Remote Sensing for Paddy Rice Statistics**

In December 2013, ADB approved a major technical assistance project (Regional Capacity Development Technical Assistance 8369: Innovative Data Collection Methods for Agricultural and Rural Statistics) to promote the use of space-based and remote sensing technologies in formulating and monitoring food security policies across Asia and the Pacific. The project, administered by ADB and financed through a grant from the Japan Fund for Poverty Reduction, aimed to improve the quality and timeliness of rice crop area and production estimates and forecasts made by national statistical agencies.

The three major activities of the project were to (i) develop customized software applications and methodologies to estimate paddy rice cultivation area and production based on satellite data, (ii) train counterpart staff in the economies involved in

the pilot study, and (iii) develop an online training program on the use of satellite data for agricultural and rural statistics. Ground-truthing field validation, crop cutting experiments (CCEs), and farmer recall surveys were also conducted in the pilot economies.

Through a partnership agreement with ADB, JAXA agreed to the modification and enhancement of the INternational Asian Harvest mOnitoring system for Rice (INAHOR), a software application developed for estimating rice crop area and production using radar satellite imagery. Under the pilot project, INAHOR was modified as INAHOR-AD, with 'AD' referring to the advanced version of the base INAHOR software application. Apart from providing access to the INAHOR software, JAXA also acted as the project technical adviser.

The pilot project was implemented in four Asian economies—the Lao PDR, the Philippines, Thailand, and Viet Nam—which were chosen because of the substantial contribution of rice to their agriculture sector and overall economic welfare. The implementing agencies for the project included the Center for Agricultural Statistics, Ministry of Agriculture and Forestry in the Lao PDR; the Philippine Statistics Authority in the Philippines; the Office of Agricultural Economics, the Ministry of Agriculture and Cooperatives, and Geo-Informatics and Space Technology Development Agency in Thailand; and the Center for Informatics and Statistics, Ministry of Agriculture and Rural Development in Viet Nam. Technical staff from the implementing agencies were trained on basic remote sensing concepts and on use of the INAHOR-AD application in estimating rice area and production. Training was also provided on the implementation of ground-truthing field validation, CCEs, and farmer recall surveys (ADB 2013).

## 1.6 Objectives and Layout of the Handbook

This handbook is intended as a guide to using INAHOR-AD software and other remote sensing based techniques that were applied in the ADB pilot project to estimate paddy rice cultivation area and production. It aims to serve as a guidebook for national agriculture statistical agencies that may be interested in implementing the same methodology in estimating rice area and production. The handbook complements a web-based online training course on the use of remote sensing technology for agricultural and rural statistics, INAHOR-AD, CCEs, and farmer recall surveys developed under the project. It covers all activities and data processes conducted in the four economies chosen for the pilot project, and makes references to the particular experiences of the studies conducted in each economy.

Chapter 2 provides an introduction to basic remote sensing concepts. Chapter 3 discusses installation procedures and offers a step-by-step

illustration of how to use INAHOR-AD software. Chapter 4 provides the method of conducting ground-truthing exercises and gathering field data to validate and assess the accuracy of rice area estimates derived from satellite data. It includes discussion on generating random points using an open source geographic information system software called QGIS, and describes the sampling method employed in selecting sample sites for field surveys.

The conduct of CCEs and farmer recall surveys is discussed in Chapter 5, including detailed information such as selection of plots and subplots, field methodology, questionnaire design, and paddy yield estimation procedure using the crop cutting data. Chapter 6 presents a comparison of paddy area estimates from various sources including INAHOR-AD, ground-truthing and global positioning system track files, farmer estimates, and official statistics available from each economy. Adjusting threshold values to improve paddy area estimation using INAHOR-AD is also discussed in Chapter 6.

## Chapter 2: Basic Remote Sensing Concepts

This chapter focuses on basic remote sensing concepts and how these can be applied in estimating paddy area and production. It includes an overview of the different modes of gathering remotely sensed data, the concept of electromagnetic spectrum, types of sensors, satellite data resolution, and the differences between optical and radar satellite data.

An understanding of the most basic concepts of remote sensing is essential to effectively process and analyze satellite data. Knowing what type of satellite images to select and the appropriate geographic information system (GIS) software to use will affect the results obtained from satellite data analysis. Whether the purpose of satellite data analysis is to derive agricultural statistics or to determine the effects of extreme weather conditions, using the appropriate satellite information is of great importance. For instance, during the wet season in Southeast Asia where cloud coverage is a significant concern, it may be best to use radar data because radar satellites can penetrate through clouds. On the other hand, in areas where cloud cover is not a problem, optical satellite images may be a better option. There is some discussion below on optical satellite data; however, this handbook primarily focuses on the use of synthetic aperture radar (SAR) data, which serves as an input for the advanced version of International Asian Harvest mOnitoring system for Rice (INAHOR-AD) software.

### 2.1 Definition of Remote Sensing

Remote sensing is defined as “the practice of deriving information about the Earth’s land and water surfaces using images acquired from an overhead perspective, by employing electromagnetic radiation in one or

more regions of the electromagnetic spectrum, reflected or emitted from the Earth’s surface” (Campbell and Wynne 2011). To better grasp the idea of remote sensing, each of the three elements in the definition is explained in detail.

#### 2.1.1 Eyes in the Sky

The first part of the definition of remote sensing talks about acquiring images from an overhead perspective. In the early 19<sup>th</sup> century, remote sensing was done by strapping cameras to pigeons, literally to get a bird’s eye view over a city, or by using hot air balloons or kites. In 1858, in France, Gaspard-Félix Tournachon, also known as “Nadar”, acquired the very first aerial photograph using a camera placed on a tethered balloon (Campbell and Wynne 2011). Later, in the spring of 1888, Arthur Batut, considered the father of Kite Aerial Photography, developed a flat, diamond-shaped 2.5 meter (m) x 1.75 m kite equipped with a camera made from cardboard and cork. He took the first aerial photo using a kite over an area in Labruguière, France (Chemins de MÉMOIRE n.d.). The first aerial photographs taken from an airplane were pictures of the Italian landscape, captured from a plane piloted by Wilbur Wright in 1909 (Campbell and Wynne 2011). In the years that followed, particularly in the 1960s, there was a shift from using airplanes to using satellites in capturing images. The use of weather satellites and remote sensing observation from space then started. Today, both regular and micro satellites are being launched into space for different purposes and more-advanced sensors are being developed for use on board these satellites. Figure 2.1 depicts the early methods of capturing images on the ground.



**Figure 2.1: Early Methods of Capturing Images on the Ground**

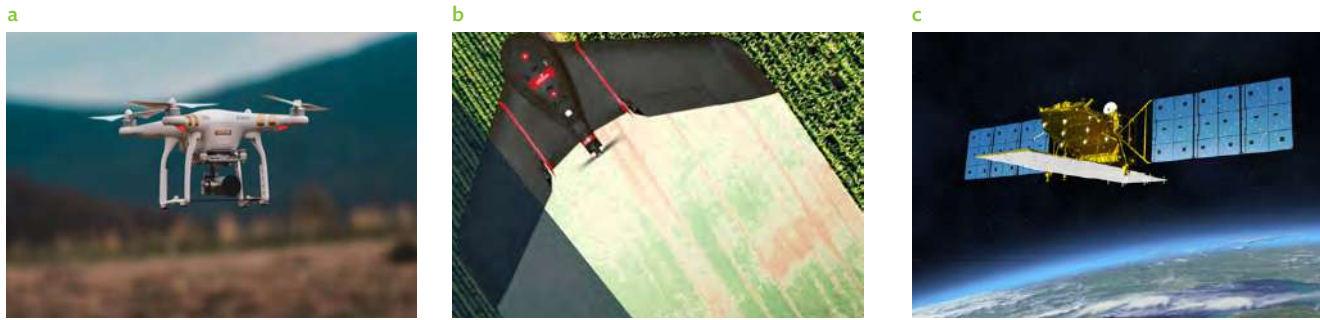


The pictures above depict the ways in which the aerial photographs were in early days including fixing camera(s) to a bird, hot air balloons, kites, and airplanes. Photo credits: <sup>a, c</sup> P. Baumann, <sup>b</sup> Asian Development Bank, and <sup>d</sup> Home Science Tools.

Although some of the earlier methods of taking aerial photographs are still used today—for example, using cameras installed on kites or balloons—other more-advanced means of capturing images have now been developed. Unmanned aerial vehicles (UAVs) or “drones” have become easily accessible and are often used to capture images and videos for military, commercial, scientific, agricultural, or recreational purposes. Undoubtedly, drones are helping to resolve some of society’s most-pressing problems, particularly those related to humanitarian aid, animal science and research, anti-poaching operations and curbing wildlife crime, fighting illegal logging, medical emergencies, sexual health and reproductive rights, curbing pollution, refugee

search and rescue missions, and connecting the developing world (Petronzio 2017). Drones can either be quad-rotor, which are flown between 5 m and 50 m; or fixed-wing UAVs or small airplanes that can fly at much higher altitudes, say, over 1,000 m. However, in this handbook and in the online course, the focus is on satellites orbiting hundreds of kilometers above the Earth, and how they are used to capture data useful in identifying and estimating cultivated crop areas, specifically rice paddy areas. Figure 2.2 shows examples of drones and UAVs used in agriculture, as well as a photo of the Advanced Land Observation Satellite (ALOS)-2 operated by the Japan Aerospace Exploration Agency (JAXA).

Figure 2.2: Examples of Drones and Satellites Used in Agriculture



The pictures above show drones and satellites whose data are used and reinterpreted using GIS techniques to generate agricultural statistics. Photo credits: <sup>a</sup> Brashier, <sup>b</sup> senseFly SA, and <sup>c</sup> Japan Aerospace Exploration Agency.

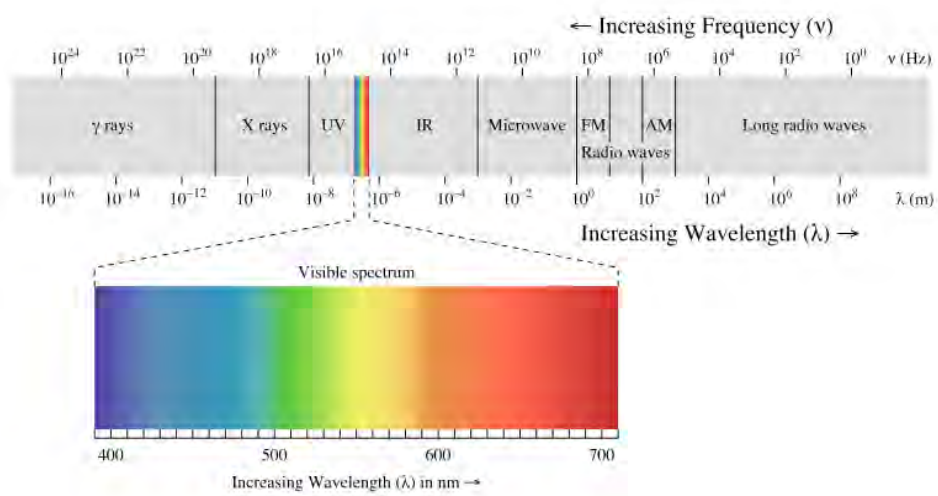
### 2.1.2 The Electromagnetic Spectrum

The second part of the definition of remote sensing focuses on employing electromagnetic radiation. This relates to the concept of the electromagnetic spectrum, which basically refers to light. Figure 2.3 provides an illustration of the electromagnetic spectrum.

Energy is characterized by wavelengths and frequencies. At the higher energy end of the spectrum are gamma rays, x-rays, and ultraviolet rays, which are

characterized by very short wavelengths but very high frequencies. At the other end of the spectrum, which has very low frequencies but very high wavelengths, are long radio waves as well as amplitude modulation (AM) and frequency modulation (FM) radio waves. Only a small part of the electromagnetic spectrum can be seen by the naked eye. That small part is known as “the visible spectrum” and is expanded into the colored block in Figure 2.3, showing color changes from blue to green, to yellow, and to red. The full cross-section also shows lines separating the sections along the electromagnetic spectrum.

Figure 2.3: Cross-Section of the Electromagnetic Spectrum



AM = amplitude modulation, FM = frequency modulation, Hz = hertz, IR = infrared, nm = nanometer, UV = ultraviolet.  
Source: P. Ronan. 2007. File:EM spectrum.svg. *Wikimedia Commons*. [https://commons.wikimedia.org/wiki/File:EM\\_spectrum.svg](https://commons.wikimedia.org/wiki/File:EM_spectrum.svg).

These lines are used to illustrate the fine gradation between each section, and as a convenient way of describing the different sections. They do not in any way represent an immediate change from one section to the next.

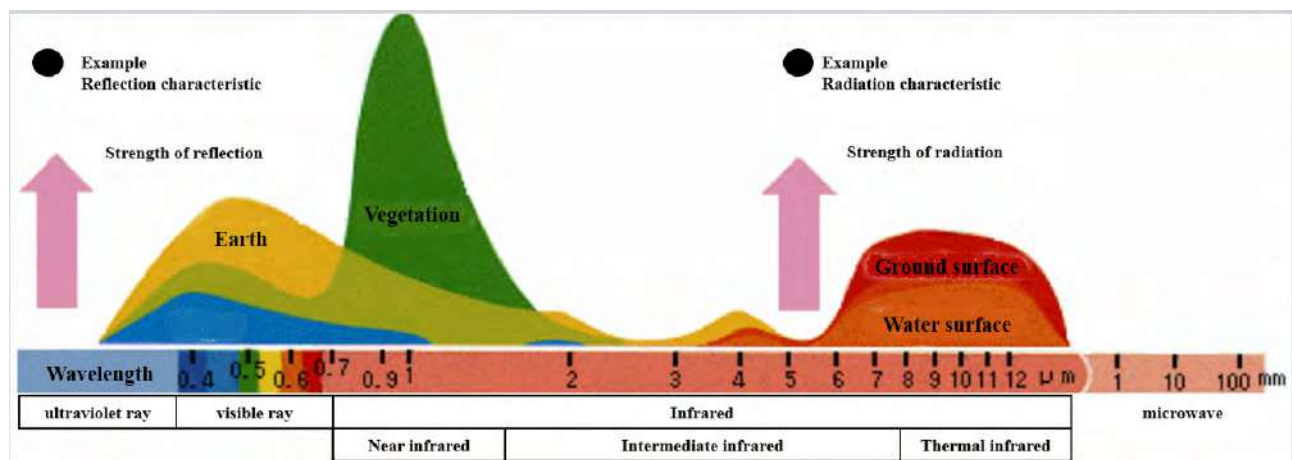
In remote sensing, the useful parts of the total electromagnetic spectrum are the visible spectrum; the infrared section, which contains both reflected and emitted infrared radiation; and microwave radiation, which is either emitted from the Earth naturally or is sent down from space by sensors. When substances or objects on the Earth's surface are exposed to electromagnetic waves, they reflect energy to varying degrees. Figure 2.4 shows the different strengths of reflection and radiation of electromagnetic waves from the Earth's surface, from plants or vegetation, and from water or watery surfaces. It shows that different substances or objects under observation reflect light differently, depending on their characteristics or the conditions that they are in. The magnitude and frequency of this reflected

energy or electromagnetic radiation is measured and recorded by sensors mounted on satellites.

### 2.1.3 Active and Passive Sensors

In the last part of the definition of remote sensing, a distinction is made between reflected or emitted electromagnetic radiation recorded by the sensors. To explain this concept, the focus will be on the visible, infrared, and microwave sections of the electromagnetic spectrum (the sections on the spectrum that are applicable in remote sensing). The different types of sensors commonly used in remote sensing will also be discussed. Figure 2.5 provides an illustration of the two types of sensors—active or passive—and how they operate. It also shows the three main types of remote sensing: (i) visible and reflected infrared remote sensing, (ii) thermal infrared remote sensing, and (iii) microwave remote sensing. Active and passive sensors are discussed in connection with the source of light or radiation and the characteristic of the object being observed.

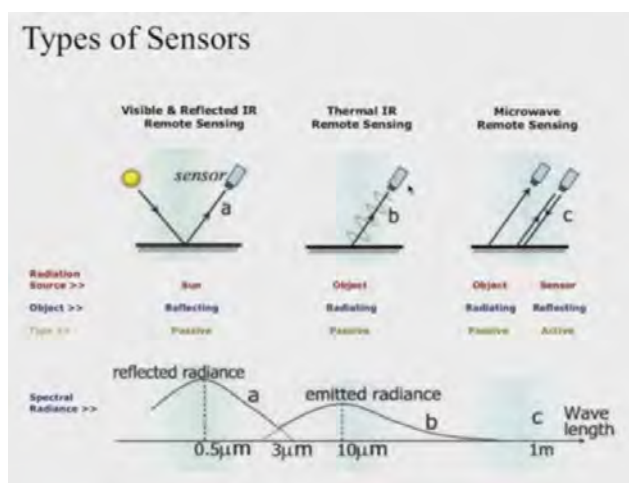
Figure 2.4: Reflection and Radiation of Electromagnetic Waves



mm = millimeter.

Source: Earth Observation Research Center, Japan Aerospace Exploration Agency, 2016.

Figure 2.5: Types of Sensors Used in Remote Sensing



IR = infrared, m = meter,  $\mu\text{m}$  = micrometer.

Source: Asian Development Bank. 2017. Innovative Data Collection Methods for Agricultural and Rural Statistics. Online Training Course. <http://cars.adbx.online/e-learning.html>.

*Visible and reflected infrared remote sensing* is the most general type of remote sensing, in the sense that the source of energy or radiation is the sun. Sunlight reaches the Earth and objects on the landscape reflect part of the light's energy. Sensors then capture part of the light energy reflected by the objects under observation. Sunlight is captured in the visible and the infrared sections of the electromagnetic spectrum, specifically the near-infrared and the shortwave infrared parts of the spectrum (noted as "a" in Figure 2.5). Because sunlight is abundant during the day, except when clouds block the view between the sensor and the objects being observed, visible and reflected infrared remote sensing is the best means of capturing satellite information on sunny days with clear skies. In this form of remote sensing, the sensors do not do anything except look at the scene and record information gathered from the objects observed. Thus, the sensors are passive.

In *thermal infrared remote sensing*, sensors are able to collect information both during the day and in the night, since the sources of energy are the objects themselves. All objects emit thermal radiation if their temperatures are greater than absolute zero. At the temperatures common at the Earth's surface, this radiation is in the infrared region

of the electromagnetic spectrum, specifically in the longwave infrared section (noted as "b" in Figure 2.5). Whether the objects obtain heat from the sun or from other energy sources, they will radiate and emit electromagnetic radiation that is invisible to the naked eye. This emitted energy will be captured by the sensor, which is still passive and is looking at wavelengths of about 10 micrometers ( $\mu\text{m}$ ).

In *microwave remote sensing*, either passive or active sensors can be used. In the first case, using a passive sensor, the source of radiation is the object being observed and the radiation is simply captured by the sensor, similar to thermal infrared remote sensing. Objects absorb heat during the day and release radiation all the time. So, with microwave remote sensing, there is also no restriction on when the sensor can gather information. The radiation source is microwave radiation, which is naturally occurring from the Earth's surface, although it is less abundant than thermal radiation. The sensors capture emitted energy in the longer wavelengths on the electromagnetic spectrum (noted as "c" in Figure 2.5). In the second case, using active sensors, the sensor itself is the source of radiation. The ALOS-2 satellite carries an active microwave sensor, Phased Array type L-band Synthetic Aperture Radar (PALSAR)-2, which projects a beam of microwave radiation towards the objects under observation. The objects then reflect part of that energy back to the sensor. The sensor captures the energy that is reflected back to it, which is called the *backscatter*. Energy reflected back by the objects depends on the object's characteristics, so the sensors are able to differentiate objects on the ground—for example, if certain areas contain vegetation, forests, bodies of water, or buildings—based on the backscatter information. To simplify, in the active type of sensing, the sensor sends out radiation and also collects it. One advantage of using active sensors in microwave remote sensing is that these sensors can see through cloud cover. For instance, if information is needed on a rice cultivated area during the wet season, active remote sensing may be the best option when it is often too cloudy to collect data via other remote sensing methods.



## 2.2 Spatial, Temporal, Spectral, and Radiometric Resolution

Four types of resolution are important in remote sensing: (i) *spatial resolution* which refers to the fineness of details visible in an image, (ii) *temporal resolution* which denotes the time it takes for a sensor to return to a precise area or location, (iii) *spectral resolution* which refers to the specific wavelength intervals that a sensor can record, and (iv) *radiometric resolution* which determines how accurately the sensor can distinguish between different levels of reflection.

### 2.2.1 Spatial Resolution

In computer graphics, resolution refers to the number of pixels a monitor can display, which determines the sharpness of any image that can be seen on the screen. Similarly, in remote sensing, spatial resolution is defined as the size of the smallest image element or pixel in a scene. Clearer and sharper image details can be seen in high-resolution satellite images, making it easier to identify objects than is the case with low-resolution images.

Figure 2.6 provides information on the different spatial resolutions of a few selected sensors. The Moderate Resolution Imaging Spectroradiometer (MODIS) has been flown on two spacecraft (Terra and Aqua) and is operated by the National Aeronautics and Space Administration (NASA). It is a multispectral sensor that operates in three different spatial resolutions: 1 kilometer (km), 500 m, and 250 m. The PALSAR-2, on board the ALOS-2 satellite and operated by JAXA, is an active microwave sensor that operates at ~100 m spatial resolution in the modes used in estimating rice paddy area and production. Two Landsat sensors, the Enhanced Thematic Mapper Plus (ETM+)/Operational Land Imager (OLI), operate at 30 m spatial resolution in the multispectral bands or 15 m in the panchromatic band. Landsat sensors are operated under the joint initiative between the United States Geological

Survey and NASA. Lastly, Sentinel-2, managed by the European Space Agency, operates at 10 m spatial resolution in the multispectral bands.

Figure 2.6: Spatial Resolutions of Selected Sensors

	Color	Black/White
MODIS	1km/500m/250m	---
PALSAR-2	---	100m
ETM+/OLI	30m	15m
Sentinel-2	10m	---

ETM+ = Enhanced Thematic Mapper Plus, km = kilometer, m = meter, MODIS = Moderate Resolution Imaging Spectroradiometer, OLI = Operational Land Imager, PALSAR = Phased Array type L-band Synthetic Aperture Radar.

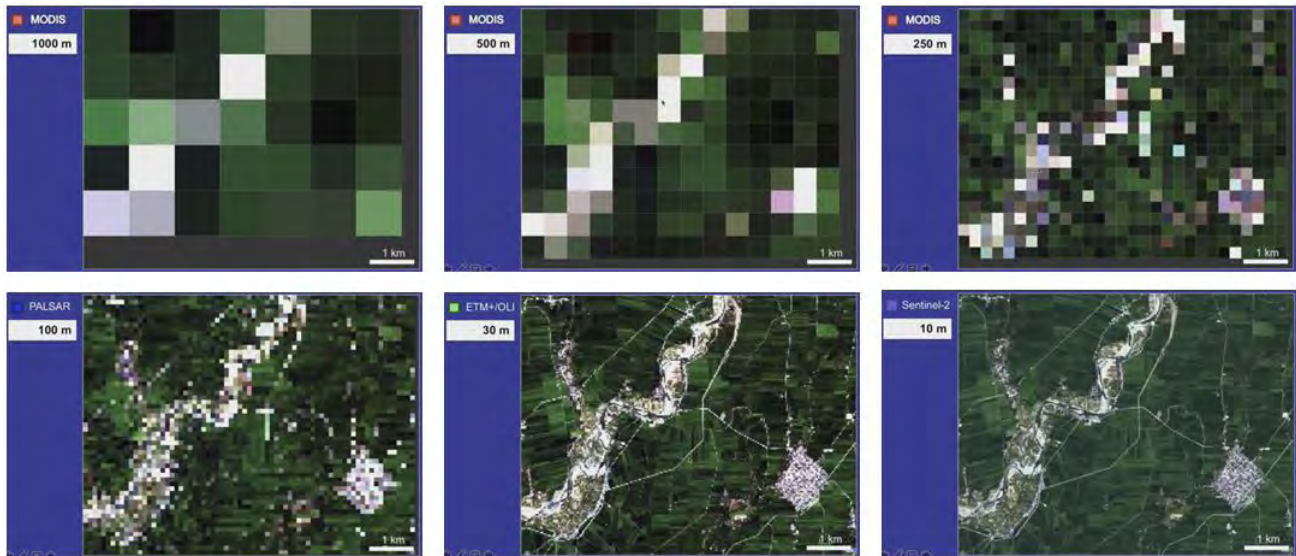
Source: Asian Development Bank. 2017. Innovative Data Collection Methods for Agricultural and Rural Statistics. Online Training Course. <http://cars.adbx.online/e-learning.html>.

A series of images provided in Figure 2.7 help illustrate the differences in spatial resolutions of the different sensors and depict how spatial resolution affects the sharpness of the image. At lower spatial resolutions (higher pixel sizes of 1000 m, 500 m, and 250 m), the images are blurry and the objects in the area covered by the image are difficult to identify. However, at higher spatial resolutions (particularly in the smaller pixel sizes of 30 m and 10 m), vegetation, roads, and other objects within the image are more clearly identifiable.

Although it is important to consider spatial resolution, it should be noted that there are instances where it can also be a problem having images made up of pixels of 1 m or less. Sharper images have larger file sizes. They can therefore be more difficult to download and require computers with larger memory capacity. Images at resolutions of, say, 10 m or 30 m can be more practical because paddy fields are often clearly visible at these resolution levels and the file sizes are manageable. At 100 m resolution, file sizes for PALSAR-2 images are generally not very large, but the images can still be useful in identifying



Figure 2.7: Spatial Resolution for Different Sensors



ETM+ = Enhanced Thematic Mapper Plus, km = kilometer, m = meter, MODIS = Moderate Resolution Imaging Spectroradiometer, OLI = Operational Land Imager, PALSAR = Phased Array type L-band Synthetic Aperture Radar.

Note: The original image used in the example was a Sentinel-2 image with a pixel size of 10 m. It was scaled up to the equivalent resolution of the other sensors for illustration purposes.

Source: Asian Development Bank. 2017. Innovative Data Collection Methods for Agricultural and Rural Statistics. Online Training Course. <http://cars.adb.xonline/e-learning.html>.

agriculture and nonagriculture areas. Even at 250 m, 500 m, or 1000 m resolutions, the lower spatial resolution images of MODIS can be appropriate if the objective is to observe a larger area, say, at the national level instead of at the provincial level or where more specific topography is required. Note that the management of satellite images is becoming easier with the advent of cloud computing and online resources such as Google Earth Engine<sup>3</sup>.

### 2.2.2 Temporal Resolution

Satellites follow an orbit, which can be either sun-synchronous (where the satellite passes over the same part of the Earth over a certain period of time) or geostationary (where a satellite's position is fixed with respect to a position on the Earth, i.e., it is travelling at exactly the same speed as the Earth).

By definition, temporal resolution is relevant only to satellites that follow a sun-synchronous orbit.

Temporal resolution refers to how often a given sensor is able to capture an image of a specific area or location. Different sensors have different return times, i.e., the period it takes for a satellite to return to the same position over the Earth or to collect an image over the same area. Figure 2.8 presents the return times of some selected sensors. MODIS passes over the same part of the Earth about the same time in approximately 1-2 days. The return time for Sentinel-2 is about 5 days; for PALSAR-2, 14 days; and for the two Landsat sensors, 16 days. MODIS, Sentinel-2, and ETM+/OLI all have consistent return times, while the return time for PALSAR-2 is variable, meaning that users may request the satellite operator, JAXA, to task the sensor for a specific area of interest.

<sup>3</sup> Additional information on Google Earth Engine can be found in <https://earthengine.google.com/>.

Figure 2.8: Return Time of Selected Sensors

	Return time	Type
<b>MODIS</b>	1–2 days	Consistent
<b>Sentinel-2</b>	5 days	Consistent
<b>PALSAR-2</b>	14 days	Variable
<b>ETM+/OLI</b>	16 days	Consistent

ETM+ = Enhanced Thematic Mapper Plus, MODIS = Moderate Resolution Imaging Spectroradiometer, OLI = Operational Land Imager, PALSAR = Phased Array type L-band Synthetic Aperture Radar.

Source: Asian Development Bank. 2017. Innovative Data Collection Methods for Agricultural and Rural Statistics. Online Training Course. <http://cars.adbx.online/e-learning.html>.

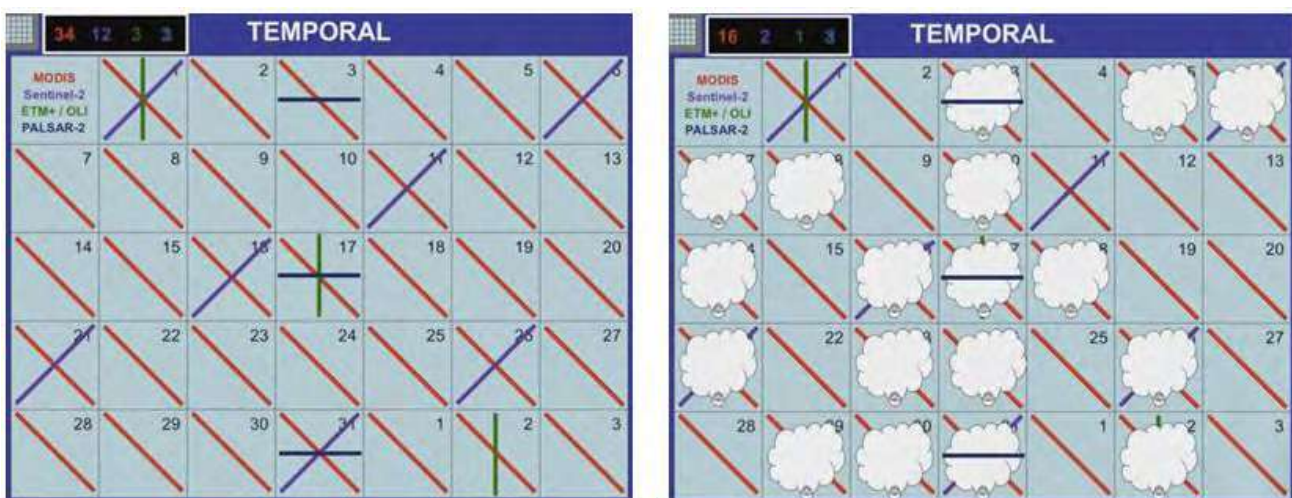
As an illustration, the return times of the four sensors are marked on a calendar, as shown in Figure 2.9. Considering a 34-day period, it is expected that MODIS will be able to capture approximately 34 images. Sentinel-2 can capture 7 images, while ETM+/OLI and PALSAR-2 can capture about 3 images each. In reality, however, the presence of clouds can limit the sensors from making clear observations on the ground, except in cases where a radar sensor is used. For example, if the target

period for collecting satellite information is during a cloudy time of year—such as the rainy season when rice paddies are being transplanted or are in the early growing stages—it is very likely that clouds will affect the ability to capture data on most days. There are situations where it is possible that no images will be available due to clouds for a given month. In these situations, active radar sensors, which can take measurements and observations through the clouds, are most effective in collecting information.

### 2.2.3 Spectral Resolution

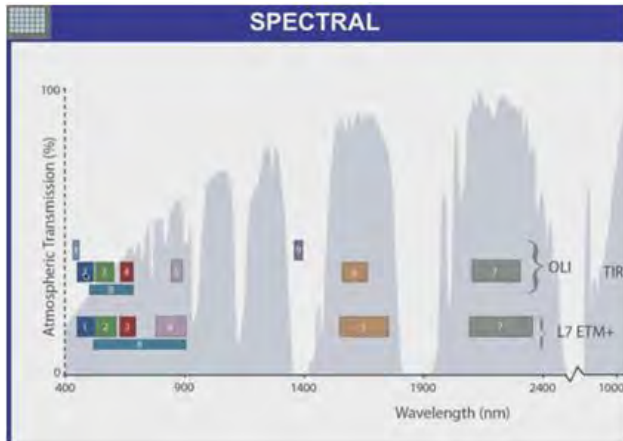
The third type of resolution used in remote sensing is spectral resolution. It refers to the locations and widths of “bands” or cameras installed on sensors. On board the satellites orbiting the Earth are different sensors, and inside those sensors are different cameras. Each camera is sensitive to a different portion of the electromagnetic spectrum. As mentioned previously, electromagnetic radiation is measured at varying wavelengths. In remote sensing, sensors are able to take measurements in the visible spectrum, the infrared section, and the microwave section of the total spectrum.

Figure 2.9: Summary of Return Time of the Four Sensors



ETM+ = Enhanced Thematic Mapper Plus, MODIS = Moderate Resolution Imaging Spectroradiometer, OLI = Operational Land Imager, PALSAR = Phased Array type L-band Synthetic Aperture Radar.

Source: Asian Development Bank. 2017. Innovative Data Collection Methods for Agricultural and Rural Statistics. Online Training Course. <http://cars.adbx.online/e-learning.html>.

**Figure 2.10: Different Bands for Landsat**

ETM+ = Enhanced Thematic Mapper Plus, nm = nanometer, OLI = Operational Land Imager, TIRS = Thermal Infrared Sensor.

Source: Asian Development Bank. 2017. Innovative Data Collection Methods for Agricultural and Rural Statistics. Online Training Course. <http://cars.adbx.online/e-learning.html>.

Landsat OLI has a number of bands and these are illustrated in Figure 2.10. The wavelength at which each band in the Landsat OLI and Thermal Infrared Sensor operates, along with their specific uses, are given in Table 2.1. Band 1 is the coastal aerosol band, which is useful for imaging shallow water and tracking fine particles such as dust and smoke. Bands 2, 3, and 4 (the familiar blue, green, and red bands) and Band 5 (a red-edge, near-infrared band) are all important for observing vegetation. Bands 6 and 7 are shortwave infrared bands useful in measuring the moisture content of soil and vegetation. Band 8 is a panchromatic band which is a grayscale image that covers the red, green, and

blue portions of the electromagnetic spectrum, while Band 9 is the cirrus band which detects of high-altitude cloud contamination that may not be visible in other spectral bands. Landsat OLI also has Bands 10 and 11, which are sensitive to thermal infrared radiation.

A graph depicting the spectral images for different types of land cover (soil, dry vegetation, and green vegetation) is provided in Figure 2.11. It shows that, for a specific type of land cover, there is a corresponding curve (based on a combination of reflectance values at certain wavelengths), which characterizes and defines that specific type of land cover.

Figure 2.12 illustrates how Landsat OLI captures the different types of land cover, based on the values that the sensor gives at different bands. The small blocks within Figure 2.12 refer to the bands—Bands 1 to 5 (left), Band 9 (middle), and Bands 6 and 7 (right). The figure shows the different points along different wavelengths with different reflectance values, which follow the pattern or the spectral image of a specific type of land cover. The image on the left, for example, shows the values at different bands following the pattern of a spectral image for soil.

The middle image shows that, compared with the reflectance values for soil, the sensor gives higher values in the red-edge near-infrared (Band 5), the cirrus (Band 9), and the shortwave infrared 1 (Band

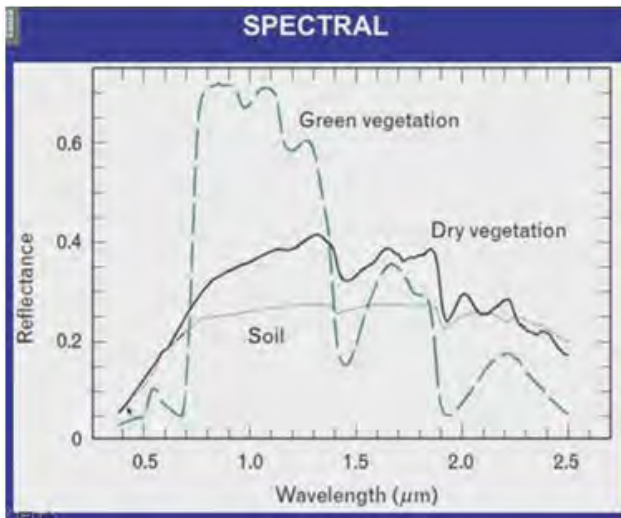
**Table 2.1: Landsat 8 Operational Land Imager and Thermal Infrared Sensor**

Bands	Wavelength (micrometers)	Useful for mapping
Band 1 – Coastal aerosol	0.43–0.45	Coastal and aerosol studies
Band 2 – Blue	0.45–0.51	Bathymetric mapping, distinguishing soil from vegetation and deciduous from coniferous vegetation
Band 3 – Green	0.53–0.59	Emphasizes peak vegetation, which is useful for assessing plant vigor
Band 4 – Red	0.64–0.67	Discriminates vegetation slopes
Band 5 – Near Infrared	0.85–0.88	Emphasizes biomass content and shorelines
Band 6 – Shortwave Infrared 1	1.57–1.65	Discriminates moisture content of soil and vegetation; penetrates thin clouds
Band 7 – Shortwave Infrared 2	2.11–2.29	Improved moisture content of soil and vegetation and thin cloud penetration
Band 8 – Panchromatic	0.50–0.68	15 meter resolution, sharper image definition
Band 9 – Cirrus	1.36–1.38	Improved detection of cirrus clouds
Band 10 – Thermal Infrared Sensor 1	10.60–11.19	100 meter resolution; thermal mapping and estimated soil moisture
Band 11 – Thermal Infrared Sensor 2	11.50–12.51	100 meter resolution; improved thermal mapping and estimated soil moisture

Source: United States Geological Survey, n.d.



Figure 2.11: Spectral Values for Different Types of Vegetation



$\mu\text{m}$  = micrometer.

Source: Asian Development Bank. 2017. Innovative Data Collection Methods for Agricultural and Rural Statistics. Online Training Course. <http://cars.adbx.online/e-learning.html>.

6), which leads to the conclusion that the spectral image depicts dry vegetation. The image on the right shows reflectance values depicting green vegetation. Healthy, growing plants absorb blue and red light, which explains the very low reflectance values for Bands 2 and 3. Plants also reflect some green light, hence the slightly higher value for Band 3. In the near-infrared section (Band 5), green vegetation has very high reflectance values. Plants cannot use near-infrared light for photosynthesis, but this light does induce thermal stress. Healthy vegetation is therefore usually able to strongly reflect near-infrared light.

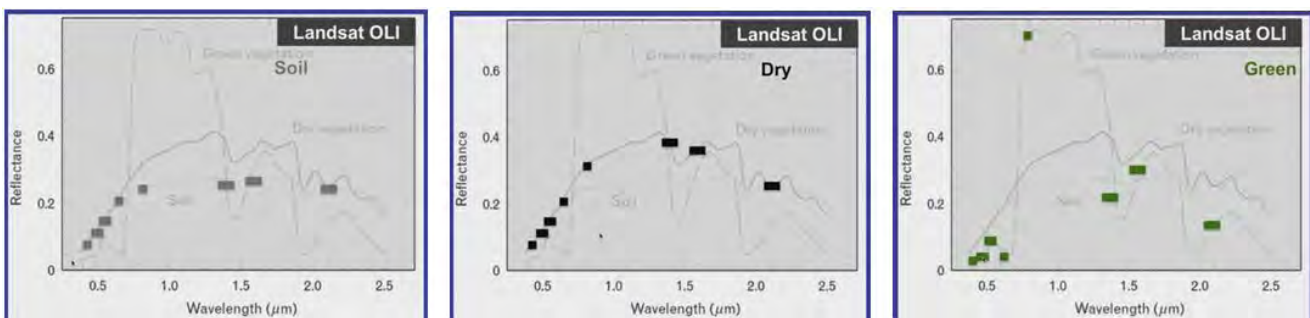
There are also changes in the shortwave infrared bands (Bands 6 and 7).

Changes in the reflectance values at different bands are signals that researchers take note of to distinguish between different types of land cover in remote sensing. However, SAR applications, such as PALSAR-2, do not operate in multiple bands; rather, they use different polarizations, which can be used in a similar fashion.

### 2.2.4 Radiometric Resolution

Radiometric resolution refers to the ability of a sensor to distinguish differences in the magnitude of electromagnetic energy from objects of similar reflectance, i.e., the sensitivity of the sensor. Light energy is captured in a digital image file measured in binary digits or “bits”, and the greater the number of bits in the file, the more levels of light can be captured. For example, a 2-bit file has 4 different levels ( $2^2$ ); a 3-bit file has 8 different levels ( $2^3$ ); and so on, such that an 8-bit file has 256 different levels ( $2^8$ ). The concept of radiometric resolution can be best explained by comparing a sensor to a ruler that is used to measure light, as shown in Figure 2.13. Imagine that the vertical lines in the figure are rulers and that the markings along each ruler represent the number of levels of electromagnetic energy that can be captured.

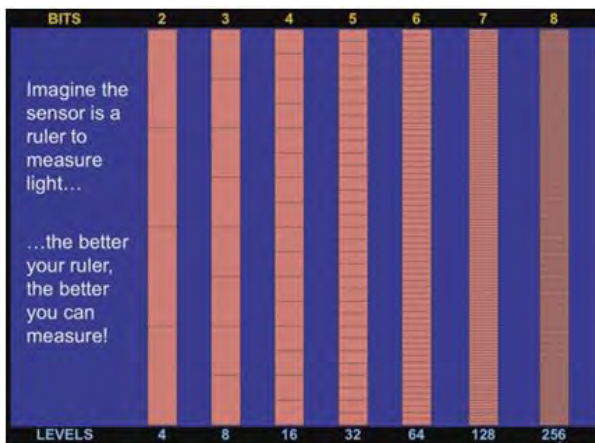
Figure 2.12: Bandwidth of Landsat Operational Land Imager



OLI = Operational Land Imager,  $\mu\text{m}$  = micrometer.

Source: Asian Development Bank. 2017. Innovative Data Collection Methods for Agricultural and Rural Statistics. Online Training Course. <http://cars.adbx.online/e-learning.html>.

Figure 2.13: Radiometric Resolution Levels by Digital File Size



Source: Asian Development Bank. 2017. Innovative Data Collection Methods for Agricultural and Rural Statistics. Online Training Course. <http://cars.adbx.online/e-learning.html>.

Figure 2.13 explains how the 8-bit file on the right can give a more precise measurement of the relative sizes of observed objects, compared with the 2-bit file on the left. In short, the better the radiometric resolution of the sensor, the more accurate the image it can obtain.

Figure 2.14 provides information on some sensors and the radiometric resolutions at which they operate. The Landsat Thematic Mapper (LTM), which is now out of commission, had an 8-bit radiometric resolution that allowed 256 different levels and had 25 different shadow levels (arbitrarily taken as values in the lowest 10% of values that could be measured). Newer sensors have higher radiometric resolutions. For example, WorldView-3, which is flown by DigitalGlobe, has a spatial resolution of 11 bits, with 2,048 different levels. Landsat ETM+/OLI, MODIS, and Sentinel-2 all have 12-bit radiometric sensors that are able to produce more than 4,000 different levels. For PALSAR-2, the values given are only approximations because the concept of radiometric resolution does not directly apply to radar imagery.

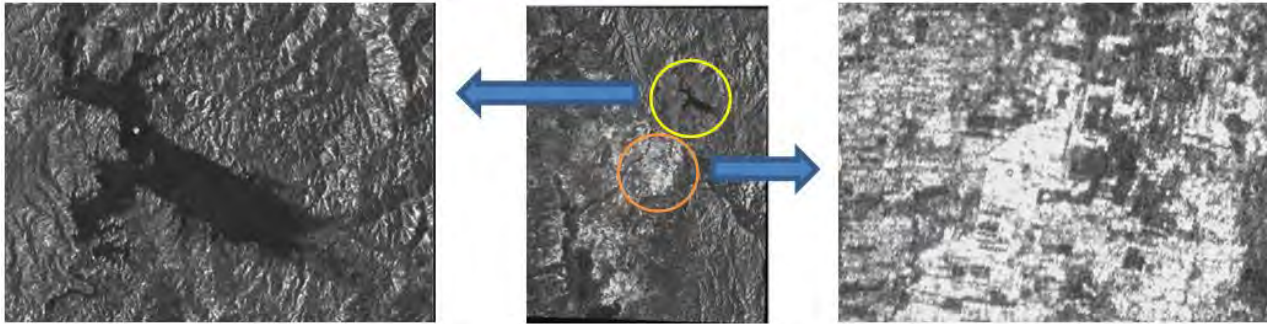
Figure 2.14: Radiometric Resolution by Sensor

	RADIOMETRIC		
	Bits	Total Levels	“Shadow” Levels
TM	8	256	25
WorldView-3	11	2,048	204
ETM+/OLI	12	4,096	409
MODIS	12	4,096	409
Sentinel-2	12	4,096	409
PALSAR-2	~16?	~65,536?	~6,553?

ETM+ = Enhanced Thematic Mapper Plus, LTM = Landsat Thematic Mapper, MODIS = Moderate Resolution Imaging Spectroradiometer, OLI = Operational Land Imager, PALSAR = Phased Array type L-band Synthetic Aperture Radar. Source: Asian Development Bank. 2017. Innovative Data Collection Methods for Agricultural and Rural Statistics. Online Training Course. <http://cars.adbx.online/e-learning.html>.

To illustrate how the approximated values for PALSAR-2 were derived, a sample PALSAR-2 image was analyzed using a GIS tool (Figure 2.15). The image on the left shows a dark area, which is a reservoir. In radar images, water is usually shown as dark sections on the map. The dark area on the sample image gives values of about less than 1,000 to 2,000. On the other hand, objects that have high backscatter values are shown as bright images. In the image on the right, the bright sections are paddy areas with healthy, growing rice. Such sections give values of more than 19,000. Overall, the sample images used in Figure 2.15 give values ranging from less than 1,000 to about 40,000. If these values are converted to levels in the radiometric table presented in Figure 2.14, PALSAR-2 values will be approximately equivalent to a 16-bit sensor, with 65,536 different levels (but it should be noted that it is not a direct comparison between PALSAR-2 and the other sensors). PALSAR-2 gives a wide range of values in identifying the different objects in the image. This means that the sensor has a high sensitivity and is able to distinguish between the different objects on the map.

Figure 2.15: Sample PALSAR-2 Image



PALSAR = Phased Array type L-band Synthetic Aperture Radar.

Source: Asian Development Bank. 2017. Innovative Data Collection Methods for Agricultural and Rural Statistics. Online Training Course. <http://cars.adbx.online/e-learning.html>.

## 2.3 Synthetic Aperture Radar, Sensors, and Satellites

Optical sensors such as Landsat OLI or Sentinel-2 are widely used in remote sensing and in land cover analysis. However, the biggest limitation in these types of sensors is their inability to take clear images when there are clouds present in target areas (as discussed in the section on temporal resolution, clouds obstruct the view for optical sensors). The objectives in conducting a remote sensing analysis will greatly determine the type of satellite images to use. If the objective is to estimate rice paddy areas during the wet cropping season, radar images should be considered because there is a high probability that, throughout the cropping period, clouds will be present over the target areas.

### 2.3.1 Synthetic Aperture Radar

SAR operates using active sensors in the microwave region of the electromagnetic spectrum, so it is very useful when trying to capture images through clouds. The sensor itself transmits microwave energy to the ground and receives the reflection or signal, known as backscatter, from target objects on the ground. Table 2.2 outlines some of the pros and cons for using SAR. The most important advantage of SAR is that it works under any set of weather conditions. In addition, active sensors such as PALSAR-2 do not require the object's surface to be illuminated by sunlight, so these sensors can also operate during the night.

Table 2.2: Pros and Cons of Using Synthetic Aperture Radar in Remote Sensing

Pros	Cons
<ul style="list-style-type: none"> <li>• Can observe under all weather conditions</li> <li>• Can work day or night</li> <li>• Can make polarimetric observation (HH, VV, HV, VH)</li> <li>• Has the coherency information</li> </ul>	<ul style="list-style-type: none"> <li>• Difficult image interpretation (characteristic of a microwave image)</li> <li>• Geometric distortion due to observation system (foreshortening, layover, radar shadow)</li> </ul>

HH = horizontal transmit and horizontal receive, HV = horizontal transmit and vertical receive, VH = vertical transmit and horizontal receive, VV = for vertical transmit and vertical receive.

Source: Asian Development Bank. 2017. Innovative Data Collection Methods for Agricultural and Rural Statistics. Online Training Course. <http://cars.adbx.online/e-learning.html>.



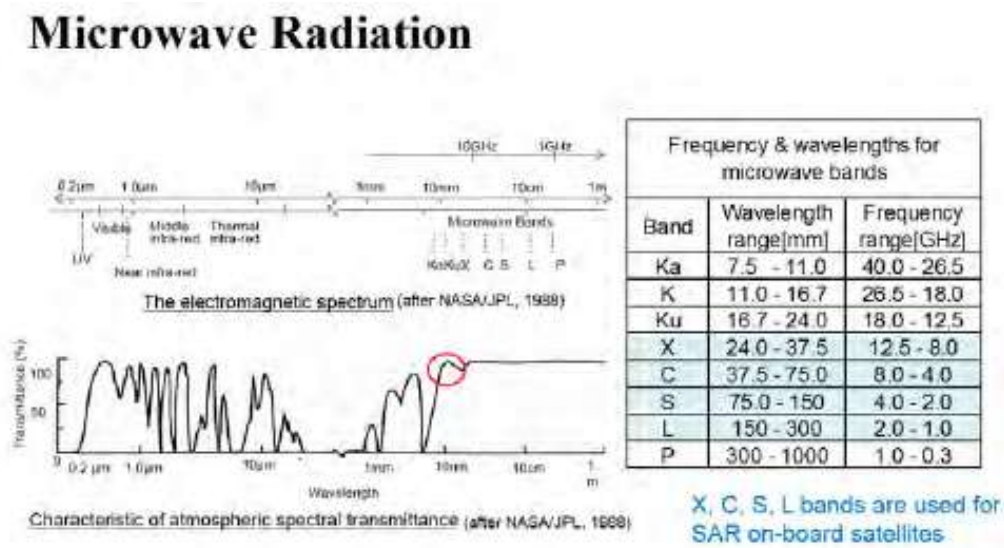
Active radar sensors are designed to transmit and receive electromagnetic waves of a specific polarization. Similar to spectral resolution in optical sensors, radar sensors make polarimetric observations, including horizontal-horizontal (HH), vertical-vertical (VV), horizontal-vertical (HV), and vertical-horizontal (VH). In HH polarization, the beam is sent down in horizontal polarization and the sensor receives backscatter also in the horizontal plane. The same principle applies in the other three polarization combinations. The way polarization works is that, for example, if the observation targets are healthy, standing rice crops, these will have very high backscatter values in the VV polarization. However, if rice paddies were damaged and lying flat on the ground due to strong winds or a typhoon, these will have very strong backscatter in the HV or VH polarizations. HH and VV polarizations are referred to as “like-polarized”, because the polarizations transmitted and received are the same; while HV and VH are referred to as “cross-polarized”, because the transmitted and received polarizations are orthogonal to one another. In addition, radar systems can also

have different levels of polarization complexity—single polarization (HH, VV, HV, or VH), dual polarization (HH+HV, VV+VH, or HH+VV), or quad polarization (HH+VV+HV+VH) (NRC 2014). Lastly, SAR has coherency information, which is important when observing land deformations around volcanoes due to landslides, earthquakes, or tectonic shifts.

One disadvantage in using SAR is that the images are grayscale. Because SAR operates in the microwave region of the electromagnetic spectrum, images are not easily converted to the colors that humans are familiar with in optical images, which are in the visible or infrared spectrum. Another disadvantage is the presence of geometric distortions in SAR images, due to foreshortening, layovers, or radar shadows. It is, however, possible to remove these distortions through image processing.

The region of **microwave radiation** on the electromagnetic spectrum can be divided into different bands, which have a range of wavelengths and frequencies, as shown in Figure 2.16.

Figure 2.16: Bands of Microwave Radiation



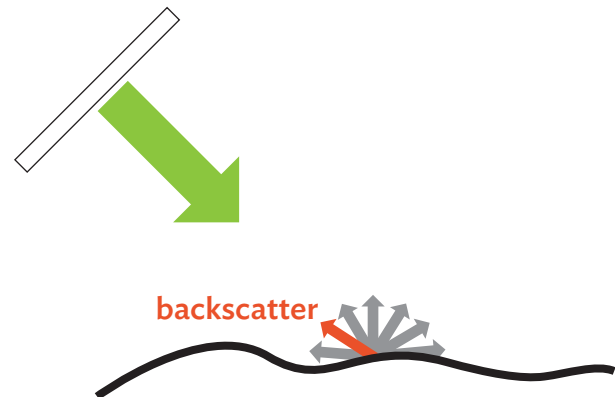
GHz = gigahertz, JPL = Jet Propulsion Laboratory, mm = millimeter, NASA = National Aeronautics and Space Administration, SAR = synthetic aperture radar, UV = ultraviolet.

Source: Asian Development Bank. 2017. Innovative Data Collection Methods for Agricultural and Rural Statistics. Online Training Course. <http://cars.adbx.online/e-learning.html>.

The X, C, S, and L bands are used in SAR. For example, the PALSAR-2 sensor on board the ALOS-2 satellite is an L-band sensor, operating at wavelengths between 150-300  $\mu\text{m}$  and frequencies between 2.0 and 1.0 gigahertz (GHz). Referring to the graph in Figure 2.16, the microwave bands start from the point indicated by the red circle. The transmittance rate—the percentage of the light or energy sent down by the sensors, or reflected back by the objects, that is transmitted through the atmosphere—is virtually 100% in the microwave region, indicating the atmosphere's transparency to these wavelengths. This means there is no interference between the sensor and the objects under observation.

**Backscatter** is the portion of the outgoing radar signal that the target redirects back towards the radar antenna (RESTEC 2015). It refers to the energy that returns to the radar and is received and recorded by the sensor (Figure 2.17). The strength of backscatter is expressed in terms of the backscatter cross-section (noted as  $\sigma$ ) and the backscatter coefficient (written as  $\sigma^0$  and pronounced “sigma naught”).

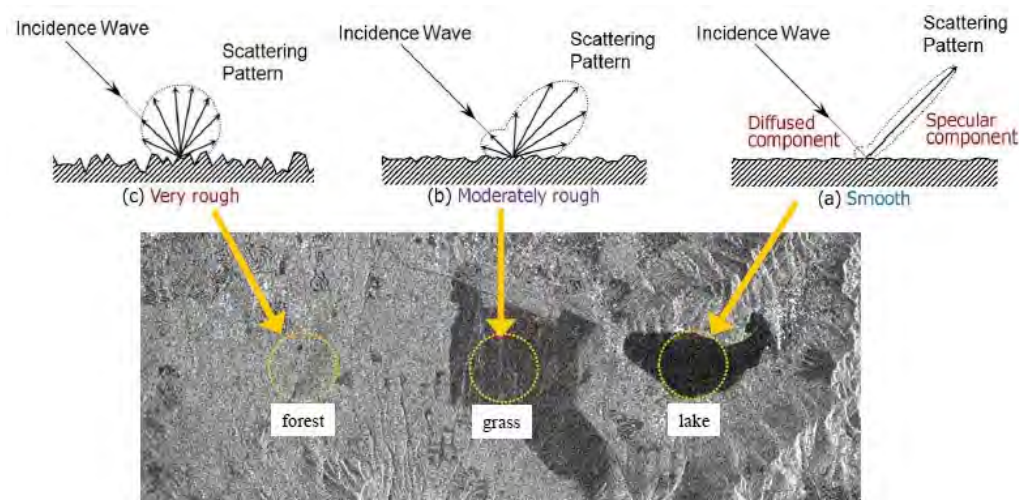
Figure 2.17: Illustration of Backscatter



Source: Asian Development Bank. 2017. Innovative Data Collection Methods for Agricultural and Rural Statistics. Online Training Course. <http://cars.adbx.online/e-learning.html>.

The backscatter towards the sensor varies depending on the roughness or smoothness of the surface targeted by the microwave radiation sent down by the sensor. As shown in Figure 2.18, rough surfaces reflect microwave radiation in all directions,

Figure 2.18: Surface Scatter Mechanism



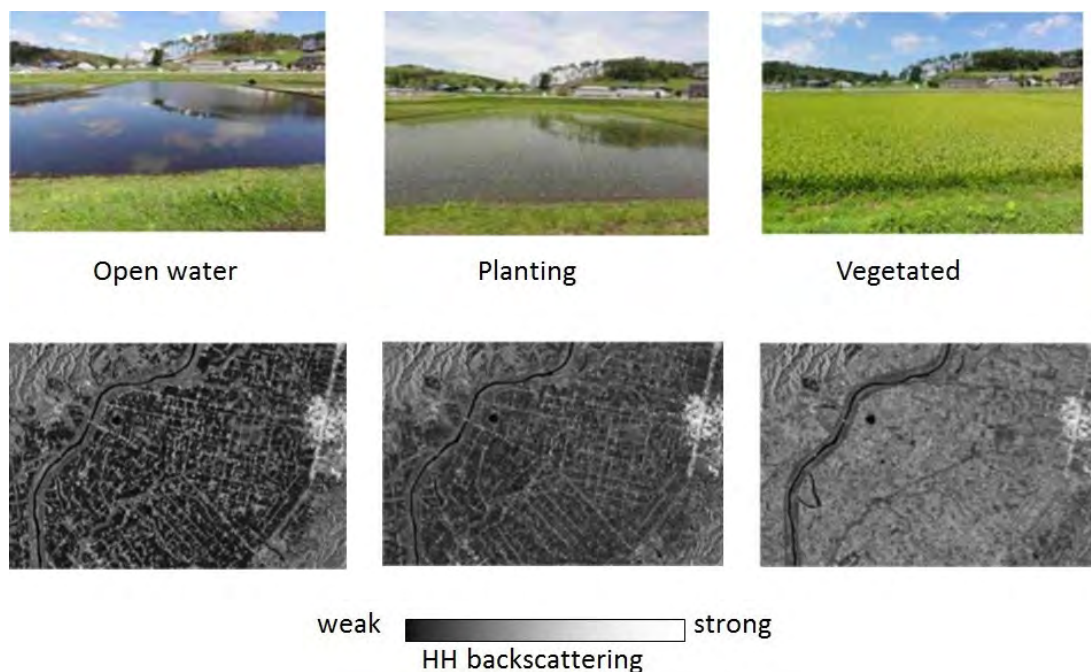
Source: Asian Development Bank. 2017. Innovative Data Collection Methods for Agricultural and Rural Statistics. Online Training Course. <http://cars.adbx.online/e-learning.html>.

with a scattering pattern that is almost spherical. This means that the rough surface reflects a large amount of microwave radiation back to the sensors, making the image appear bright. For moderately rough surfaces, the backscatter may not be as strong because, although some microwave radiation is sent back to the sensors, most of the stronger signals may be going in other directions. Lastly, on smooth surfaces, there is very little chance for the incident wave to be directed back towards the sensor. Most of the signal bounces off in almost the opposite angle, so the sensor receives hardly any signal, which results in the image appearing dark. In Figure 2.18, forest areas appear bright, grasslands appear somewhat darker, and the lake appears dark.

Figure 2.19 presents another illustration of the strength of backscatter, but in terms of its application in observing paddy fields. Rice cultivation involves

flooding the rice field in preparation for planting or transplanting rice. At this time, when sensors pass the target areas, they will get very weak signals coming from the smooth surface of the flooded rice fields (weak backscattering shown as darker images on the map in Figure 2.19). At the planting stage or immediately after planting, the signals are somewhat stronger, because some backscattering from the newly planted or transplanted rice is received by the sensor. However, if some water remains on the field, the image still appears slightly dark. Finally, when rice paddies are in the healthy and vegetative stages, backscattering is very strong due to the signal coming from the rough surface of the growing rice crop. The image appears much lighter than when the rice fields were flooded. In conclusion, the change in backscatter from the dark to bright image indicates that rice is grown in that specific area.

**Figure 2.19: Backscatter Change in a Paddy Field**



HH = horizontal transmit and horizontal receive.

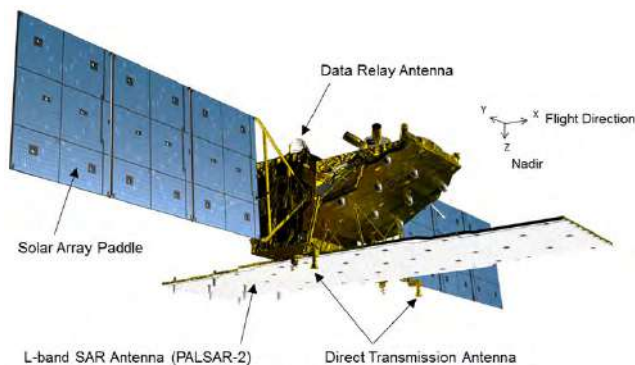
Source: Asian Development Bank. 2017. Innovative Data Collection Methods for Agricultural and Rural Statistics. Online Training Course. <http://cars.adbx.online/e-learning.html>.

### 2.3.2 Sensors and Satellites

Developed under assistance from the Asian Development Bank (ADB), one of the most recent software programs used to estimate paddy area and production using satellite data is INAHOR-AD, which was modified from the INAHOR software developed by JAXA. INAHOR stands for ‘International Asian Harvest Monitoring System for Rice’, and AD means that it is the advanced version of the original INAHOR software. Since INAHOR-AD makes use of data from a PALSAR-2 sensor, this section provides a basic description of the PALSAR-2 sensor on board the ALOS-2 satellite, which JAXA operates.

Figure 2.20 shows a photo of the ALOS-2 satellite, comprising its main body, the data relay antenna, the solar array paddles, direct transmission antennae, and the L-band SAR antenna, which is called PALSAR-2. The solar array paddles are solar panels that provide power to the satellite, so that it can send microwave signals towards the Earth (using the direct transmission antennae) and collect energy reflected by the objects under observation (using the PALSAR-2 antenna).

Figure 2.20: Componentry of the ALOS-2 Satellite



ALOS = Advanced Land Observation Satellite, PALSAR = Phased Array type L-band Synthetic Aperture Radar, SAR = synthetic aperture radar.  
Source: Earth Observation Research Center, Japan Aerospace Exploration Agency, n.d.

JAXA launched the ALOS-2 satellite in May 2014. It operates at an altitude of 628 km above the Earth’s surface—a low Earth orbit. It follows a sun-synchronous orbit with an orbital period of 97.33 minutes. Sun-synchronous satellites pass over the same part of the Earth at approximately the same local time each day. ALOS-2 travels from the north to the south poles as the Earth is turning below it. Its revisit time is every 14 days, which means that the satellite will pass over a precise location on Earth every 14 days. The PALSAR-2 sensor on board the ALOS-2 satellite operates at a frequency of 1.2 GHz and is an L-band active radar sensor operating in the microwave part of the spectrum at 23.5 centimeters.

PALSAR-2 can collect information at different polarizations, as detailed in Table 2.3. The ALOS-2 satellite operates at an incidence angle from 8 degrees to 70 degrees. This wide angle gives the satellite a right- or left-side looking observation capability, unlike the first ALOS satellite, which was only right-side looking and operated at an incidence angle from 8 degrees to 60 degrees. The swath width for ALOS-2 is from 25 km to 490 km. With regard to spatial resolution, ALOS-2 operates

Table 2.3: Characteristics of ALOS-2 satellite (PALSAR-2 sensor)

Satellite Name (Sensor Name):	ALOS-2 (PALSAR-2)
Country:	Japan
Launch Date:	May 2014
Altitude:	628 kilometers
Orbit Period:	97.33 minutes
Revisit Time	14 days
Frequency:	1.2 gigahertz (L-band)
Wavelength:	23.5 centimeters
Polarization:	Single (HH, HV, VH, VV) Dual (HH+HV, VV+VH) Quad (HH+HV+VH+VV)
Incidence Angle:	8–70 degrees
Swath Width:	25–490 kilometers
Spatial Resolution:	1 meter (Spotlight mode) 100 meters (ScanSar mode)
Antenna size:	2.9 meters x 9.9 meters

ALOS = Advanced Land Observation Satellite, HH = horizontal transmit and horizontal receive, HV = horizontal transmit and vertical receive, PALSAR = Phased Array type L-band Synthetic Aperture Radar, VH = vertical transmit and horizontal receive, VV = for vertical transmit and vertical receive.

Source: Remote Sensing Technology Center of Japan. 2014. PowerPoint presentation developed for a training workshop in remote sensing. Tokyo.



in two modes with different spatial resolutions—in Spotlight mode and in Scanning Synthetic Aperture Radar (ScanSar) mode. In Spotlight mode, it operates at a spatial resolution of 1 m, which produces high radar resolution images that are mainly used for disaster assessment (where there is a need to have a good view of the disaster situation in small areas). In ScanSar mode, the satellite operates at 100 m spatial resolution and has a much wider swath width.

The orbit of the ALOS-2 satellite in real time can be accessed at [www.n2yo.com](http://www.n2yo.com). On the landing

page, the website initially shows the International Space Station's location. Upon entering "ALOS" in the search box, we can track the current position of ALOS-2 satellite in space. An example of real time information of the current location of ALOS-2 satellite is given in Figure 2.21. The curves or the arcs shown on the image found in the website are moving because, as the satellite moves around the Earth, the Earth is rotating. Due to the map's projection and the Earth's rotation, the path or orbit of the satellite is shown as curves on the map, although the satellite is actually going in a circle around the Earth.

Figure 2.21: Sample Information on Advanced Land Observation Satellite-2 Real Time Location

**ALOS 2**

NORAD ID:	39766
LOCAL TIME:	11:46:41
UTC:	03:46:41
LATITUDE:	-79.27
LONGITUDE:	-9.89
ALTITUDE [km]:	660.16
ALTITUDE [mi]:	410.2
SPEED [km/s]:	7.53
SPEED [mi/s]:	4.68
AZIMUTH:	188.8 S
ELEVATION:	-53.9
RIGHT ASCENSION:	11h 44m 01s
DECLINATION:	-50° 58' 57"
Local Sidereal Time:	23h 12m 48s
<b>The satellite is in day light</b>	
SATELLITE PERIOD:	98m

Source: N2YO.com, 2016.

## Chapter 3: Installing and Using the INAHOR-AD Software

This chapter presents the system requirements and software applications needed to effectively analyze satellite data; the process of downloading satellite images, specifically the Advanced Land Observing Satellite-2/Phased Array type L-band Synthetic Aperture Radar-2 (ALOS-2/PALSAR-2) images; and the step-by-step procedure for using the advanced version of INternational Asian Harvest mOnitoring system for Rice (INAHOR-AD). INAHOR-AD software to identify and estimate paddy area using ALOS-2 satellite images. These latter sections include detailed steps for the preparation of folders and files to be used in the analysis; preparation of satellite data; pre-processing of extracted GeoTIFF images; and processing of data using the Rice Crop Mapper module and the Rice Production Calculator module. Information presented in this chapter is also contained in an online training course, which can be accessed through <http://cars.adbx.online>. All screenshots were taken from the online training course videos.

### 3.1 System Requirements

Processing satellite data requires large computer processing power due to the large file sizes required for the volumes of satellite data used. In addition, the INAHOR-AD software used in processing radar satellite data has specific high-end system requirements as well. Table 3.1 presents the system requirements to run the INAHOR-AD software.

Although the INAHOR-AD runs on a Linux operating system, the user's computer need not

necessarily run on Linux natively. Since most computers run on either Apple OS X or Microsoft Windows, INAHOR-AD can still run on these platforms, but will require users to install the VMware Player. The VMware Player allows the user to run Ubuntu (the INAHOR choice for Linux distribution) on the same computer running on another operating system. Other important specifications to note are the memory size, which should be at least 8 gigabytes (GB) and ideally 16 GB. The disk space should be at least 100 GB, and is preferable to have at least an Intel Pentium 4 processor at 3 gigahertz (GHz) or higher.

### 3.2 Setting up the System

Several supporting software programs need to be installed on a user's computer to perform image analysis and estimate paddy area and production using INAHOR-AD. Most of the required programs are available for free download via the internet. To effectively use INAHOR-AD, the following software should be installed:

- **Quantum GIS or QGIS**, a free and open source geographic information system (GIS);
- **Google Earth Pro**, a geospatial software application that displays a virtual globe and offers the ability to analyze and capture geographical data;
- **OpenOffice**, an open-source office software suite for word processing, spreadsheets, presentations, graphics, databases and more (for those with access to Microsoft Excel already installed, there is no need for OpenOffice);

	Specification	Version (with notes)
Operating system:	Linux (64-bit)	Ubuntu 12.04 or higher
Compiler:	GNU Compiler Collection	Version 4.6.1 or higher
Shell:	Perl, Bash	—
Central Processing Unit:	64-bit architecture	Intel Pentium 4 processor; 3 gigahertz or higher
Memory:	At least 8 gigabytes; preferably 16 gigabytes or more	—
Disk Space:	100 gigabytes or higher	Will depend on the Synthetic Aperture Radar data to be used in analysis

Source: Remote Sensing Technology Center of Japan. 2014. PowerPoint presentation developed for a training workshop in remote sensing. Tokyo.



- **7-zip**, a software program for zipping or unzipping files; and
- **VMware Player**, a streamlined desktop virtualization application that runs one or more operating systems on the same computer without rebooting.

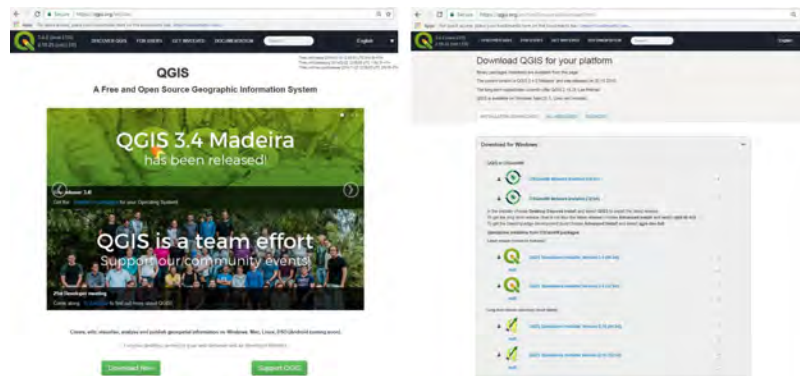
This section provides some brief information on each software program, the web pages where the installation files can be downloaded, and screen shots of the relevant graphical user interfaces of the programs.

**QGIS** is a free, open-source GIS licensed under the GNU General Public License. It is an official

project of the Open Source Geospatial Foundation. QGIS runs on Linux, UNIX, Mac OS X, Windows, and Android, and supports numerous vector, raster, and database formats and functionalities. It has the capability to visualize, manage, edit, and analyze data, and compose printable maps. For the purposes of using INAHOR-AD, QGIS versions 2.0 and above are acceptable.

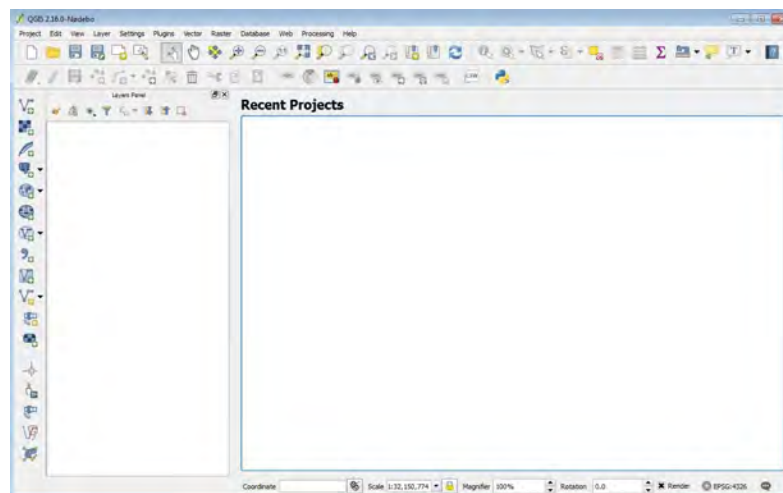
Installation files for the QGIS software can be downloaded at <http://qgis.org/en/site/> or <http://qgis.org/en/site/forusers/download.html>. Screen shots of the download pages are presented in Figure 3.1, while the QGIS user interface is presented in Figure 3.2.

Figure 3.1: QGIS Download Page



Source: QGIS, 2018. <http://qgis.org/en/site/>.

Figure 3.2: QGIS Graphical User Interface

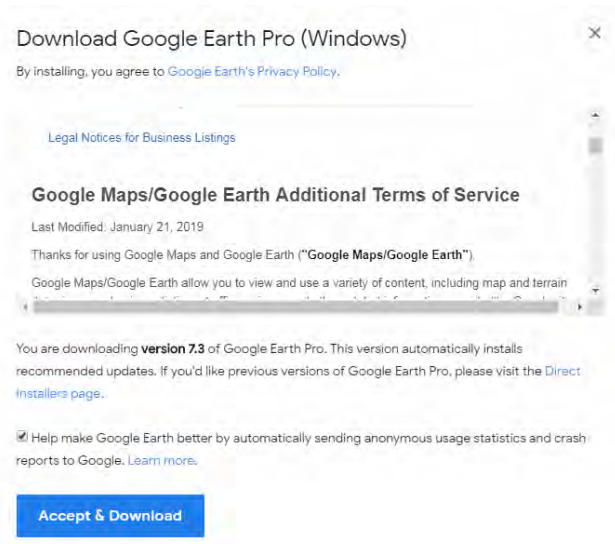


Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

**Google Earth Pro** provides tools for exploring and visualizing geographical content, in addition to the features available in the commonly used Google Earth. Google has now made this pro version free. Some of the more advanced features include the ability to compute distances and areas using measurement tools; visualize, manipulate, and export GIS data; use Movie Maker to produce media collateral; and go back in time with historical imagery (<https://www.google.com/earth/desktop/>).

To install Google Earth Pro, access <https://www.google.com/earth/download/gep/agree.html> and download the installation file. Google Earth Pro installation requires a license key, but the user's email address and the key "GEPFREE" can be used to sign in. A screen shot of the download page is presented in Figure 3.3, while the Google Earth Pro user interface is presented in Figure 3.4.

**Figure 3.3: Google Earth Pro Download Page**



Source: Google Earth. 2018. <https://www.google.com/earth/download/gep/agree.html>.

**Figure 3.4: Google Earth Pro Graphical User Interface**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

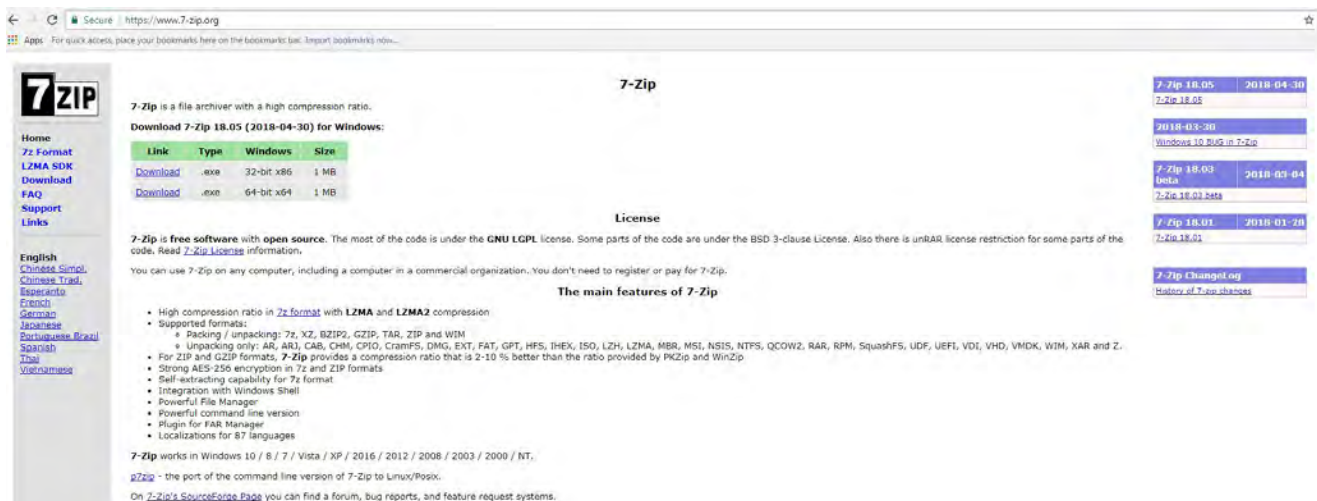


Install 7-Zip by downloading the installation files from <http://www.7-zip.org/>. A screenshot of the download page is presented in Figure 3.8, while its user interface is shown in Figure 3.9.

**VMware Player** will need to be installed on computers running either Apple OS X or Microsoft Windows, because the INAHOR-AD software runs on a Linux 64-bit operating system. VMware Player

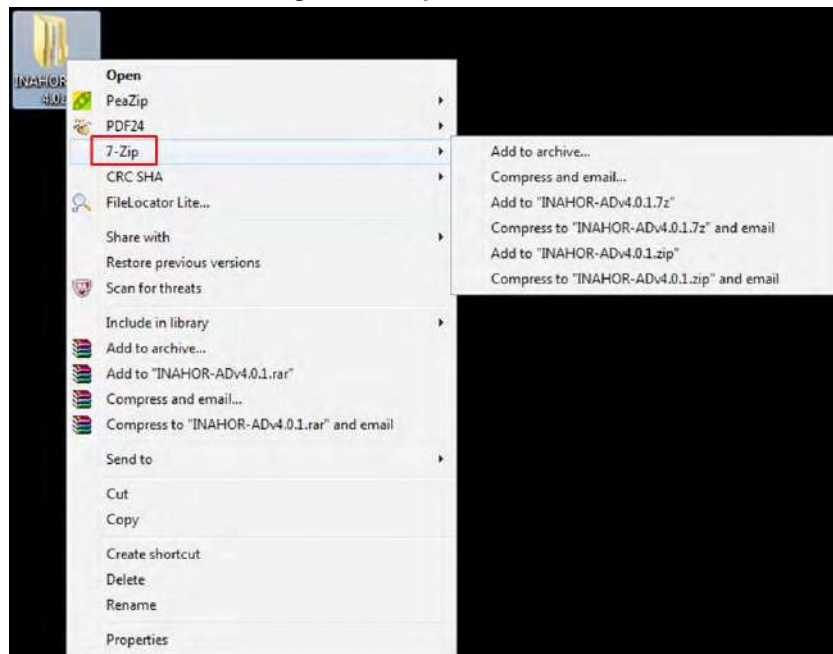
is a streamlined desktop virtualization application that runs one or more operating systems on the same computer, without rebooting. This means a user is able to switch between, for example, the Windows operating system and the VMware Player, without restarting their computers ([https://pubs.vmware.com/Release\\_Notes/en/player/7/player-714-release-notes.html](https://pubs.vmware.com/Release_Notes/en/player/7/player-714-release-notes.html)).

Figure 3.8: 7-Zip Download Page



Source: 7-Zip. 2018. <http://www.7-zip.org/>.

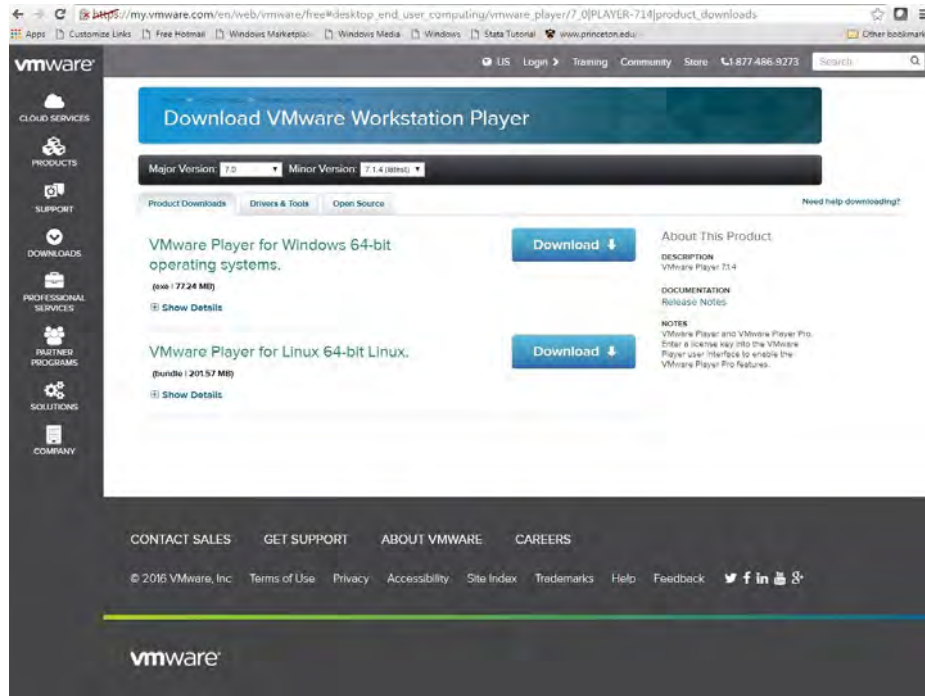
Figure 3.9: 7-Zip User Interface



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.



Figure 3.10: VMware Player Download Page



Source: VMware, Inc. 2017. [https://my.vmware.com/web/vmware/details?dlg=wkst\\_714\\_win&baseCode=ZG0lYnR0akBiZGh0Kg==](https://my.vmware.com/web/vmware/details?dlg=wkst_714_win&baseCode=ZG0lYnR0akBiZGh0Kg==).

To install the virtual machine where the INAHOR-AD software will run, go to [https://my.vmware.com/web/vmware/details?dlg=wkst\\_714\\_win&baseCode=ZG0lYnR0akBiZGh0Kg==](https://my.vmware.com/web/vmware/details?dlg=wkst_714_win&baseCode=ZG0lYnR0akBiZGh0Kg==). This link provides installation files for the VMware Workstation 7.1.4 Player version, which is the earliest version that works with INAHOR-AD. A newer version of VMWare Workstation may be available, but it has not been tested. Download the installation files and install the VMware Player. A screenshot of the download page is presented in Figure 3.10, while its startup screen is shown in Figure 3.11.

### 3.3 Getting to Know the INAHOR-AD Software

The **INAHOR-AD** software is a result of several improvements made on the basic functionalities of the INAHOR software developed by Japan Aerospace Exploration Agency (JAXA) for estimating paddy area and production. The modified software, INAHOR-AD,

Figure 3.11: VMware Player Startup Screen



Source: Screenshot generated by Asian Development Bank staff. 2016. Manila.

was developed for an Asian Development Bank (ADB) pilot project and is jointly owned by ADB and JAXA. The final version of the software is INAHOR-AD Version 4, which has also been translated into Laotian, Thai, and Vietnamese. Users who wish to get a copy of the software may send a request to ADB (ta8369@adb.org). The detailed installation process of INAHOR-AD v4 will be discussed in Section 3.4.

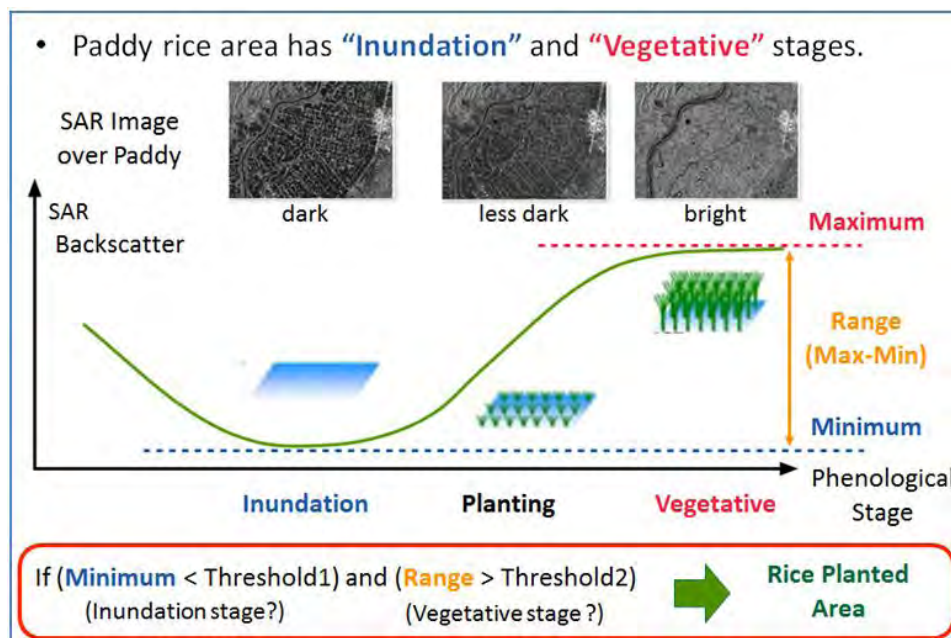
INAHOR-AD uses a time-series of Synthetic Aperture Radar (SAR) images taken during the planting season and the healthy or vegetative stage of rice growth, right before the harvest season. INAHOR-AD supports the use of ALOS PALSAR and ALOS-2 PALSAR-2 SAR data. Other SAR data can be used in the INAHOR-AD software if the following requirements are satisfied:

- Format: GeoTIFF
- Map projection: Latitude-longitude coordinate system
- Value of pixel: Backscattering coefficient
- Other: Orthorectified, slope corrected, etc.

Boundary information in the form of boundary shapefiles are likewise needed to be able to get paddy area estimates for specific geographic areas. To get the estimate of production, yield information should be available, which could be based on official yield estimates of the national statistical office or based on the results of crop cutting experiments conducted to estimate yield.

Figure 3.12 illustrates how INAHOR-AD detects paddy area based on backscatter information (see Chapter 1 for a detailed explanation). The backscatter coefficients from the SAR images vary depending on the phenological or growth stages of rice. In the illustration, backscatter coefficients during inundation or flooding of the rice fields are very low, and the SAR images are quite dark. The backscatter coefficients gradually increase until a maximum value is reached during the vegetative stage of rice growth, or some time near the harvest season, indicated by the bright SAR images.

Figure 3.12: Rice-Planted Area Detection in INAHOR-AD



SAR = Synthetic Aperture Radar.

Source: Asian Development Bank. 2017. Innovative Data Collection Methods for Agricultural and Rural Statistics. Online Training Course. <http://cars.adbx.online/e-learning.html>.



INAHOR-AD compares the backscatter coefficients in each pixel to a set of threshold values to determine whether or not an area is planted with rice. Threshold 1 is set to a reasonable value such that it can capture the minimum backscatter value during the inundation stage, thus, Threshold 1 should be higher than the minimum backscatter coefficient. Threshold 2, on the other hand, is set such that it is lower than the range or the difference between the maximum backscatter value (during the harvest season) and the minimum backscatter value (during the inundation period). For any given pixel, if the minimum backscatter coefficient is less than Threshold 1 and the range is greater than Threshold 2, then the specific area will be classified as a rice-planted area. Therefore, setting these threshold values correctly is very important to derive the correct estimates of rice-planted area.

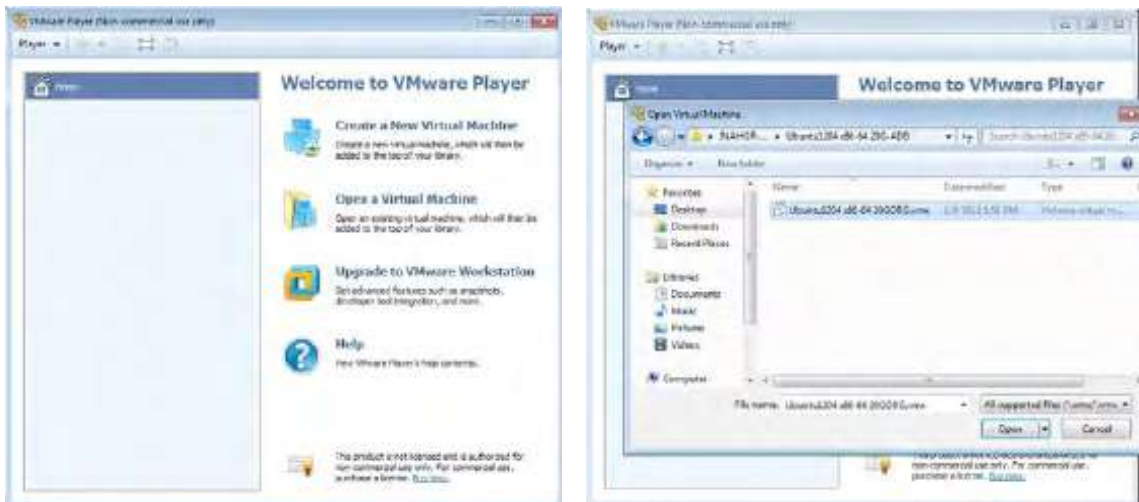
### 3.4 Installing the INAHOR-AD Software

To install INAHOR-AD v4, users must first send a request to ADB (ta8369@adb.org) for a copy of the software and related images. The INAHOR-AD v4 software and other necessary files should be copied onto the user's computer.

Start by opening the VMware Player and clicking on "Open Virtual Machine". Open the Ubuntu\*.vmx file inside the "INAHOR-AD v4/Ubuntu" directory. The VMX file will be recognized by the VMware Player in order to access INAHOR-AD v4. Screenshots following this procedure are given in Figure 3.13.

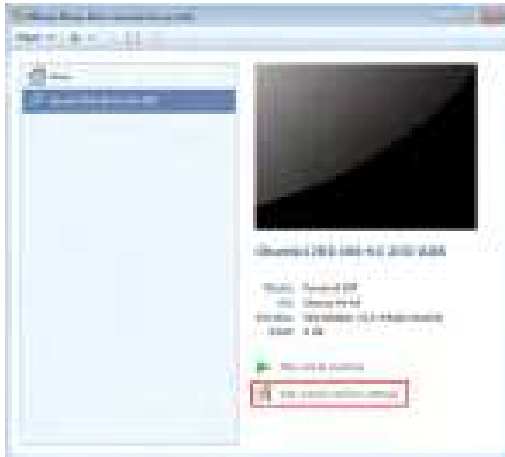
Before opening the virtual machine to access INAHOR-AD v4, some settings need to be changed. Click on "Edit virtual machine settings" on the VMware Player startup screen.

Figure 3.13: Opening the Virtual Machine



Source: Asian Development Bank. 2017. Innovative Data Collection Methods for Agricultural and Rural Statistics. Online Training Course. <http://cars.adbx.online/e-learning.html>.

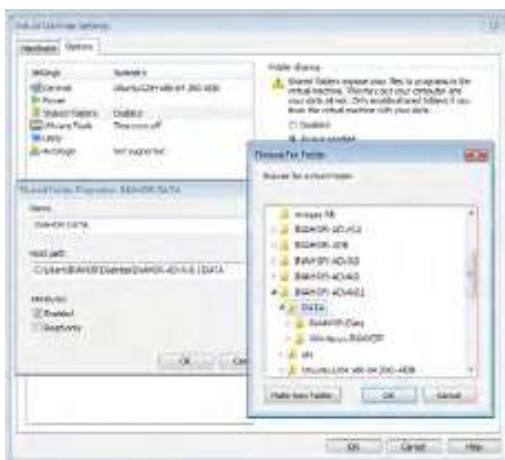
**Figure 3.14: Setting Up INAHOR-AD on the Virtual Machine, Step 1**



Source: Asian Development Bank. 2017. Innovative Data Collection Methods for Agricultural and Rural Statistics. Online Training Course. <http://cars.adbx.online/e-learning.html>.

On the “Hardware” tab, change the memory to the maximum recommended setting. Then, on the “Options” tab, go to “Shared Folders” and activate folder-sharing by clicking on “Always enabled”. Click on the default folder and click “Properties” to change it to the location where the “DATA” folder inside the “INAHOR-AD v4” folder (INAHOR-ADv4/DATA) is stored.

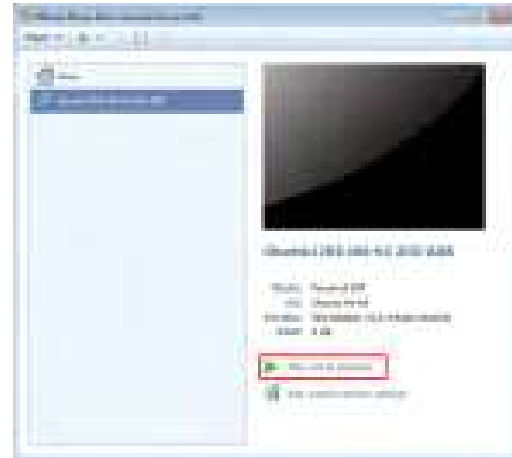
**Figure 3.15: Setting Up INAHOR-AD on the Virtual Machine, Step 2**



Source: Asian Development Bank. 2017. Innovative Data Collection Methods for Agricultural and Rural Statistics. Online Training Course. <http://cars.adbx.online/e-learning.html>.

Once the changes are made, the virtual machine can be opened by clicking on “Play virtual machine” and the INAHOR-AD v4 software can be started.

**Figure 3.16: Setting Up INAHOR-AD on the Virtual Machine, Step 3**



Source: Asian Development Bank. 2017. Innovative Data Collection Methods for Agricultural and Rural Statistics. Online Training Course. <http://cars.adbx.online/e-learning.html>.

### 3.5 Accessing ALOS-2 PALSAR-2 Images

As part of the INAHOR-AD package, JAXA has provided images for the test area of Nueva Ecija in the Philippines. For images of a different target area, users are encouraged to write to JAXA directly through their webpage at <http://global.jaxa.jp/activity/pr/inquiries/index.html>.

### 3.6 Accessing Data for Use with INAHOR-AD

Users who intend to procure SAR data may send a request to JAXA to access the ALOS User Interface Gateway (AUIG) website where orders can be placed and the data eventually downloaded (<https://auig2.jaxa.jp/openam/UI/Login?goto=http%3A%2F%2Fal2mwb01%3A80%2Fips%2Fhome>). For the ADB project, four sets of SAR data were purchased for use in satellite data analysis using the INAHOR-AD software. These data sets cover the Lao People’s Democratic Republic, the Philippines, Thailand, and Viet Nam. Each set of SAR data contains four images; two images during the first 2 months of the rice-


planting and rice-growing seasons, and the other two images during the harvest months. Table 3.2 shows the satellite data used for analysis in Nueva Ecija, Philippines, with the corresponding image capture dates.

Scene ID	Observation Date
ALOS2053973300-150524	24 May 2015
ALOS2064323300-150802	02 August 2015
ALOS2072603300-150927	27 September 2015
ALOS2076743300-151025	25 October 2015

Source: Remote Sensing Technology Center of Japan. 2014. PowerPoint presentation developed for a training workshop in remote sensing. Tokyo.

The downloaded satellite data files are in compressed or zipped format and are usually about 1.2 GB in size. Within each of these compressed files, the satellite images or scenes are extracted. These are GeoTIFF images with file sizes of about 566 megabytes for each scene. These are the files that will be used for analysis using the INAHOR-AD software.

### 3.7 Starting the INAHOR-AD Software

Start the VMware Player and the Linux environment opens. The user (named “rice”) will be prompted to enter a password. Enter “123456” as the password (without quotes). After logging in, the Ubuntu desktop will show the INAHOR-AD icon,  which starts up the INAHOR-AD software. Screenshots following this procedure are given in Figure 3.17.

**Figure 3.17: Starting the INAHOR-AD Software**



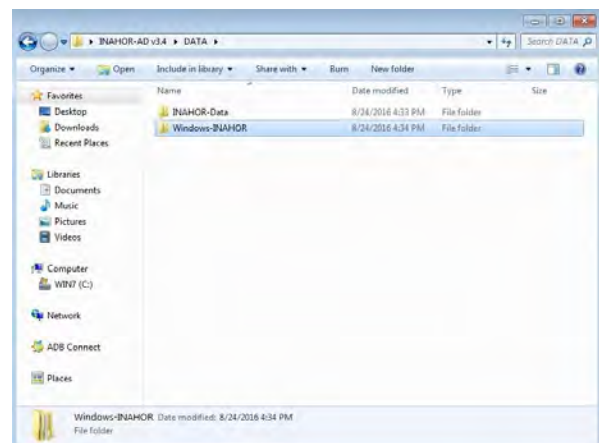
Source: Asian Development Bank. 2017. Innovative Data Collection Methods for Agricultural and Rural Statistics. Online Training Course. <http://cars.adbx.online/e-learning.html>.

### 3.8 Creating Folders and Files

Performing satellite data analysis requires users to work with several data sets in different file formats. Data sets used in the analysis include SAR images, which in this case are in GeoTIFF format, and geographical boundary shapefiles. INAHOR-AD outputs, on the other hand, are saved in GeoTIFF, Keyhole Markup Language Zipped (KMZ), or comma-separated values (CSV) formats, while field photos (in JPEG or other formats) and survey results (in Excel or CSV) are also used in validation. This means different software programs running under different environments are also used. For example, INAHOR-AD runs in the Ubuntu environment, while the other software programs like QGIS, Google Earth Pro, or OpenOffice, run in Windows or Mac OS X. Switching between the Ubuntu and Windows or Mac OS X environments may therefore be necessary. It also helps that files and folders are kept organized to avoid confusion when switching environments and to immediately find where the INAHOR-AD and other results are saved.

The folder that will be used mostly in the analysis is the “DATA” folder located inside the “INAHOR-AD” main folder. When the INAHOR-AD software installation files are provided to users, the “DATA” folder and its subfolders, the “INAHOR-Data” folder and “Windows-INAHOR” folder will already be created.

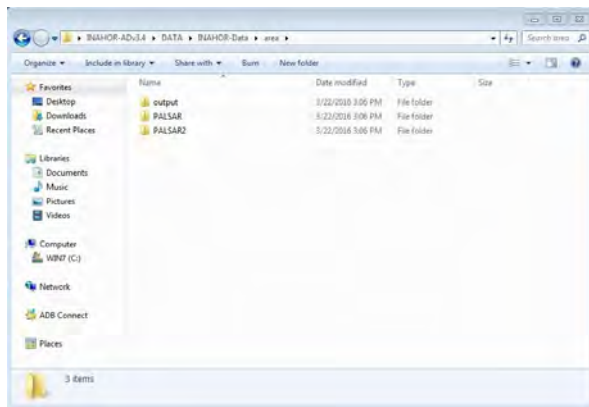
**Figure 3.18: Setting Up Folders, Step 1**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Contained in the “INAHOR-Data/area/” directory are subfolders “PALSAR” and “PALSAR-2”, where the SAR images to be used in INAHOR-AD are located, as well as an “output” folder where the INAHOR-AD output maps and CSV files are saved. In pre-processing, the SAR images (GeoTIFF files) for use in INAHOR-AD are extracted into the “PALSAR2” folder. A “PALSAR” folder is also created in case archived PALSAR data will be used.

**Figure 3.19: Setting Up Folders, Step 2**

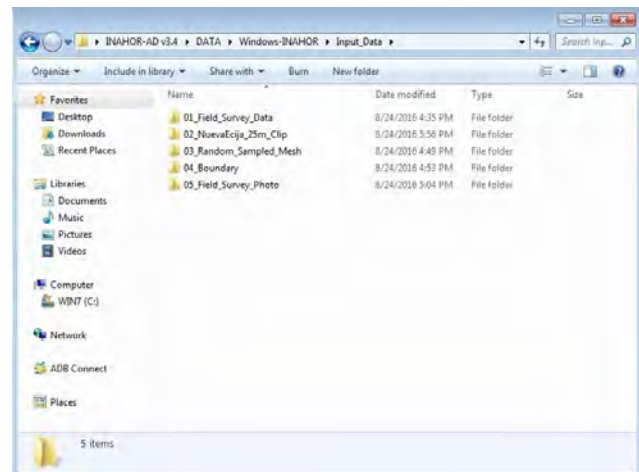
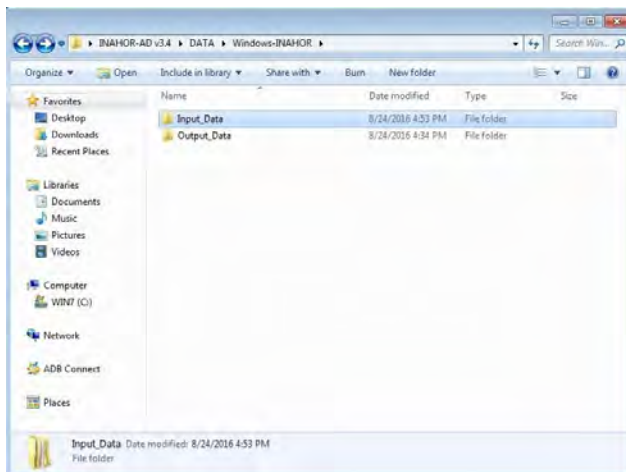


Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Inside the “Windows-INAHOR” folder are two subfolders: “Input\_Data” and “Output\_Data”. The “Output\_Data” folder will mostly be used during the validation of the INAHOR-AD results. All of the INAHOR-AD output files saved in the Ubuntu environment will be copied into this folder to facilitate the validation of results, which will be done working under the Windows environment. The “Input\_Data” folder, on the other hand, will contain all of the input files, categorized into five different subfolders.

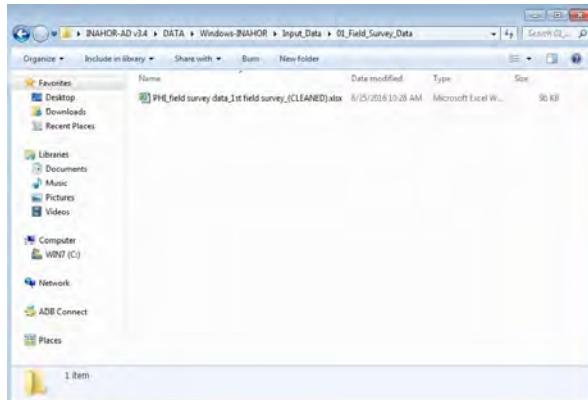
The “01\_Field\_Survey\_Data” folder contains an Excel file or CSV file of the encoded data from the ground-truthing field survey conducted during the start of the rice-planting season. The ground-truthing field survey is conducted on a randomly selected sample of meshes, and is done to identify and estimate paddy areas within the sample meshes, which will be compared with the paddy area estimates from INAHOR-AD. Details on the conduct of the ground-truthing field survey are discussed in Chapter 4 of the Handbook.

**Figure 3.20: Setting Up Folders, Step 3**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Figure 3.21: Setting Up Folders, Step 4

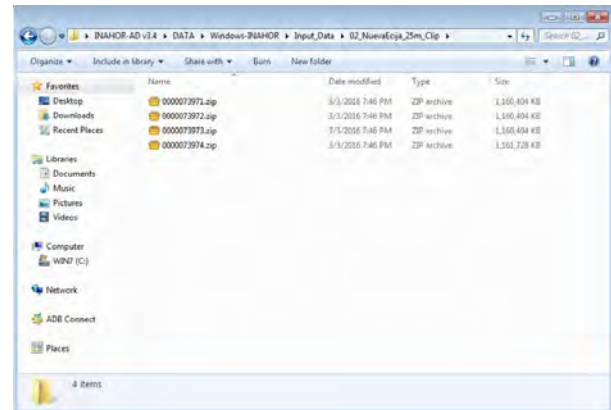


Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

For illustration purposes, data used in the following discussions on the INAHOR-AD software will be for the province of Nueva Ecija in the Philippines. Some names of folders and files may therefore be specific for Nueva Ecija province. Appropriate folder and file names should be used if work is done for other localities or other specific areas of interest. The “02\_NuevaEcija\_25m\_Clip” folder contains the PALSAR-2 data downloaded from JAXA’s AUIG-2 website.

Users may opt to use the full PALSAR-2 images, which could have very large file sizes of about 1.2 GB,

Figure 3.22: Setting Up Folders, Step 5

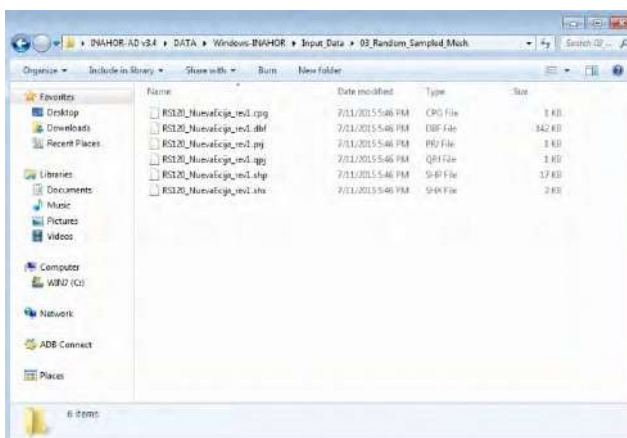


Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

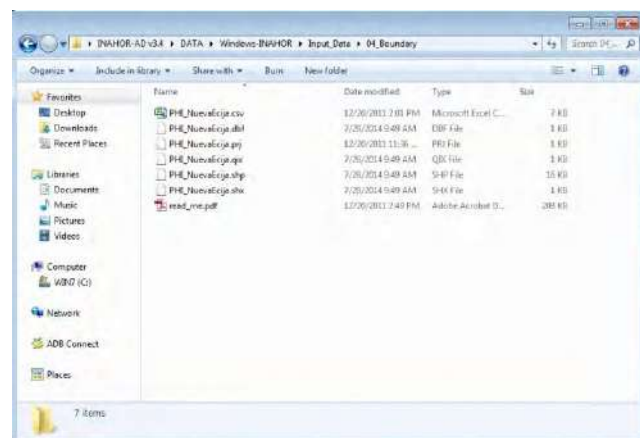
or to use clipped images or smaller images covering only a specific area of interest. Clipped images would have a smaller file size compared with the full image, and will be easier to work with, especially for computers with limited memory and/or processing power. In the illustration, clipped images are used.

The “03\_Random\_Sampled\_Mesh” folder contains the shapefile and other files related to the randomly selected sample meshes where the ground-truthing field survey is conducted. The administrative boundary files are located in the “04\_Boundary” folder. Generating the random sample

Figure 3.23: Setting Up Folders, Step 6



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

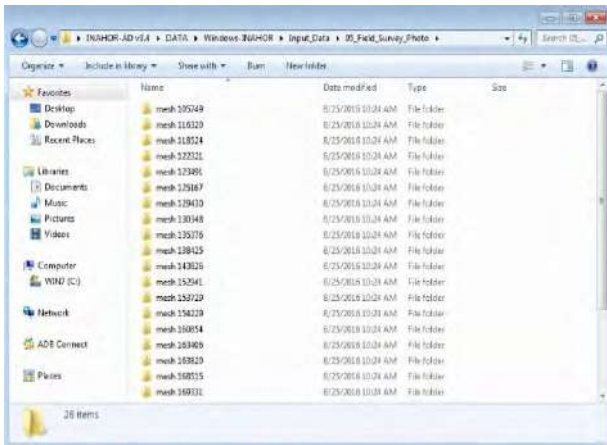




points using the QGIS software will be discussed in Section 4.1 of Chapter 4.

Lastly, photos taken during the ground-truthing field survey, which will be used in the validation of results, are located in the “05\_Field\_Survey\_Photo” folder. For ease of use, photos should be organized by mesh identification, as given in the illustration.

**Figure 3.24: Folder for the Field Survey Photo**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Sample field photos are also provided. Strategies on how to properly take field photos to ensure that actual field conditions are well documented are provided in Section 4.6 of Chapter 4.

**Figure 3.25: Sample Field Photos**

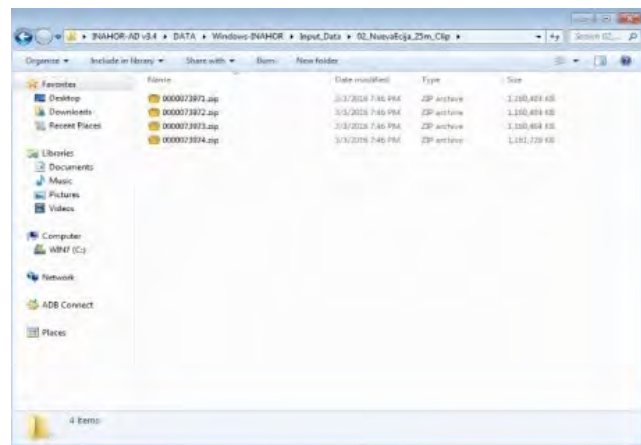


The pictures above showcase a typical rice farm in Nueva Ecija, Philippines. Photo credits: The Philippine Statistics Authority.

### 3.9 Preparing the Data

The four sets of SAR data downloaded from JAXA’s AUIG-2 website are in compressed or zipped format. These files first need to be unzipped using 7-Zip, which should be installed on the user’s computer. The compressed SAR data files are located in the directory “INAHOR-AD/DATA/Windows-INAHOR/Input\_Data/02\_NuevaEcija\_25m\_Clip/”.

**Figure 3.26: Unzipping a Compressed File, Step 1**

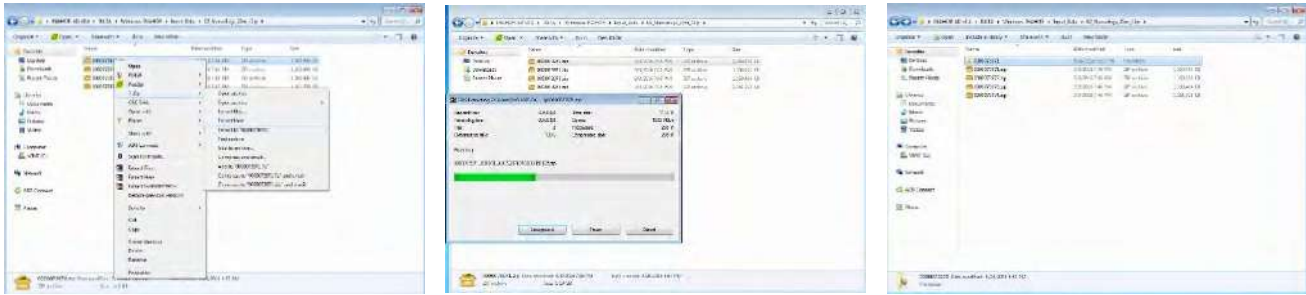


Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Unzip each file one at a time by right-clicking on a zipped file, selecting “7-zip”, and clicking “Extract to <default folder name>”. A new folder will be automatically created containing files from the unzipped file.



Figure 3.27: Unzipping a Compressed File, Step 2

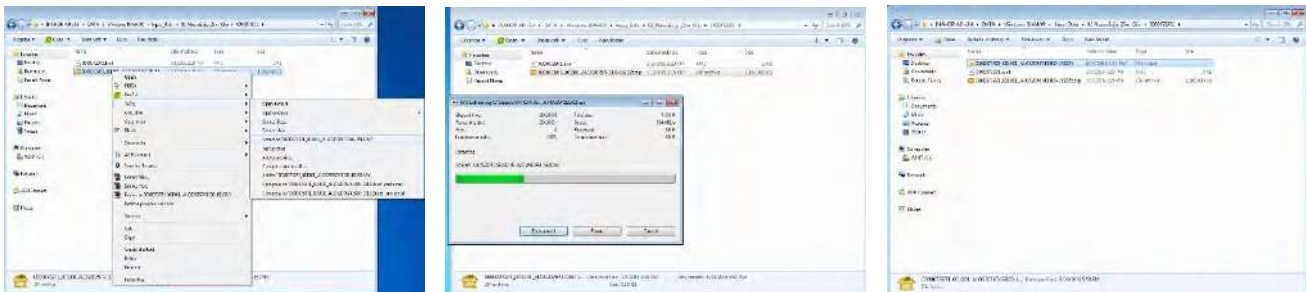


Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Within the newly created folder are a Keyhole Markup Language (KML) file and another zipped file that needs to be unzipped. Unzip this file as described previously, extracting the files to a new folder created automatically by 7-zip.

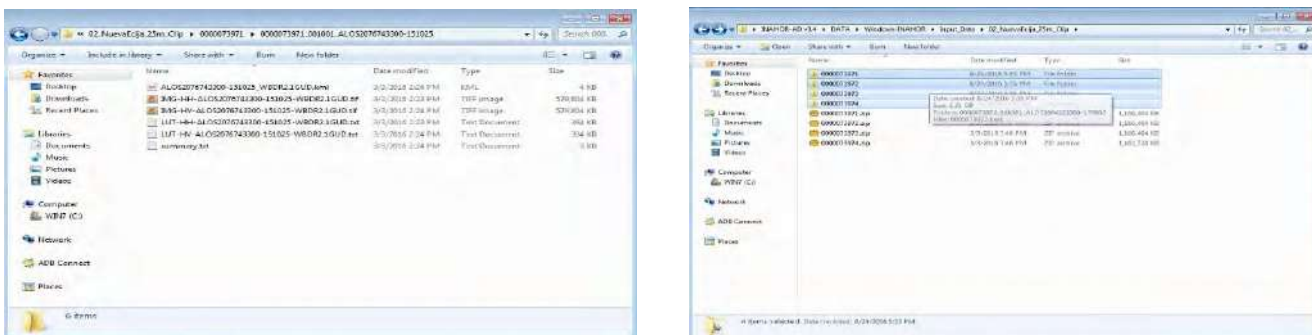
The new folder where files are extracted will contain a KML file, some text documents, and the GeoTIFF images, which will be used as input to INAHOR-AD. Unzipping of files should be done for all four sets of SAR data.

Figure 3.28: Unzipping a Compressed File, Step 3



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Figure 3.29: Unzipping a Compressed File, Step 4



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

### 3.10 Copying SAR Data to a Designated Folder in Ubuntu

The unzipped files are still in the “Windows-INAHOR” folder and need to be transferred to a specific folder in the Ubuntu environment, where the INAHOR-AD software is programmed to access the SAR images.

Firstly, users should log in to the Ubuntu environment, using the username “rice” and password “123456” (without quotes). Open the “PALSAR2” folder inside Ubuntu by accessing the following directory: “home/inahor/data/area/PALSAR2/”. The GeoTIFF images will be copied to this folder.

Open the source directory “home/Desktop/Windows-INAHOR/Input\_Data/02\_NuevaEcija\_25m\_Clip/”, which contains four folders where the first set of unzipped files are saved. Within each of these folders is another folder containing the second set of unzipped files including the GeoTIFF images. Two GeoTIFF images have already been extracted into the folder; one image file with horizontal-horizontal (HH) polarization and the other with horizontal-vertical (HV) polarization. The image polarization can easily be identified from the file names.

Figure 3.30: Copying Synthetic Aperture Radar Data in Ubuntu, Step 1



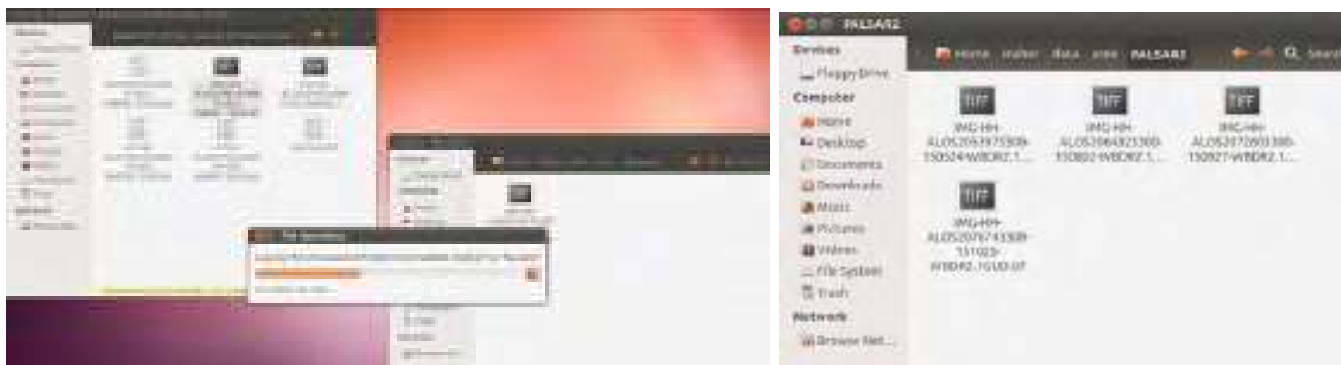
Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Figure 3.31: Copying Synthetic Aperture Radar Data in Ubuntu, Step 2



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Figure 3.32: Copying Synthetic Aperture Radar Data in Ubuntu, Step 3

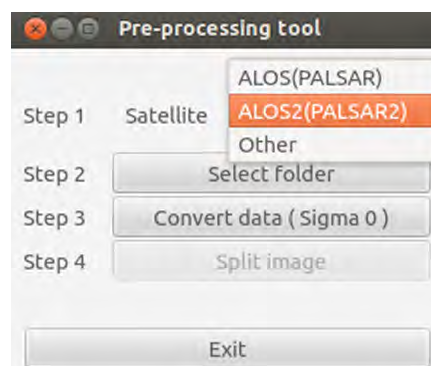


Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Copy only the GeoTIFF file with the HH polarization and paste it into the “PALSAR2” folder. Access the other three GeoTIFF files located in their specific folders, then copy and paste these files into the “PALSAR2” folder. All four GeoTIFF images with the HH polarization should be copied to the “PALSAR2” folder.

Next, specify the satellite from which the SAR data were sourced. This could be ALOS (PALSAR), ALOS-2 (PALSAR-2), or others. In the illustration, the SAR data used is sourced from ALOS-2 (PALSAR-2).

Figure 3.34: Using the Pre-Processing Tool in INAHOR-AD, Step 2



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

### 3.11 Using the Pre-Processing Tool

The pre-processing tool in INAHOR-AD is used to prepare the extracted GeoTIFF images for use with the software. The step-by-step procedure is described below.

Open the INAHOR-AD main menu, and click the “Pre-processing tool” button.

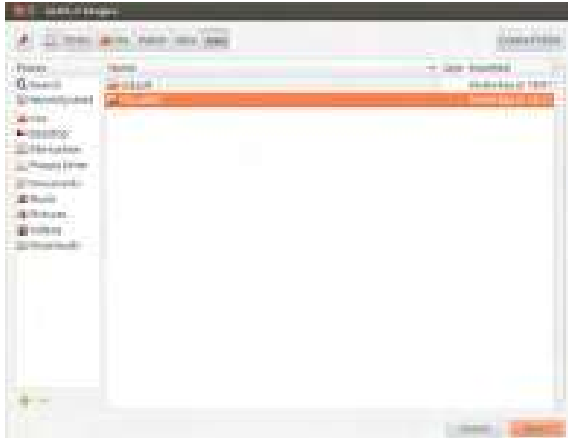
Figure 3.33: Using the Pre-Processing Tool in INAHOR-AD, Step 1



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Select the folder where the GeoTIFF images were saved, as explained in Appendix 2.2. In the example, the GeoTIFF files were copied to the directory “home/rice/inahor/data/area/PALSAR2/”.

Figure 3.35: Using the Pre-Processing Tool in INAHOR-AD, Step 3

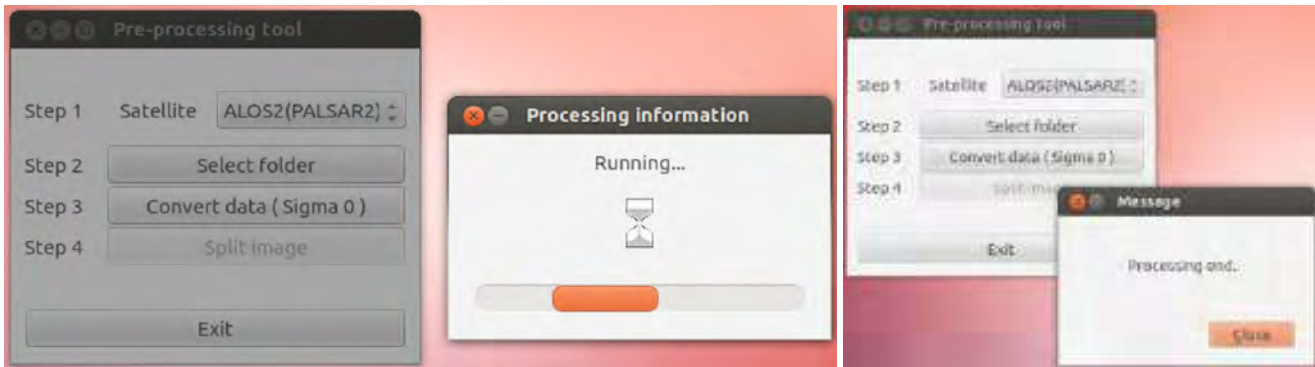


Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

In the next step, data is converted to Sigma0, which refers to the backscatter coefficient. Click the “Convert data (Sigma 0)” button to instruct INAHOR-AD to start the data conversion. Dialog boxes appear to indicate the status of processing.

For cases when the data conversion takes a long time to process—usually when the GeoTIFF images have large file sizes—the images can be split into smaller images. Click the “Split image” button and specify the number of tiles the original image will be divided into. Otherwise, this step may be skipped and the pre-processing of the SAR images will be completed.

Figure 3.36: Using the Pre-Processing Tool in INAHOR-AD, Step 4



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Figure 3.37: Using the Pre-Processing Tool in INAHOR-AD, Step 5



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Figure 3.38: Using the Pre-Processing Tool in INAHOR-AD, Step 6



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

To check the converted data files, go to the directory “home/rice/inahor/data/area/PALSAR2/” where a new folder named “Sigma0” has been created. Files containing the processed backscatter coefficient data are located inside this folder.

### 3.12 Using the Rice Crop Mapper

The Rice Crop Mapper module of INAHOR-AD is used to detect rice area based on SAR images captured during the planting and harvesting seasons. The step-by-step procedure is described below.

Open the INAHOR-AD main menu, and click the “Rice Crop Mapper” button.

Figure 3.39: Using the Rice Crop Mapper of INAHOR-AD, Step 1



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

A map window and the control dialog will appear. In some cases when the control dialog window is not readily visible on the screen, try moving the map window because the control dialog may be behind the map window. On the “Control Dialog”, click the “Open Images” button on the “Step 1” tab. This will open the satellite images to be used in identifying and estimating the paddy area.

Figure 3.40: Using the Rice Crop Mapper of INAHOR-AD, Step 2



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

On the “Open images” window, the following information needs to be specified:

- sensor;
- direction on how the satellite obtains the images (i.e., ascending or descending);



- observation mode (one of WBS-ScanSAR nominal [14 megahertz] mode Single polarization, WBD-ScanSAR nominal [14 megahertz] mode Dual polarization, or UBS-Ultra-fine mode Single polarization);
- directory where the extracted GeoTIFF images are located; and
- target harvest period.

**Figure 3.41: Using the Rice Crop Mapper of INAHOR-AD, Step 3**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Since SAR data from ALOS-2 PALSAR-2 are used in the analysis, and for purposes of demonstration, the following details are specified:

- sensor: PALSAR-2;
- direction: DESCENDING;
- mode: WBD;
- directory: /home/rice/inahor/data/area/PALSAR2/Sigma0; and
- target harvest period: 1 September 2015 to 31 October 2015 (which was the harvest period in Nueva Ecija in the Philippines during the 2015 wet cropping season for rice).

After specifying all required information in Step 1 tab, INAHOR-AD automatically activates the “Step 2” tab on the control dialog. Click the “View images” button to view the target images for analysis.

**Figure 3.42: Processing Sample Images in INAHOR-AD, Step 1**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

The four GeoTIFF images are displayed. Images marked in green correspond to images taken during the planting season, while images marked in orange correspond to images taken during the target harvest period. Observation dates for the images are also indicated above each image. Clicking “OK” instructs INAHOR-AD to start processing the selected images.

**Figure 3.43: Processing Sample Images in INAHOR-AD, Step 2**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Go to the “Step 3” tab to specify the threshold values, which will be used by INAHOR-AD in detecting rice areas. There are two available modes in specifying threshold values, the simple and the advanced modes. In the simple mode, the threshold

**Figure 3.44: Processing Sample Images in INAHOR-AD, Step 3**

The “Planting time image” displays the satellite image during the planting season.

The “Latest image” displays the satellite image during the harvest period.

The “Difference image” displays the differences between the planting and harvesting periods. Bright areas on the map are likely to be classified as rice areas.

Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

values will be the basis for detecting rice area in all pixels. The default values for “Threshold 1” is -15.00 and for “Threshold 2” is 3.00. These values can be used in the first round of analysis and can be adjusted in the succeeding rounds of analysis to be based on the results of field work

**Figure 3.45: Processing Sample Images in INAHOR-AD, Step 4**

Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

In the advanced mode, INAHOR-AD makes adjustments on the threshold values for each case of “mixcels” or mixed pixels (pixels that are a mix of rice areas and non-rice areas). Click the “Auto” button to automatically adjust the threshold values for each mixcel.

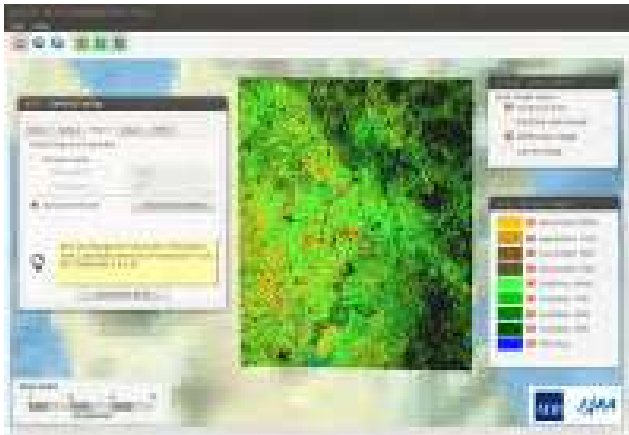
**Figure 3.46: Setting Up of Threshold in INAHOR-AD, Step 1**

Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

To illustrate, if INAHOR-AD detects the whole pixel as flooded area during the planting season (whole pixel is blue) and detects vegetation on the same area during the harvest season (whole pixel is green), the pixel will be detected as 100% paddy area. A pixel can also be identified as 75% rice area, with the other 25% identified as either urban area or water area. In this case, INAHOR-AD detects 75% of the area as flooded during the planting season and detects vegetation on same area during the harvest season, thus identifying those areas as paddy area. However, in 25% of the pixel, INAHOR-AD detects flooding during both the planting and harvesting seasons, meaning there was no change in the landscape. The same is true for identifying urban areas, and for the other mixcel cases.

After the threshold values are specified, click the “Detection RUN” button on the “Step 3” tab in the control dialog to instruct INAHOR-AD to start detecting the paddy areas. Once the process is completed, the detected paddy area is shown on the map window.

**Figure 3.47: Setting Up of Threshold in INAHOR-AD, Step 2**



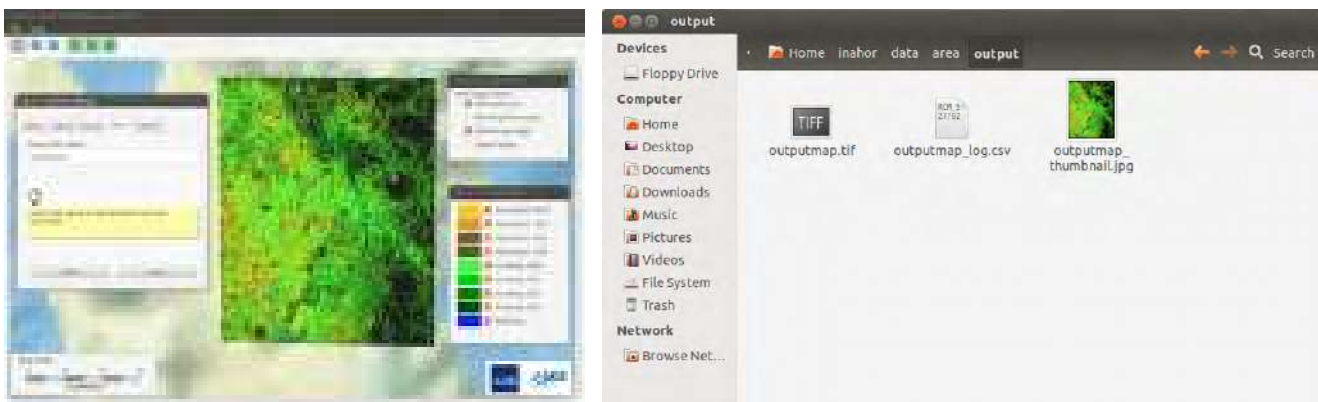
Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

INAHOR-AD also identifies the different growth stages of rice, indicated by a specific color palette shown on the “Growth stage” dialog box: blue for rice areas in the planting stage, different hues of green for rice areas in the growing stage, and different hues of yellow for rice areas at the harvest stage. For example, “Growing 75%” means that 75% of the pixel is detected as paddy area, which is in the growing stage; “Harvesting 50%” means that 50% of the pixel is detected as paddy area, which is in the harvest stage; and so on.

On the “Step 4” tab, the output map of the detected paddy area can be saved as a GeoTIFF file. Specify the output file name and click the “Save” button. The GeoTIFF file will be automatically saved in the “/home/rice/inahor/data/area/output/” directory.

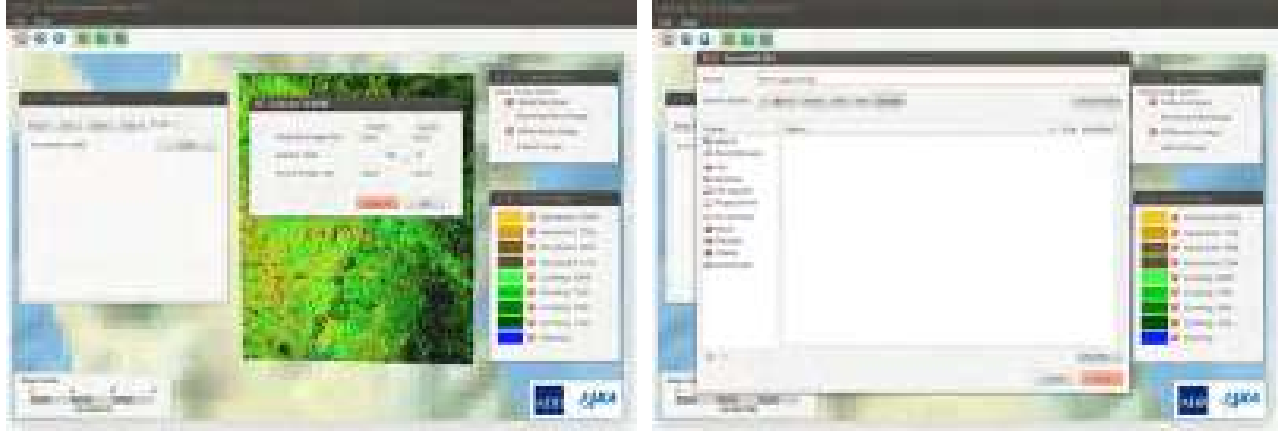
The same output map (showing the detected paddy area) can be saved as a KMZ file, which can be opened by Google Earth. On the “Step 5” tab, click the “Save” button to convert the map to a KMZ file, then specify the directory where the file will be saved.

**Figure 3.48: Setting Up of Threshold in INAHOR-AD, Step 3**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Figure 3.49: Setting Up of Threshold in INAHOR-AD, Step 4



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

### 3.13 Using the Rice Production Calculator

The Rice Production Calculator module of INAHOR-AD is used to calculate rice production estimates based on rice area estimates calculated using the Rice Crop Mapper, and on yield estimates, which could be based on official yield estimates from a national statistical office or on the results of crop cutting exercises conducted to estimate yield. The step-by-step procedure is described below.

Open the INAHOR-AD main menu, and click the “Rice Production Calculator” button.

The Rice Production Calculator (RPC) window opens. On the “Project” tab, click the “Create project” button and enter the project name and the operator or the user’s name.

Select the name of the created project to activate it.

Figure 3.50: Using the Rice Production Calculator Module of INAHOR-AD, Step 1



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Figure 3.51: Using the Rice Production Calculator Module of INAHOR-AD, Step 2



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

**Figure 3.52: Using the Rice Production Calculator Module of INAHOR-AD, Step 3**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Go to the “Planted Area” tab and click the “Open area” button. This will open the GeoTIFF file of the identified paddy areas created in the Rice Crop Mapper.

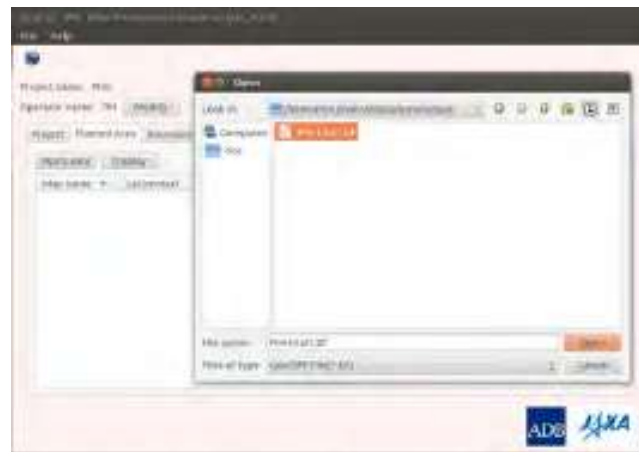
Open the GeoTIFF file (the example file was saved as “trial1.tif”) saved on the Ubuntu directory “/home/rice/inahor/data/area/output/”.

**Figure 3.53: Using the Rice Production Calculator Module of INAHOR-AD, Step 4**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

**Figure 3.54: Using the Rice Production Calculator Module of INAHOR-AD, Step 5**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

To view the rice area map created in the Rice Crop Mapper, toggle the map window by clicking on the “View Map” icon (the small picture of the Earth on the upper left-hand side of the RPC window). Click on the map name (the row must be highlighted in orange), then click the “Display” button.

**Figure 3.55: Using the Rice Production Calculator Module of INAHOR-AD, Step 6**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.



The rice area map created in the Rice Crop Mapper is displayed.

**Figure 3.56: Using the Rice Production Calculator Module of INAHOR-AD, Step 7**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Go to the “Boundary” tab and click the “Open boundary data” button. This will open the shapefile of the geographical boundary of interest. The boundary data can be downloaded from the Global Administrative Areas website (<https://gadm.org/>).

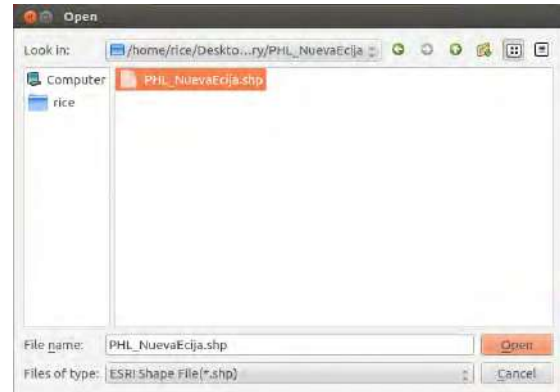
**Figure 3.57: Using the Rice Production Calculator Module of INAHOR-AD, Step 8**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Open the boundary shapefile saved on the shared Windows directory “/home/rice/Desktop/Windows-INAHOR/Input\_Data/04\_Boundary/”. The example file used is named ‘PHL\_NuevaEcija.shp’.

**Figure 3.58: Using the Rice Production Calculator Module of INAHOR-AD, Step 9**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

The pilot province of Nueva Ecija in the Philippines, and its municipalities and villages or “barangays” is displayed.

**Figure 3.59: Using the Rice Production Calculator Module of INAHOR-AD, Step 10**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

To view the village or barangay boundaries, click on the village names (the rows must be highlighted in orange), then click the “Display” button.

**Figure 3.60: Using the Rice Production Calculator Module of INAHOR-AD, Step 11**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Zooming in on the map and unchecking the “Base map” and “Planted area” checkboxes on the “View image layers” window, the village or barangay boundaries are displayed.

Go back to the RPC window, click on the village names (again, the rows must be highlighted in orange), then click the “Yield edit” button.

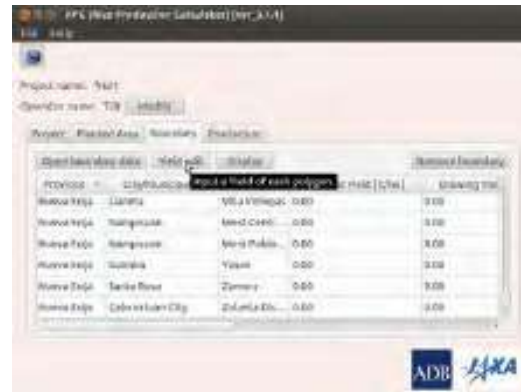
**Figure 3.61: Using the Rice Production Calculator Module of INAHOR-AD, Step 12**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

On the “Yield edit” window, input the value for the harvest yield, growing yield, and planting yield. By default, the yield value should be in tons

**Figure 3.62: Using the Rice Production Calculator Module of INAHOR-AD, Step 13**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

per hectare. Essentially, these yield values refer to the same value. The reason why the same value is inputted for the different stages (harvest, growing, and planting) is because INAHOR-AD estimates rice-planted area separately for the three different stages, and therefore also calculates rice production separately for the three stages.

**Figure 3.63: Using the Rice Production Calculator Module of INAHOR-AD, Step 14**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Users can likewise select whether the input yield values apply in the provincial, city or municipal, or village level by clicking on the appropriate button.

Looking at the list of villages on the RPC window, values on the harvest yield, growing yield, and planting yield columns were changed to the yield value input, which is 4 tons per hectare in the given example.

**Figure 3.64: Using the Rice Production Calculator Module of INAHOR-AD, Step 15**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Go to the “Production” tab, and click the “Production” button. This will calculate rice production based on the estimate of paddy areas derived from the Rice Crop Mapper, and the yield value input in the previous step.

**Figure 3.65: Using the Rice Production Calculator Module of INAHOR-AD, Step 16**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Once the “Production” button is clicked, INAHOR-AD will process and calculate rice production values.

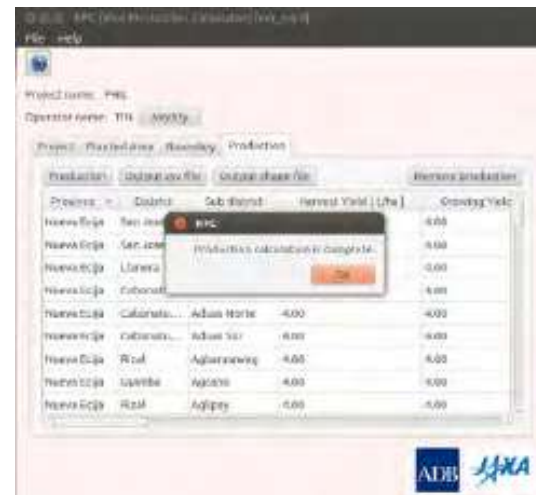
**Figure 3.66: Using the Rice Production Calculator Module of INAHOR-AD, Step 17**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

After it finishes its calculation, the software signals that the process is complete.

**Figure 3.67: Using the Rice Production Calculator Module of INAHOR-AD, Step 18**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Scrolling to the right, users will be able to see the estimates for rice production as well as the paddy area estimates for each village.

**Figure 3.68: Using the Rice Production Calculator Module of INAHOR-AD, Step 19**

Village	Area (Ha)	Yield (kg/ha)	Production (kg)	Area (Ha)	Yield (kg/ha)	Production (kg)
...	...	...	...	...	...	...

Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Save the paddy area and production estimates into a CSV file format by clicking the “Output csv file” button.

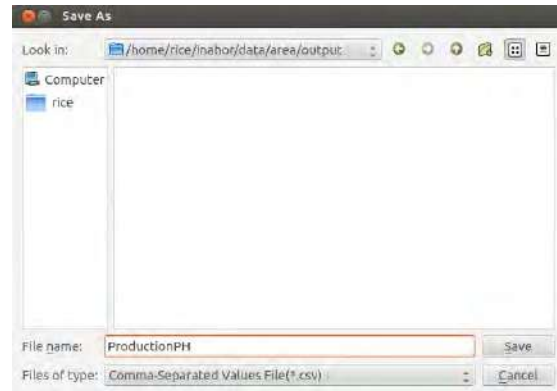
**Figure 3.69: Using the Rice Production Calculator Module of INAHOR-AD, Step 20**

Province	Subdiv. name	Subdiv. description	Area (Ha)	Yield (kg/ha)	Production (kg)
Albay	San Jose City	Albay Div.	428	428	428
Albay	San Jose City	Albay Div.	428	428	428
Albay	San Jose City	Albay Div.	428	428	428
Albay	San Jose City	Albay Div.	428	428	428
Albay	San Jose City	Albay Div.	428	428	428
Albay	San Jose City	Albay Div.	428	428	428

Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

In the “Save As” window, specify the directory where the paddy area and production estimates will be saved. The example CSV file is saved in the directory “home/rice/inahor/data/area/output/”.

**Figure 3.70: Using the Rice Production Calculator Module of INAHOR-AD, Step 21**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

The paddy area and production estimates can also be saved in a shapefile format, which depicts the paddy area and production estimates in each village through a map image, and can be used in further GIS analysis.

**Figure 3.71: Using the Rice Production Calculator Module of INAHOR-AD, Step 22**

Province	Subdiv. name	Subdiv. description	Area (Ha)	Yield (kg/ha)	Production (kg)
Albay	San Jose City	Albay Div.	428	428	428
Albay	San Jose City	Albay Div.	428	428	428
Albay	San Jose City	Albay Div.	428	428	428
Albay	San Jose City	Albay Div.	428	428	428
Albay	San Jose City	Albay Div.	428	428	428
Albay	San Jose City	Albay Div.	428	428	428

Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

## Chapter 4: Gathering Field Data and Conducting Accuracy Assessments

It is important that results of the application of remote sensing techniques and use of satellite imagery in estimating paddy areas are evaluated for accuracy. These estimates are validated using ground-truthing field surveys, where actual ground conditions are observed to verify the results derived from satellite data analysis. Ideally, these surveys should be conducted during the early part of the cropping season, specifically during the start of the planting season for rice. The field survey should be conducted within the same period that satellite data are observed, at least within 1 or 2 weeks of when the satellite makes a pass on the target area. As discussed in Chapter 3 of this handbook, advanced versions of the INternational Asian Harvest mOnitoring system for Rice (INAHOR-AD) estimates of paddy area are calculated by setting threshold values, which the INAHOR-AD software uses as a basis in classifying whether or not a specific area is a paddy area. Field surveys should be conducted in order to validate the estimates and provide information for fine-tuning the threshold values and making more-reliable estimates of harvested paddy area. Likewise, the threshold values used to classify the rice-growing stages (planting stage, growing stage, and harvesting stage) are evaluated based on the results of the ground-truthing field survey.

Among other detail, this chapter includes information on preparation activities prior to conducting the ground-truthing field work, including the selection of the sample meshes, preparing field survey maps and the survey questionnaire, selecting appropriate technology, and planning the team selection and field survey scheduling. It also addresses the activities involved in the actual conduct of the field validation survey, including navigating to the sample mesh, taking field photos, and filling out the field survey questionnaire. Lastly, encoding and managing the field survey data, the procedure for digitizing paddy area maps, and the estimation of paddy areas using Quantum geographic information

system (QGIS) are covered toward the end of the chapter.

### 4.1 Generating Random Points in QGIS

Using geographical information system (GIS) software to generate random geographic points is an important skill that is required to do many things related to ground-truthing. For example, random points must be generated to select sample sites for the field surveys. They must also be generated when performing the accuracy assessment. This section details how random points and a random 200 meter (m) x 200 m mesh can be generated using QGIS software to address the sample case of Nueva Ecija, Philippines.

The main steps in generating random points using QGIS are as follows:

- Loading Administrative Boundary shapefile;
- Executing Vector | Research Tools | Random Points tool;
- Projecting the output to Universal Traverse Mercator (UTM) 51N (for the Philippine case);
- Executing Vector | Geoprocessing Tools | Buffer tool; and
- Executing Vector | Research Tools | Polygon from Layer Extent tool.

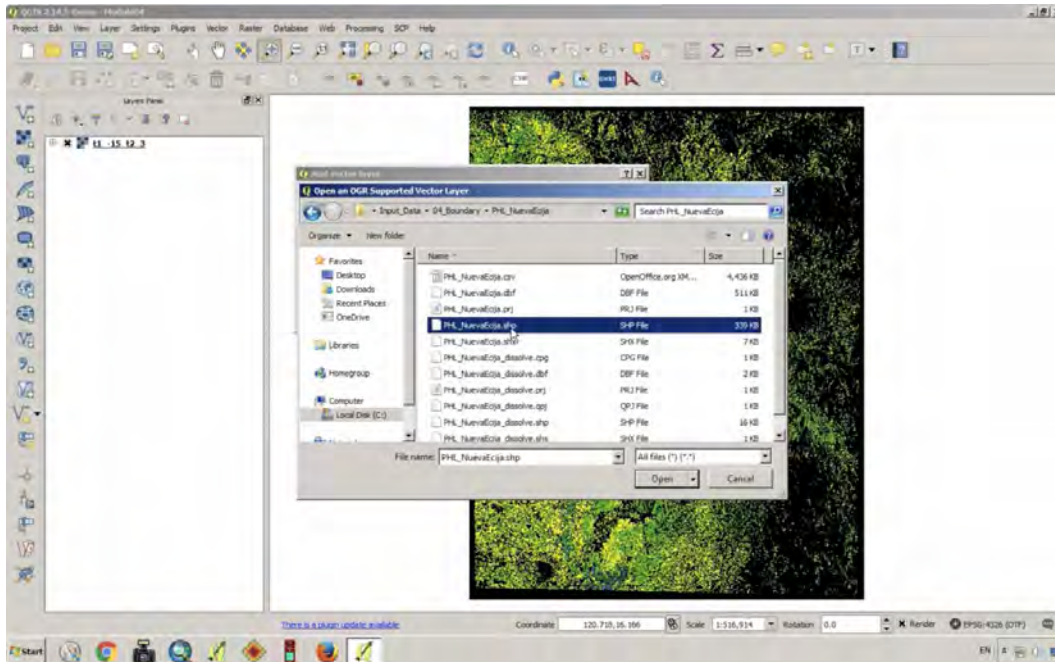
#### 4.1.1 Loading Administrative Boundaries

In the example for Nueva Ecija, Philippines, the administrative boundary file available from the Database of Global Administrative Areas (GADM) (<https://gadm.org/>) was used.

In QGIS, the file can be added by clicking the “Add Vector Layer” icon and navigating to the appropriate location and by clicking on the appropriate file with the “.shp” extension, as shown in Figure 4.1.



Figure 4.1: Adding a Vector Layer in QGIS

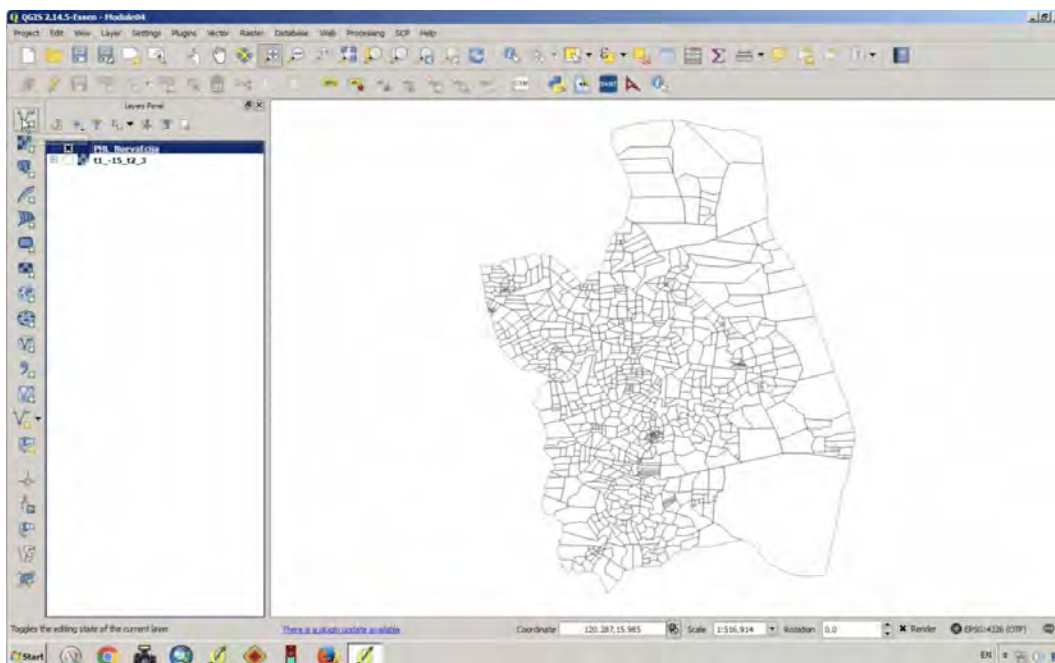


Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

To reconfigure the layer to be a simple outline, right click on the added layer in the “Layers Panel,” open “Layer Properties,” then navigate to “Style” and

alter the “Fill Style” and “Border Width” to match the desired look (one possible option is shown in Figure 4.2).

Figure 4.2: Changing Layer Properties in QGIS



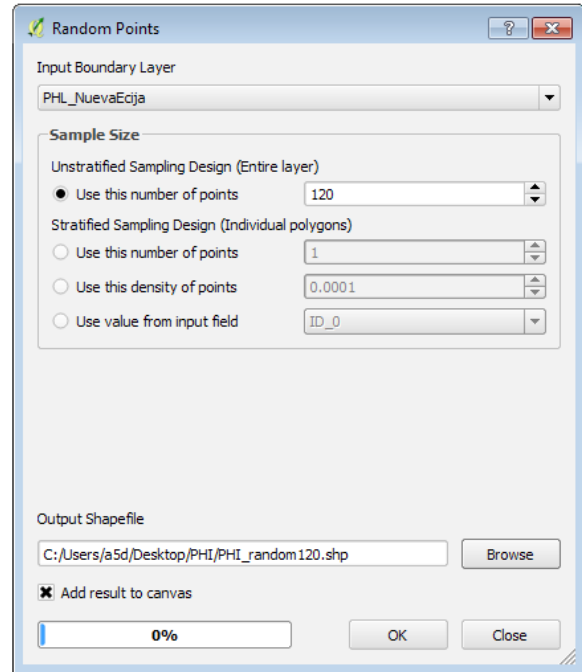
Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

#### 4.1.2 Executing Vector | Research Tools | Random Points Tool

The next step involves using the “Random Points” tool inside QGIS’s Vector menu under “Research Tools.” The “Input Boundary Layer” should be selected as “PHL\_NuevaEcija” (or, if the user is proceeding with a different example area, the relevant shapefile). This work uses an “Unstratified Sampling Design”. The number of points can vary, but the 120 points option is preselected. This could be easily adjusted to 150 or any other reasonable number. Once the location of the output shapefile has been specified, click “OK” to run the tool (Figure 4.3).

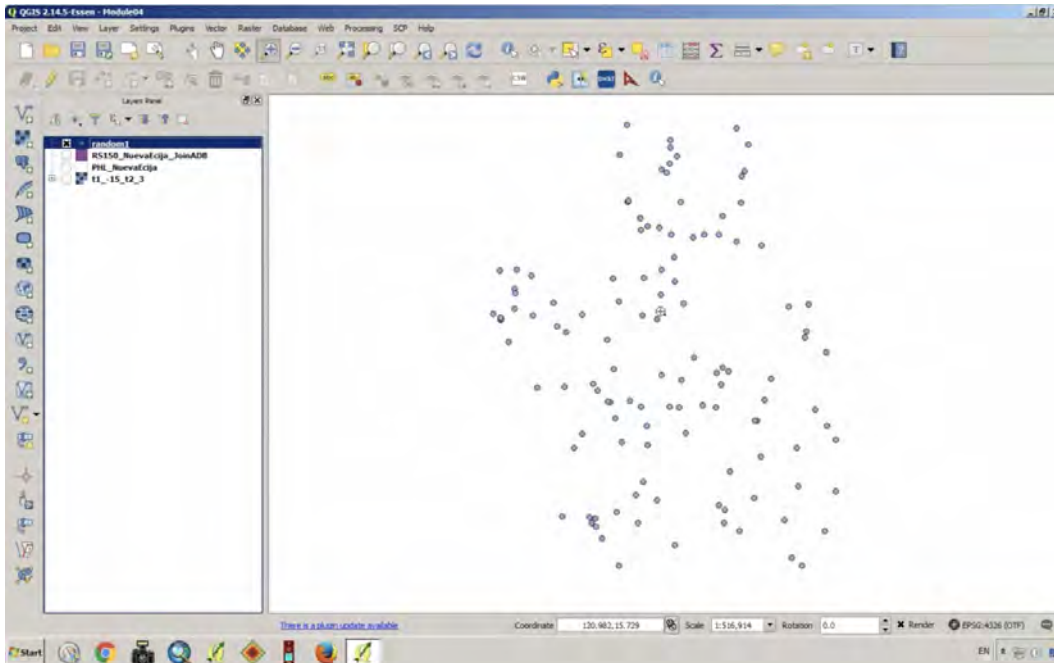
The results, by definition, will be random. The sample points generated in this example are shown in Figure 4.4.

Figure 4.3: Random Selection of Points in QGIS



Source: Screen shot generated by Asian Development Bank staff, 2016. Manila.

Figure 4.4: Random Sample Points in QGIS



Source: Screen shot generated by Asian Development Bank staff, 2016. Manila.

### 4.1.3 Projecting the output to UTM51N

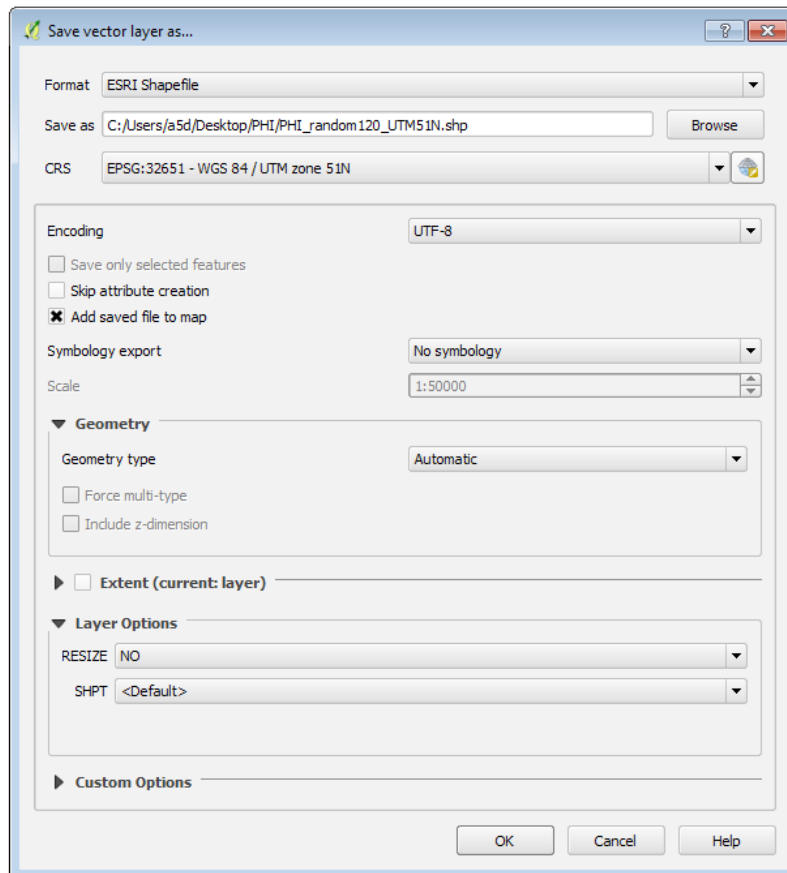
In order to make a mesh of 200 m x 200 m pixels to be used for field work, the shapefile containing the random points generated above must be converted to a “projected” coordinate system. The original GADM shapefile is in a “geographic” coordinate system that uses the World Geodetic System (WGS) 1984 datum. The units of measurement are in decimal degrees, so any distance measurements will be in the (virtually) meaningless unit of degrees. To do proper distance calculations, as with the buffer tool that soon follows, the data must be projected into a coordinate system that uses meters and does a good job of preserving distance information. The UTM system is a good

compromise that has found widespread use around the world.

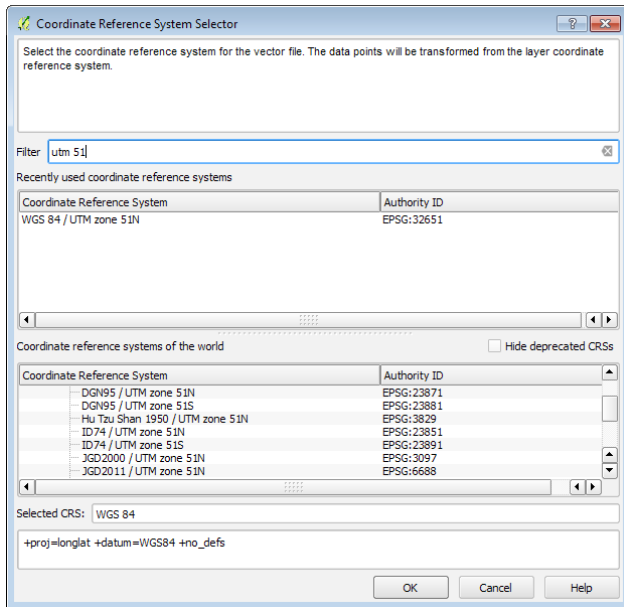
A shapefile can be reprojected quite easily in QGIS. Simply right click on the layer (the shapefile of interest in the “Layers Panel”) and select “Save as”. The dialog box shown in Figure 4.5 should open:

The name and location of the file to be saved can be specified by entering them into the “Save as” window. The Coordinate Reference System (CRS) can be selected by clicking on the small globe icon. UTM 51 can be found by typing in “UTM 51” as shown in Figure 4.6

**Figure 4.5: Reprojecting the Image to Universal Transverse Mercator in QGIS**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

**Figure 4.6: Selecting the Coordinate Reference System in QGIS**

Source: Screen shot generated by Asian Development Bank staff, 2016. Manila.

The WGS 84 / UTM zone 51N option can then be selected. Back in the “Save vector file as” dialog box, click “OK” to create a new shapefile. It will still contain the same 120 random points and be usable in the forthcoming steps, but will not have a projection of UTM51N.

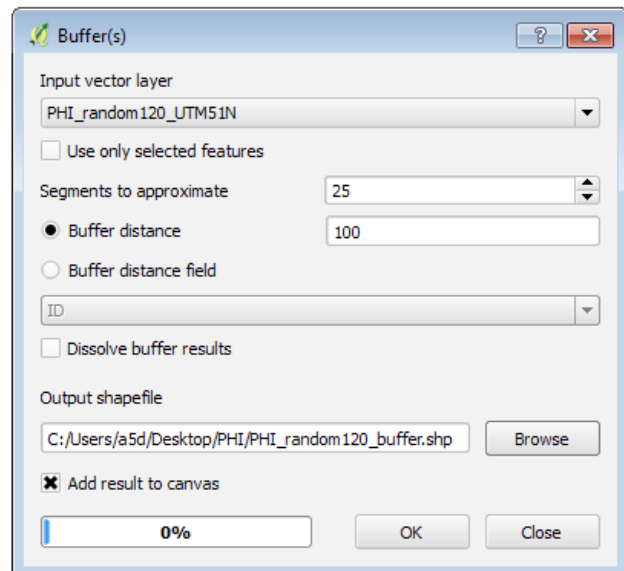
#### 4.1.4 Executing the Vector | Geoprocessing Tools | Buffer Tool

The random points must be converted from 1-dimensional point features into 2-dimensional polygons, in this case, 200 m by 200 m squares, for use in selecting sampling sites for field surveys. The “Buffer” tool (located in the “Vector” menu under “Geoprocessing tools”) should be opened (Figure 4.7). The “Input vector layer” should be specified as the UTM51N version of the random points shapefile. “Segments to approximate” can be 25 for this type of

operation. The “Buffer distance” should be 100. This is 100 m and is the distance in all directions from the central point, i.e., a circular buffer with a radius of 100 m will be created. Once the output shapefile name and location are specified, click “OK”. Zooming in on some of the individual buffers in the output file reveals their circular nature, as shown in Figure 4.8.

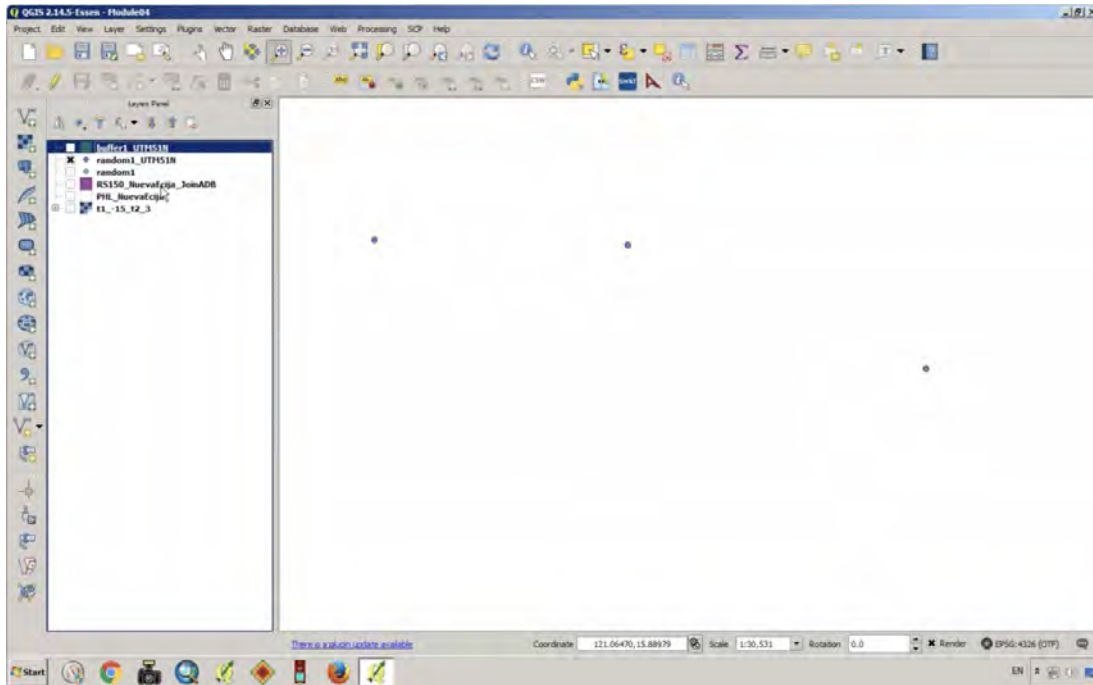
#### 4.1.5 Executing Vector | Research Tools | Polygon from Layer Extent Tool

The final step to get the 200 square meter mesh of 120 points is to open the “Layer Extent” tool located in the “Vector” menu under “Research Tools.” This dialog box requires the user to specify the “Input layer” (which refers to the buffer shapefile created). The user should also be careful to ensure that the option “Calculate extent for each feature separately” is checked. Once the output polygon shapefile name and location are set, click “OK” as shown in Figure 4.9.

**Figure 4.7: Using the Buffer Tool in QGIS**

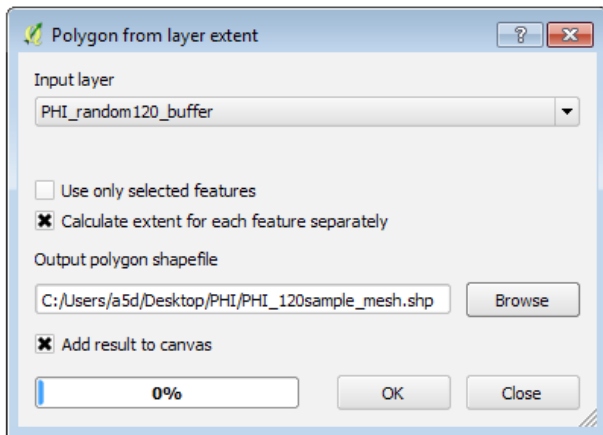
Source: Screen shot generated by Asian Development Bank staff, 2016. Manila.

Figure 4.8: Buffered Random Sample Points in QGIS



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Figure 4.9: Using the Polygon from Layer Extent Tool in QGIS



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

The output, zoomed in to a certain degree, and after changing the default display properties to make the polygons outlined instead of filled, should look similar to the image in Figure 4.10, noting that the points are randomly distributed and will be in different locations for different users.

By right-clicking on this final shapefile and using the “Save as” option, the file could be saved as a Keyhole Markup Language Zipped (KML) file.

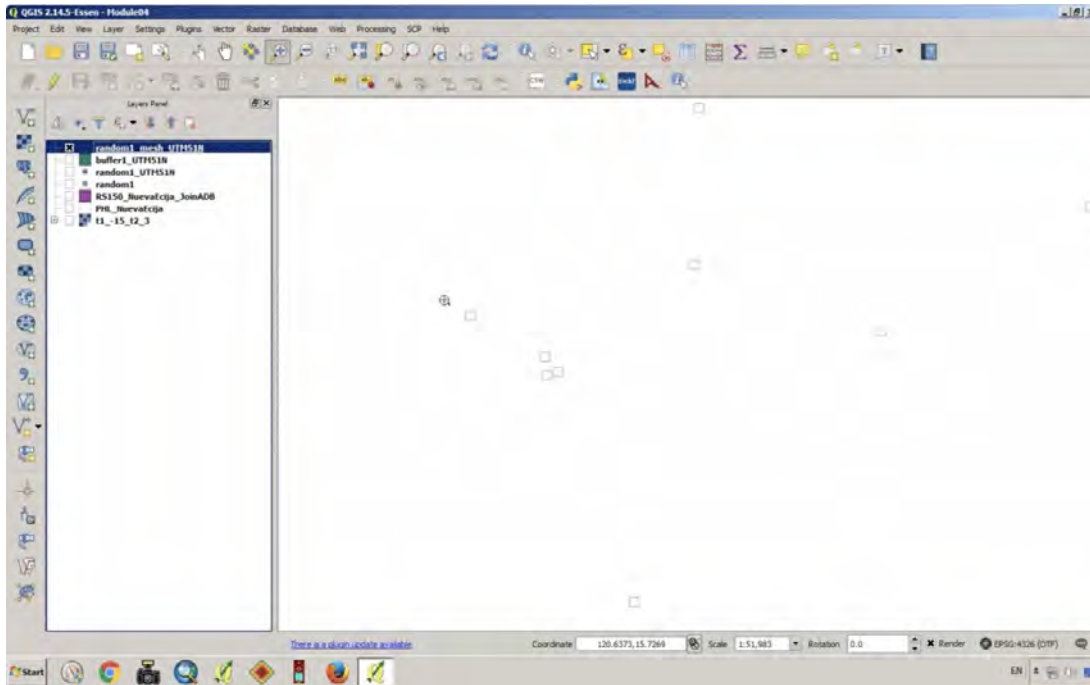
## 4.2 Using Google Maps within QGIS

One of the convenient features of QGIS is the ability to directly view satellite imagery, road data, etc., available from providers such as Google inside the GIS window itself. Normally, users will use Google Earth for this type of work (as described later in this manual). However, it is possible to also view images in QGIS.

First, the user must have the OpenLayers plugin installed. (If not already installed, the user can navigate to the “Plugins” menu, enter “OpenLayers”, and install. Note that QuickMapServices is an alternative plugin that might give some users better performance.) Once installed, go to the “Web” menu, then “OpenLayers plugin”, then “Google Maps”, then “Google Satellite”, as shown in Figure 4.11.

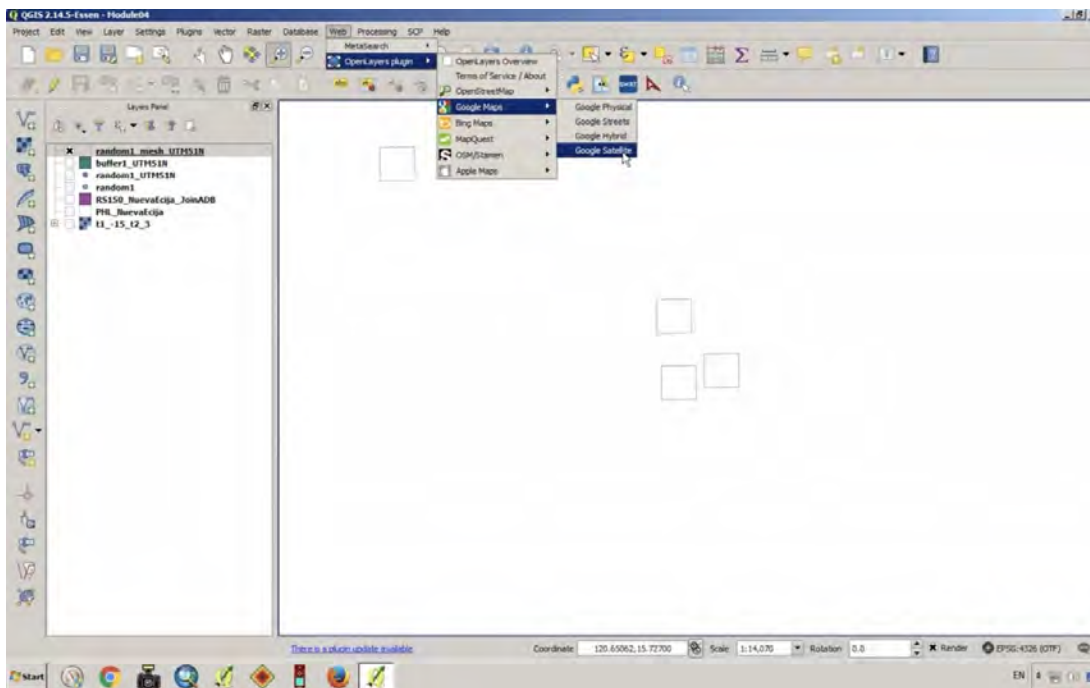


Figure 4.10: Random Sample Point after Using the Buffer Shapefile Function in QGIS



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Figure 4.11: Installing the OpenLayers Plugin in QGIS



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

An internet connection is required. Once the satellite layer is loaded, the user might need to adjust the order of layers in the “Layers Panel” to ensure that the newly created random mesh shapefile appears on top. It should appear as in Figure 4.12.

This is a zoomed-in view of one of the randomly sampled mesh polygons. Later in this chapter, a method of using Google Earth and PowerPoint (or OpenOffice) are given for constructing the maps to be used in the field survey. Here, it is simply noted that similar functionality exists for those able to use the OpenLayers plugin in QGIS.

### 4.3 Paddy Area Field Validation Ground-Truthing

The main objectives for conducting ground-truthing activities are to compare the paddy area estimates derived from the ground-truthing activity with the estimates resulting from INAHOR-AD software using synthetic aperture radar (SAR) data

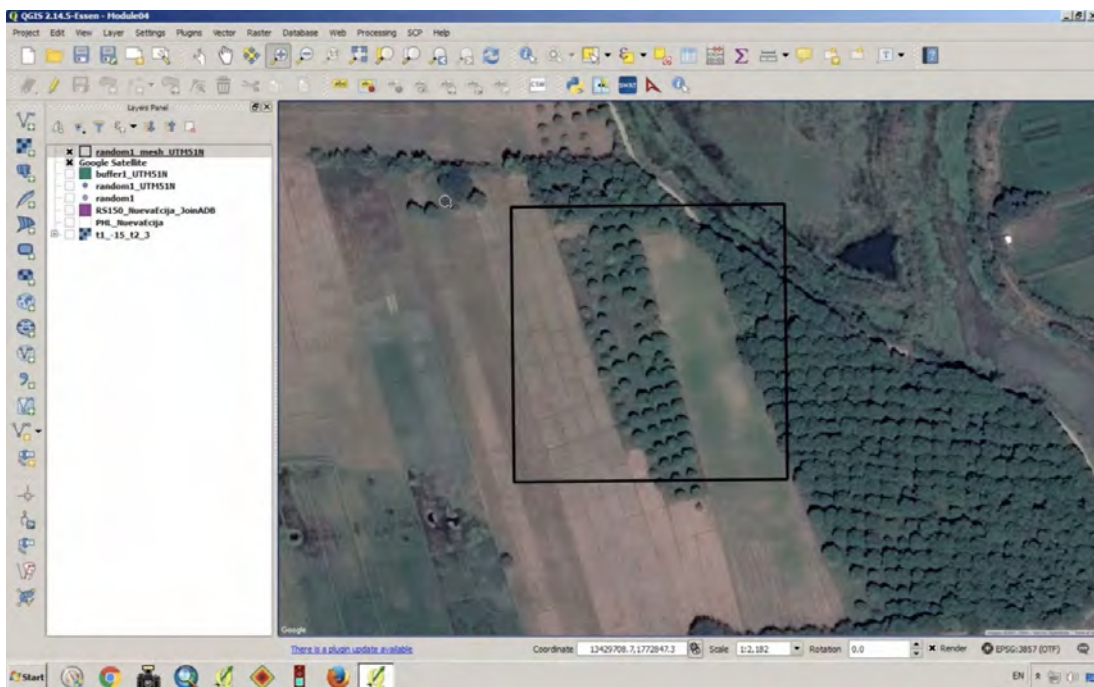
from Advanced Land Observation Satellite-2 (ALOS)-2)-2, and to use the paddy area estimates derived from the ground-truthing activity as a basis for adjusting the threshold values used in the INAHOR-AD software. It is essential for any project’s successful implementation that there is thorough planning of all activities before and during the conduct of the actual field validation survey.

## 4.4 Pre-Field Survey Preparations

### 4.4.1 Selecting the Sample Meshes

For the purposes of this handbook, and as was practiced in the four countries as part of ADB’s project, the ground-truthing field survey was done on 120 randomly selected sample pixels or meshes of 200 m x 200 m. The selection of the sample meshes was done using QGIS software, and the resulting sets of sample meshes were saved as a single Keyhole Markup Language (KML) file, which can be visualized in Google Earth. During the conduct

Figure 4.12: Using Google Maps within QGIS



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

of the actual field survey, there may be instances where the sample meshes are inaccessible due to flooding, features of the land area (e.g. forested area, mountainous area), security reasons, or other unforeseen events, hence additional sample meshes were also selected.

#### 4.4.2 Replacing Inaccessible Sample Meshes

In cases when sample meshes are inaccessible, a set of replacement meshes is prepared. In the first instance that a sample mesh is deemed inaccessible and needs to be replaced, the first mesh from the list of replacement meshes generated is taken as a replacement. If another sample mesh needs to be replaced, then the next mesh on the list should be used as replacement sample mesh. To illustrate, Figure 4.13 presents a list of 20 sample meshes (highlighted in yellow) and 10 replacement meshes in the pilot study in Nueva Ecija, Philippines. If, for example, sample mesh “68064” was inaccessible due to safety issues, it should be replaced with the first replacement mesh, “151503”. If another sample mesh becomes inaccessible, say, sample mesh “60216”, then it should be replaced by the replacement mesh “75124”.

#### 4.4.3 Printing the Field Survey Maps

The survey maps—which include maps at the provincial level, the district or municipality or commune level, and the mesh level—should be prepared before going out into the field. These maps will serve as a guide to field personnel in locating the sample meshes, in addition to navigating to the sample meshes using Map Plus installed on the users’ iPads. The printed maps will likewise be used in recording the actual conditions observed on the field.

To prepare the survey maps for printing, use Google Earth Pro to open the KML file containing the 120 sample meshes generated with QGIS. Take

a screenshot of the survey map at the provincial level, at the district level and the mesh level, and the replacement meshes. Next, paste the images into Microsoft PowerPoint or Open Office Impress. Each page in the PowerPoint or Impress file created will contain one screenshot of the specific target area or sample mesh.

In the case of Nueva Ecija, Philippines, screenshots were taken for the province, 28 municipalities, 120 sample meshes, and 30 replacement meshes. Figure 4.14 presents a screenshot of the mesh-level map for Nueva Ecija, Philippines.

Figure 4.13: Sample and Replacement Meshes in Nueva Ecija, Philippines

	A	B	C	D	E	F	G	H
1	id	x_min	x_max	y_min	y_max	x_shuffle	order	
2	171394	120.827	120.829	15.4004	15.4022	0.1050465	1	
3	56393	121.14	121.142	15.8882	15.89	0.1126509	2	
4	197336	120.858	120.859	15.2906	15.2924	0.1240255	3	
5	34681	121.074	121.075	15.98	15.9818	0.1899252	4	
6	188378	120.798	120.8	15.3284	15.3302	0.2642188	5	
7	151504	120.98	120.982	15.485	15.4868	0.2682018	6	
8	75123	121.194	121.196	15.809	15.8108	0.282826	7	
9	36811	121.083	121.084	15.971	15.9728	0.315625	8	
10	68064	120.728	120.73	15.8378	15.8396	0.3157726	9	
11	74269	121.187	121.189	15.8126	15.8144	0.3982567	10	
12	13867	121.093	121.095	16.0682	16.07	0.4117918	11	
13	65309	121.124	121.126	15.8504	15.8522	0.4292975	12	
14	75548	121.194	121.196	15.8072	15.809	0.4718227	13	
15	60216	121.137	121.138	15.872	15.8738	0.5054464	14	
16	221992	120.868	120.87	15.1862	15.188	0.5317219	15	
17	199908	120.897	120.899	15.2798	15.2816	0.5360423	16	
18	13442	121.093	121.095	16.07	16.0718	0.587027	17	
19	199909	120.899	120.901	15.2798	15.2816	0.6005678	18	
20	37236	121.083	121.084	15.9692	15.971	0.6197374	19	
21	56375	121.108	121.11	15.8882	15.89	0.6628211	20	
22	151503	120.978	120.98	15.485	15.4868	0.6910265	21	
24	75124	121.196	121.198	15.809	15.8108	0.7052671	22	
25	35105	121.072	121.074	15.9782	15.98	0.7665775	23	
26	171393	120.825	120.827	15.4004	15.4022	0.8164247	24	
27	213084	120.899	120.901	15.224	15.2258	0.8249348	25	
28	184671	121.011	121.012	15.3446	15.3464	0.8716875	26	
29	222000	120.883	120.885	15.1862	15.188	0.8872753	27	
30	213087	120.904	120.906	15.224	15.2258	0.8961869	28	
31	221991	120.867	120.868	15.1862	15.188	0.8995243	29	
32	195279	120.98	120.982	15.2996	15.3014	0.9331632	30	

Source: Remote Sensing Technology Center of Japan. 2015. PowerPoint presentation developed for a training workshop in field ground-truthing. Tokyo.



**Figure 4.14: Preparing Printed Field Survey Maps in Nueva Ecija, Philippines**



Source: Remote Sensing Technology Center of Japan. 2015. PowerPoint presentation developed for a training workshop in field ground-truthing. Tokyo.

Once screenshots of the survey maps for all municipalities and sample meshes are copied, edit the maps in PowerPoint or Impress by inserting other necessary information such as the municipality names (for municipal-level maps) and mesh numbers (for mesh-level maps) for proper identification. In addition, insert a 16-panel submesh grid for all mesh-level maps, as shown in Figure 4.15. After completely

editing the survey maps, print the colored maps on Letter or A4 paper. The mesh-level maps should be printed in two copies: one for indicating the growth stage of rice for rice plots inside the sample mesh, and another for indicating the direction and numbering of field photos to be taken during the field survey. Notations to be made on the printed mesh-level maps will be discussed later in this chapter.

**Figure 4.15: Screenshots of Provincial, Municipal, and Mesh-Level Maps for Nueva Ecija, Philippines**



Source: Remote Sensing Technology Center of Japan. 2015. PowerPoint presentation developed for a training workshop in field ground-truthing. Tokyo.

#### 4.4.4 Preparing the Questionnaire

An example of the questionnaire used in the field validation survey in Nueva Ecija, Philippines is presented in Appendix 1. The survey questionnaire is composed of three sections.

- Section A: General Information
- Section B: Mixcel Information
- Section C: Plot Details

One survey questionnaire should be prepared for each sample mesh. Additional copies should also be prepared in case of replacements. Guides for properly accomplishing the questionnaire should be presented in the enumerator's manual accompanying the field survey questionnaire. The enumerator's manual for the field validation survey conducted in Nueva Ecija, Philippines is also presented in Appendix 1.

#### 4.4.5 Selecting Appropriate Technology for Field Surveys

During the early part of project implementation in Nueva Ecija, Philippines, it was considered necessary that global positioning system (GPS) or mobile digital devices be provided to field survey personnel. At the time of that study, the iPad mini 3 was determined as the best device in terms of navigation capability and GPS accuracy, but a more updated iPad mini 4 is now available in the market and should work for this activity.

GPS accuracy is important, especially during navigation to the sample mesh and when taking geo-tagged field photos. In addition to navigation capability and GPS accuracy, an important parameter used in the selection of a device best-suited to the project's requirements is the "time to first fix", a measure of how long it takes for the device to lock onto the required satellite's position. Cell signals and wifi networks also improve a device's accuracy in determining a geographic location. The device

measures the signal strength of all nearby networks and uses this information to triangulate its current location.

Detailed steps in preparing and setting up the iPads for the field survey are presented in Section 4.5.

#### 4.4.6 Planning Team Composition and Schedule

Selecting team members, assigning particular meshes to each team, and scheduling field visits are all tasks that need to be planned in advance. These preparations will ensure that all sample meshes will be visited and that no sample mesh will be visited twice or duplicated by two different teams.

Ideally, each team will be composed of one team leader and two members, each assigned the following tasks:

The team leader should be responsible for navigating and guiding the team to the coordinates of the sample mesh, based on the GPS reading on the Map Plus app installed on the iPad, and for taking field photos using the iPad to document the growth stage of rice at each sample mesh.

An enumerator or field coordinator should be responsible for handling the interview part of the survey, asking the questions on the questionnaire. As field coordinator, this person should also be responsible for coordinating with local officials ahead of the scheduled field visit, and for providing information to the other team members with regard the location of the sample meshes in the municipality or village.

A recorder should be responsible for handling the printed copies of the survey maps and the questionnaires, and for recording the responses and other relevant information on the questionnaire during the interviewing of farmers or key participants.



One supervisor should also be assigned for the overall management and supervision of the field survey.

The number of sample meshes assigned to each team will depend on the total number of meshes sampled and the number of teams formed. The number of days required to complete the field validation survey should also be considered. In the case of Nueva Ecija, for example, 6 teams were formed, with each team assigned to survey 20 sample meshes within 6 days of the survey period. Thus, approximately 3 to 4 sample meshes were expected to be surveyed by each team each day. In addition, mesh assignments should be made based on the proximity of the sample meshes to one another. Sample meshes can be assigned to each team based on the districts or municipalities where they are located. A sample form for team compositions and mesh assignments and a sample survey schedule form are presented on the field survey enumerator's manual in Appendix 1.

#### 4.4.7 Checking Survey Equipment and Materials

A checklist of all the tools and materials needed during the field survey should be prepared to make sure that everything is ready when teams go out to the field. Some sample meshes can be very far from main roads or central districts, so it is best for teams to ensure that all materials are ready and in working order. The following are some of the tools and materials that the teams may need to prepare before the field validation survey:

1. iPad mini 3 (one unit per team)



Photo credits: The Philippine Statistics Authority.

2. Power bank (one unit per team)



Photo credits: The Philippine Statistics Authority.

3. File clipboards and pen



Photo credits: The Philippine Statistics Authority.

4. Boots, cap or hat, raincoat



Photo credits: The Philippine Statistics Authority.

5. Printed copies of survey maps



Photo credits: The Philippine Statistics Authority.

6. Printed copies of survey questionnaires



Photo credits: The Philippine Statistics Authority.

The pictures above illustrate the equipment and tools needed to conduct field validation surveys.

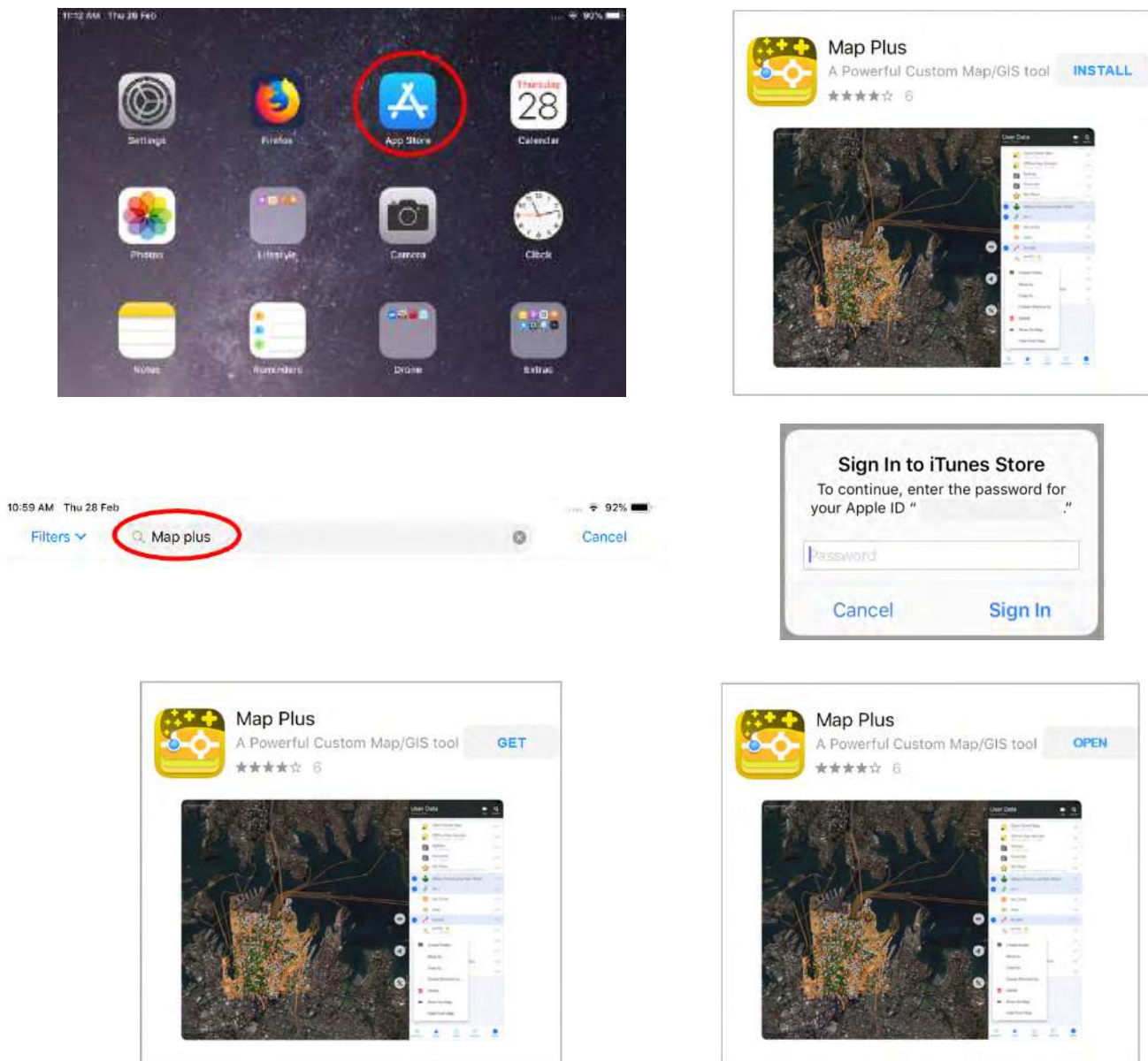
#### 4.5 Setting Up the iPads, Installing Apps, and Importing Files

The KML file containing the sample meshes and the replacement meshes generated using QGIS should be pre-loaded onto the devices before the field survey personnel proceed with field work.

Several apps including Map Plus, Google Earth or Google Maps (to be installed as an alternative for

other map tools), and Google Drive or iCloud (to be used in downloading the KML files to the iPads) should be installed and set up on the iPads provided to each field survey team. However, before the apps are installed, it is assumed that user accounts for the iPad and iCloud have been properly set up. Information on setting up the iPad and the steps in setting up iCloud can be found at the Apple Inc. website (<https://support.apple.com/en-us/HT208681>).

Figure 4.16: Installing Map Plus on the iPad

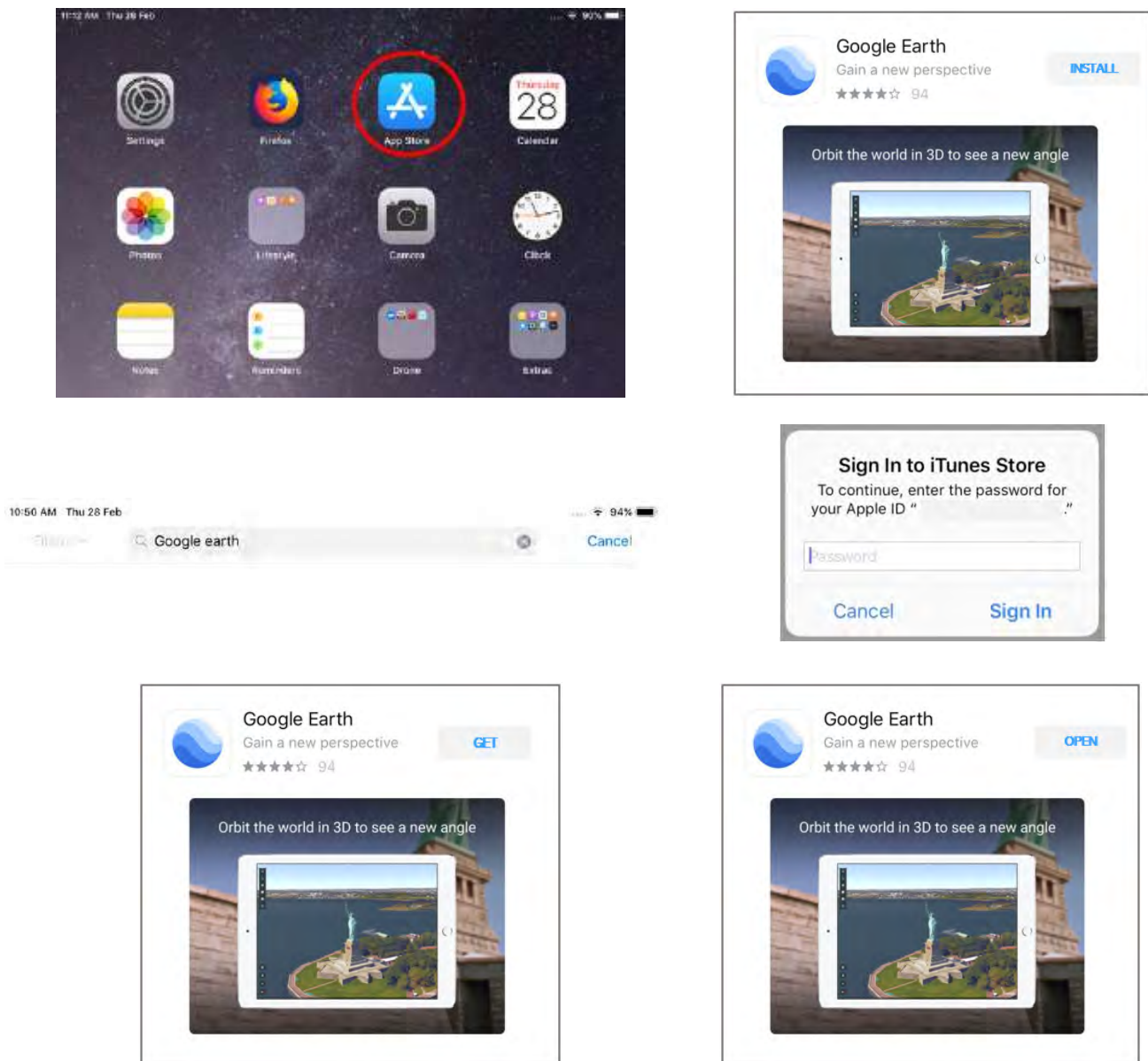


#### 4.5.1 Installing Map Plus and Google Earth from the App Store

To install Map Plus and Google Earth, access the App Store by tapping the “App Store” icon on the iPad’s home screen. On the “Search” bar, enter “map plus” to search for the Map Plus app, or “google earth” to search for the Google Earth app. Several

apps will appear on the screen. Tap “GET” on the appropriate Map Plus app or Google Earth app, then tap “INSTALL”. A window pops up requiring the user to sign in to the iTunes Store by entering an Apple user identification and password. After providing the required information, the app is installed on the iPad. Tap “OPEN” to access the installed app.

Figure 4.17: Installing Google Earth on the iPad

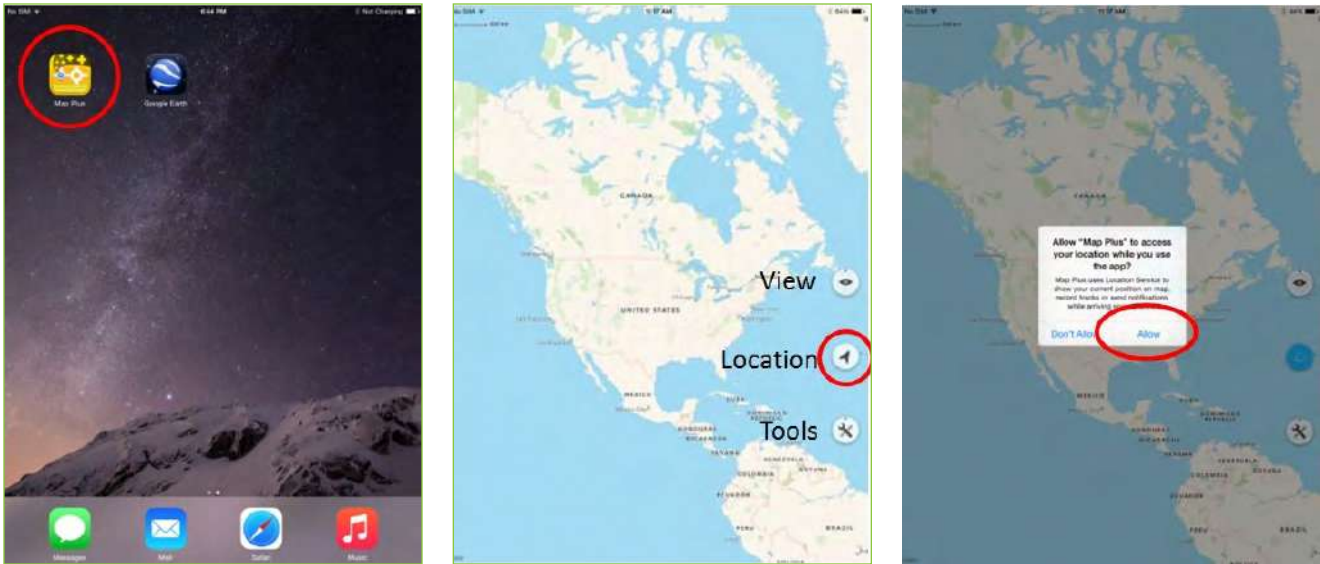




#### 4.5.2 Setting up Map Plus with the iCloud Drive

Open Map Plus by tapping the “Map Plus” icon on the home screen. Inside the Map Plus app, tap the “Location” icon to center your current position on the map. A window pops up asking for permission to access the user’s location. Tap “Allow” to give permission for access.

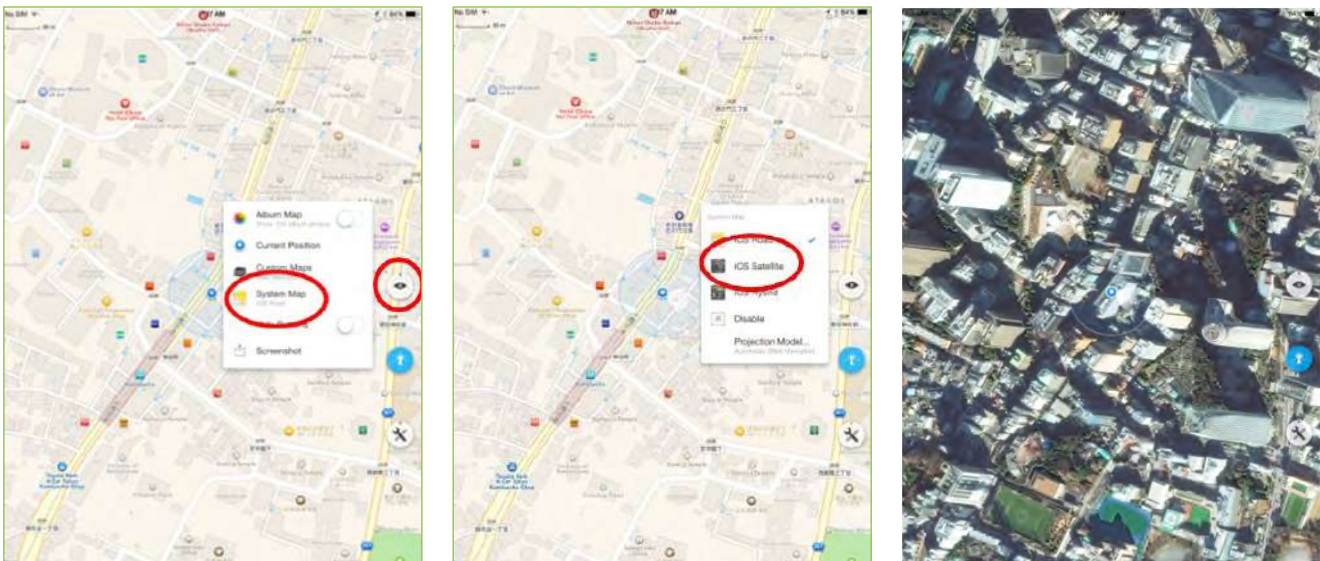
Figure 4.18: Setting User’s Current Location in Map Plus



Source: Remote Sensing Technology Center of Japan. 2015. PowerPoint presentation developed for a training workshop in field ground-truthing. Tokyo.

To set up and switch to a different system map, tap the “View” icon on the Map Plus main screen, and then choose “System Map” on the menu. Several available system maps will appear. The recommended system map to use is “iOS Satellite”, which uses Google Earth as the default map. For some countries with restricted access to Google Earth, other system maps may be used.

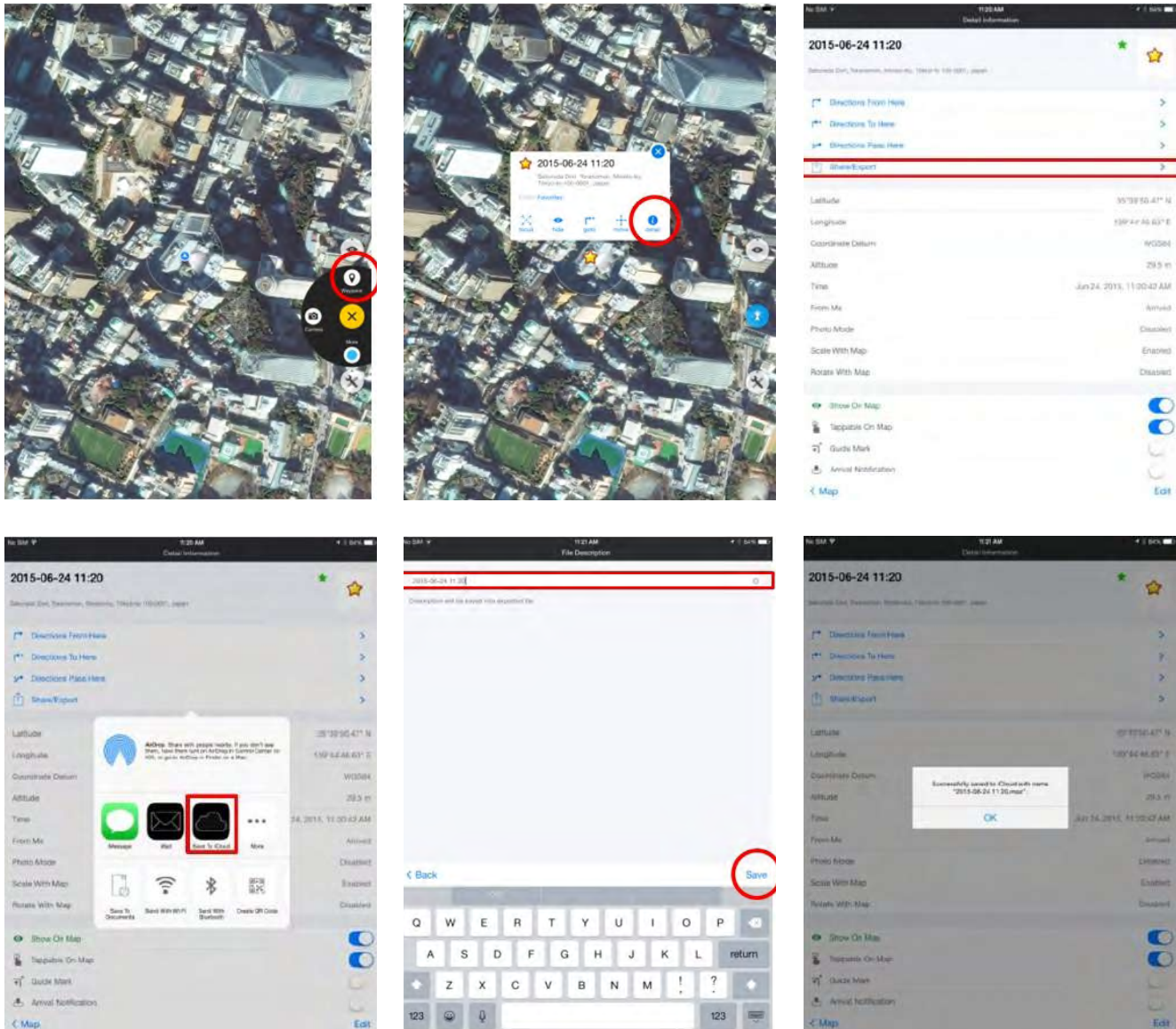
Figure 4.19: Setting the System Map in Map Plus



Source: Remote Sensing Technology Center of Japan. 2015. PowerPoint presentation developed for a training workshop in field ground-truthing. Tokyo.

After the system map is set up, the user's current location needs to be saved on iCloud. Press and hold the "Location" icon on the Map Plus main screen, and then slide to the "Waypoint" icon and release. This process saves the user's current location to the local drive. A window showing information on the user's current location pops up. Tap "detail" to access more detailed information about the location. On the window that appears, tap "Share/Export", and then tap "Save To iCloud". Rename the file and then tap "Save", which saves the file as a Miradi Project Zipped (MPZ) file.

Figure 4.20: Saving the User's Current Location Information on iCloud



Source: Remote Sensing Technology Center of Japan. 2015. PowerPoint presentation developed for a training workshop in field ground-truthing. Tokyo.



### 4.5.3 Uploading KML and KMZ Files to the iCloud Drive

The KML and KMZ files containing the sample meshes generated using QGIS need to be accessed and opened on the iPad using Map Plus. This will enable field personnel to use Map Plus in tracking the location of the sample meshes.

Using a desktop computer, open the iCloud website (<https://www.icloud.com/>). Sign in to iCloud using a registered Apple user identification and password, then click “Start Using iCloud”. Click the “iCloud Drive” icon to open iCloud Drive.

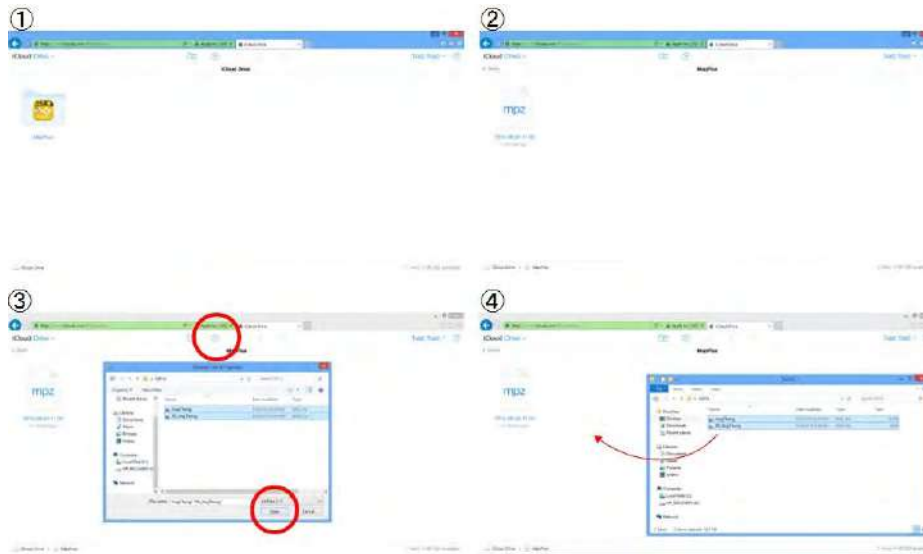
Figure 4.21: Signing in to iCloud



Source: Remote Sensing Technology Center of Japan. 2015. PowerPoint presentation developed for a training workshop in field ground-truthing, Tokyo.

Inside the iCloud Drive, open the Map Plus directory. Clicking the “Upload” icon on the top menu will open a window asking the user to select the files to be uploaded. Go to the directory where the KML and KMZ files containing the generated sample meshes are saved, select the files, then click “Open” to start uploading the files to the iCloud Drive. The KML and KMZ files may also be copied to the iCloud Drive by opening the directory where the files are located and then dragging and dropping (or copy-pasting) the files to the iCloud Drive.

Figure 4.22: Uploading or Copying the KML and KMZ Files to the iCloud Drive



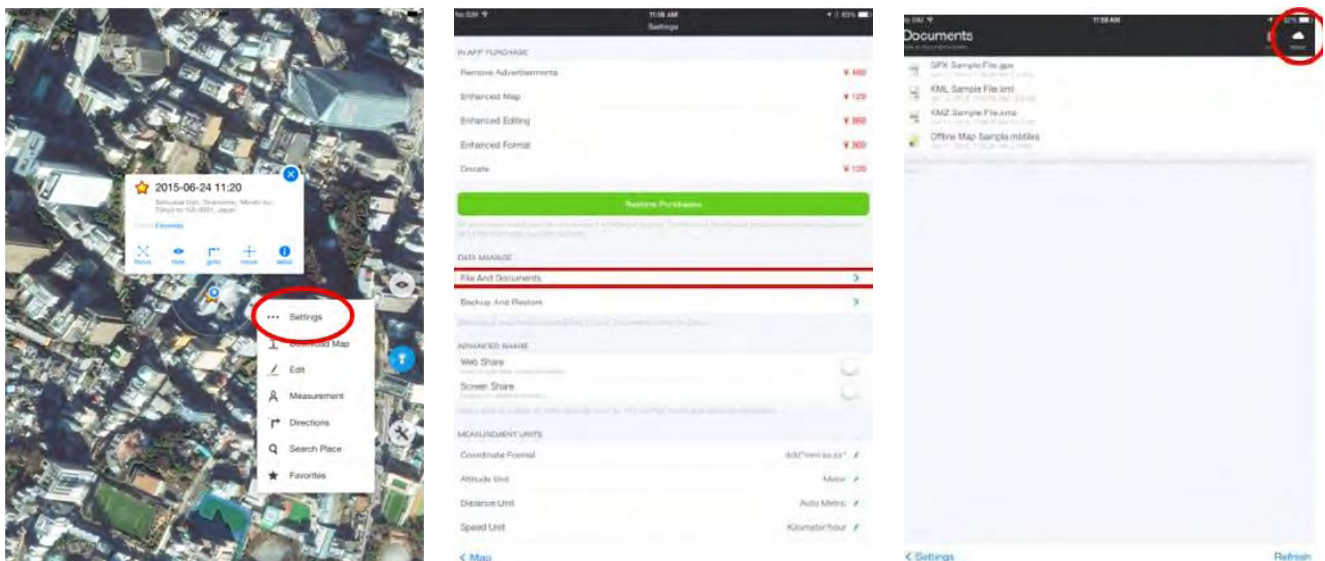
Source: Remote Sensing Technology Center of Japan. 2015. PowerPoint presentation developed for a training workshop in field ground-truthing. Tokyo.

#### 4.5.4 Importing KML and KMZ Files from the iCloud Drive to Map Plus

To access and open the KML and KMZ files of the generated sample meshes using Map Plus, the files should be exported from the iCloud Drive and saved to the local Map Plus drive on the iPad.

Tap the “Tools” icon on the Map Plus main screen, then choose “Settings”. On the settings window that opens, scroll and tap “File And Documents” under the “DATA MANAGE” section. This opens Map Plus’s document folder. Tap the “iCloud” icon on the upper right corner to open the iCloud folder in Map Plus.

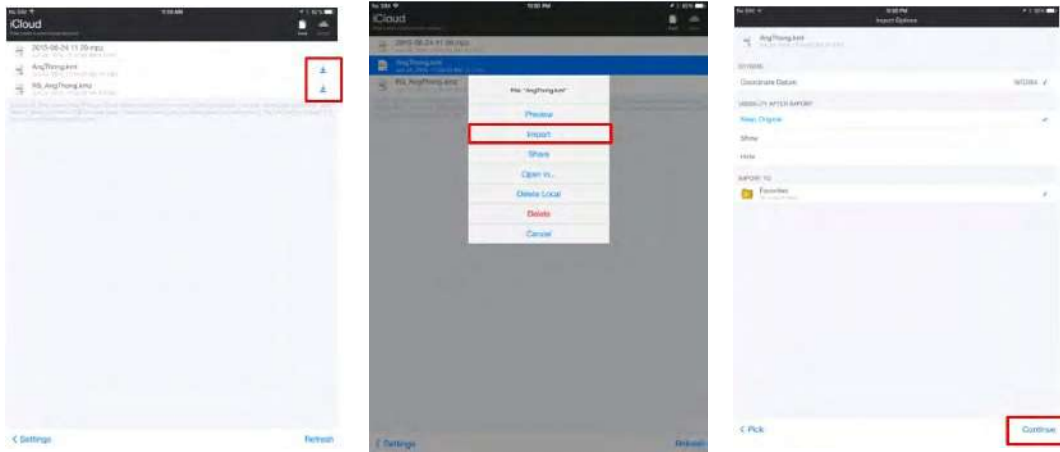
Figure 4.23: Accessing the iCloud Folder in Map Plus



Source: Remote Sensing Technology Center of Japan. 2015. PowerPoint presentation developed for a training workshop in field ground-truthing. Tokyo.

The iCloud folder in Map Plus should contain the KML and KMZ files of the generated sample meshes. To copy the files, tap the download icon on the right side of the files. At this point, Map Plus will make a local copy of the selected files. To import the files one at a time, tap the downloaded file, and then select “Import”. The “Import Options” window shows the directory to which the files will be imported. By default, the files are imported to the “Favorites” folder. Tap “Continue” to complete the process.

**Figure 4.24: Importing KML and KMZ Files from the iCloud Drive to Map Plus**

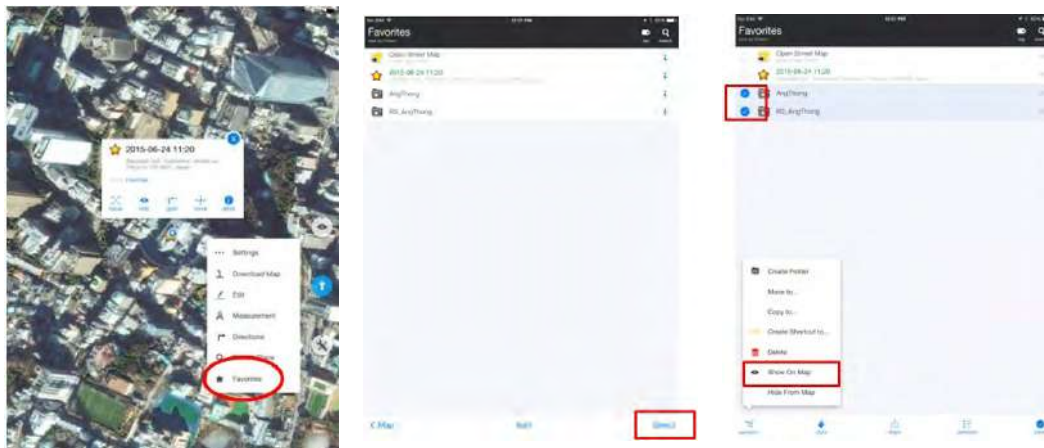


Source: Remote Sensing Technology Center of Japan. 2015. PowerPoint presentation developed for a training workshop in field ground-truthing. Tokyo.

#### 4.5.5 Opening KML and KMZ Files in Map Plus

Tap the “Tools” icon on the Map Plus main screen, then choose “Favorites”. On the “Favorites” window that opens, tap “Select” to activate file selection. Tick the KML and KMZ files, then tap “operation” on the lower left corner. Choose “Show On Map”, to show the selected files on the main view. In Figure 4.26, the sample meshes for Nueva Ecija, Philippines are shown.

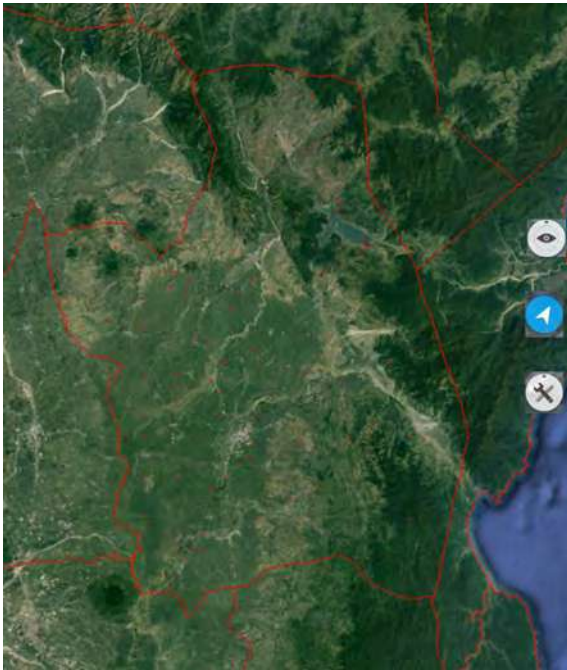
**Figure 4.25: Opening KML and KMZ Files in Map Plus**



Source: Remote Sensing Technology Center of Japan. 2015. PowerPoint presentation developed for a training workshop in field ground-truthing. Tokyo.



**Figure 4.26: Map Plus View of the 120 Sample Meshes for Nueva Ecija, Philippines**



Source: Screen shot generated by Asian Development Bank staff, 2016, Manila.

## 4.6 Ground-Truthing Field Work

### 4.6.1 Navigating to the Sample Mesh

The iPads used in navigating to the location of the sample mesh should be installed with a map tool for GPS tracking. Map Plus (Offline Map + KML Editor + GPS Recorder) provides information on the team's current location as well as the location of the sample meshes. The team leader uses Map Plus in providing directions and navigating to the target sample mesh. A more detailed description on how to use Map Plus to navigate to the location of the sample mesh is provided in Section 5.3 of Chapter 5.

Certain areas may not have good wireless internet service, so it is advisable that the teams cache the map data of the sample meshes onto the iPad in advance. The KML files containing the sample points assigned to each team should be loaded on the team's iPad before conducting the field survey.

**Figure 4.27: Navigating to the Sample Mesh**



Source: Asian Development Bank, 2015. PowerPoint presentation developed for a training workshop in field ground-truthing, Manila.

### 4.6.2 Taking Field Survey Photos


Once the teams reach the location of the sample mesh, photos of the landscape within the mesh, especially the paddy fields, should be taken to document the actual field conditions at the time of the ground-truthing field survey. The photos will be useful during the validation of results, where estimates of paddy areas based on the field survey are compared with the area estimates based on the INAHOR-AD results for each sample mesh.

There are three ways to take the field photos: (i) take photos from the four corners of the mesh; (ii) take photos from the north, then move clockwise; and (iii) take photos from the road. The direction from which the photos are taken should be written onto the printed maps and numbered from 1 to 8. These photographic methods are depicted in Figure 4.28. In cases where there are obstructions, such as buildings, houses, etc., blocking the view of areas within the mesh, it is best to take as many photos as possible from all vantage points.

**Figure 4.28: Methods of Taking Field Survey Photos**



Source: Remote Sensing Technology Center of Japan. 2015. PowerPoint presentation developed for a training workshop in field ground-truthing. Tokyo.

Take the field photos using Map Plus, so that the photos taken are geo-tagged, which means that geographical identification metadata are added to the photographs taken. To take photos using Map Plus, press and hold the “Location” icon , then slide to the “Camera” icon and release, as shown in Figure 4.29. This signals that the app is now in photo or video mode, and that field photos are ready to be taken.

Each team will be assigned to visit several sample meshes and will be taking numerous photos of each mesh. All of the photos taken will automatically be saved on the iPad assigned to each team. To ensure that the photos are properly organized, it is advisable that, before taking the field photos of each sample

**Figure 4.29: Taking Field Survey Photos Using Map Plus**

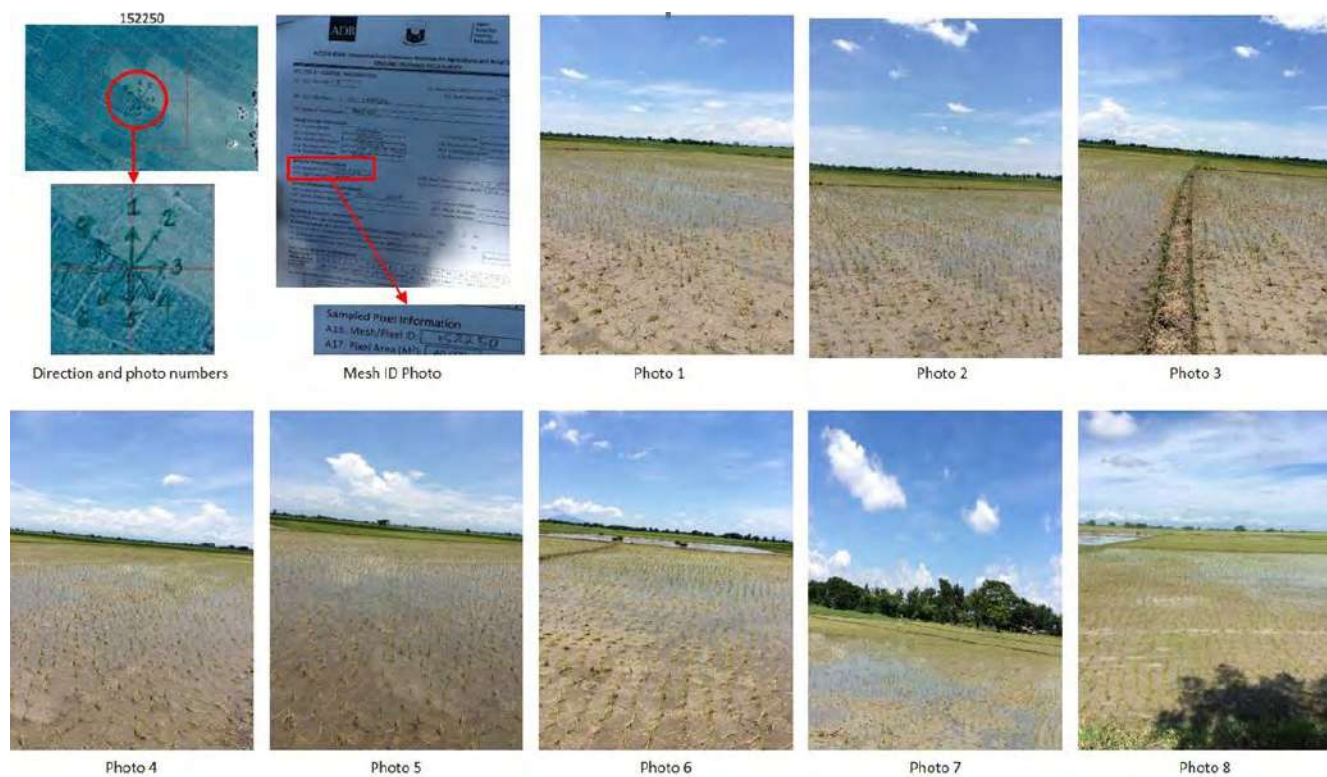


Source: Remote Sensing Technology Center of Japan. 2015. PowerPoint presentation developed for a training workshop in field ground-truthing. Tokyo.



mesh, the team member first takes a photo of that mesh's number on the questionnaire. This will act as a marker for the succeeding field photos taken and saved on the iPad. When taking field photos, the direction and numbering written on the printed map should be followed. Figure 4.30 shows an example of a set of field photos taken for sample mesh 152250 in Nueva Ecija, Philippines.

**Figure 4.30: Sample of Field Survey Photos Taken in Nueva Ecija, Philippines**



Source: Actual maps, questionnaire, and photos taken during the field validation survey in Nueva Ecija in 2015, Philippines.

#### 4.6.3 Filling Out the Field Survey Questionnaire

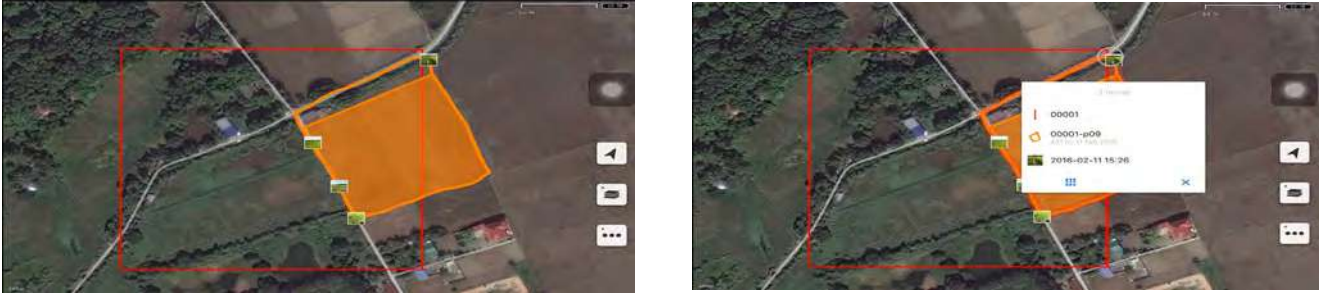
One questionnaire should be accomplished for every mesh included in the sample. Detailed instructions for enumerators on properly conducting the ground-truthing field survey, as well as guides to filling out the survey questionnaire, are presented in the enumerator's manual in Appendix 1.

#### 4.6.4 Exporting the Field Photos

Field photos taken using Map Plus may be downloaded to aid in determining the growth stages of rice planted within the mesh. These images are geo-tagged.

Tap the picture icon from the map. From the pop-up menu, select the picture to be downloaded.

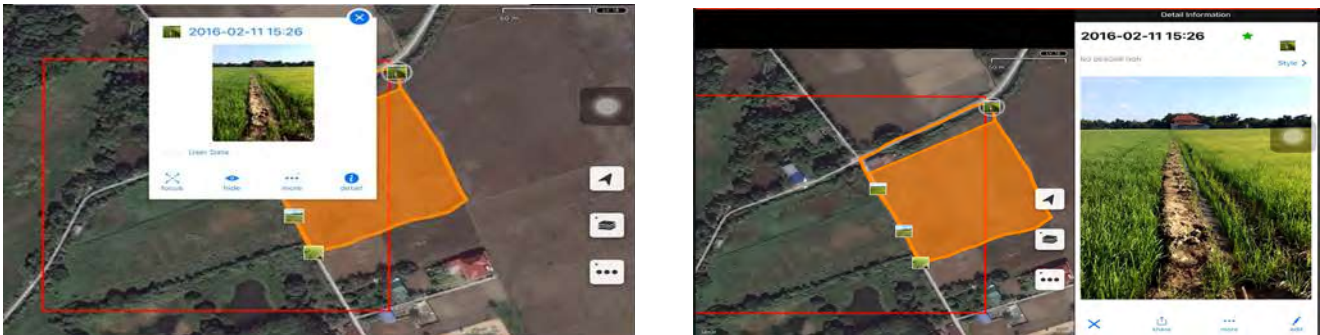
**Figure 4.31: Viewing and Selecting All Geo-Tagged Field Photos**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Tap on “detail” to show the picture’s detailed information, then tap on the “share” icon at the bottom of the menu.

**Figure 4.32: Exporting Field Photos**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Select the appropriate platform for the download. Change the file name and description as necessary.

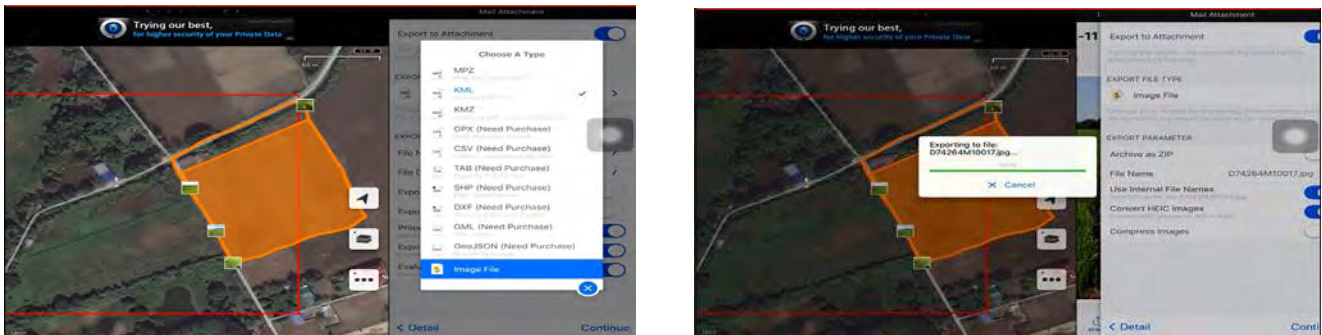
**Figure 4.33: Selecting Platform for Download**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Choose the type of file format to be exported. For geo-tagged images, select “Image File” then “Continue” to proceed.

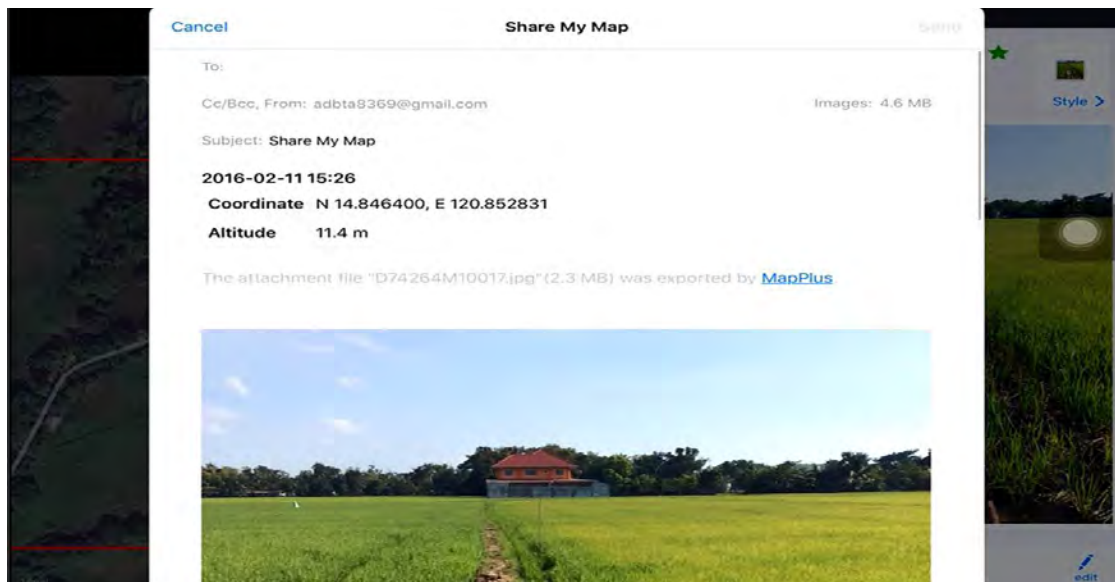
Figure 4.34: Selecting File Format



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

The file may also be sent as an email with the image capture date, coordinates, and altitude.

Figure 4.35: Exporting Image Files as Email



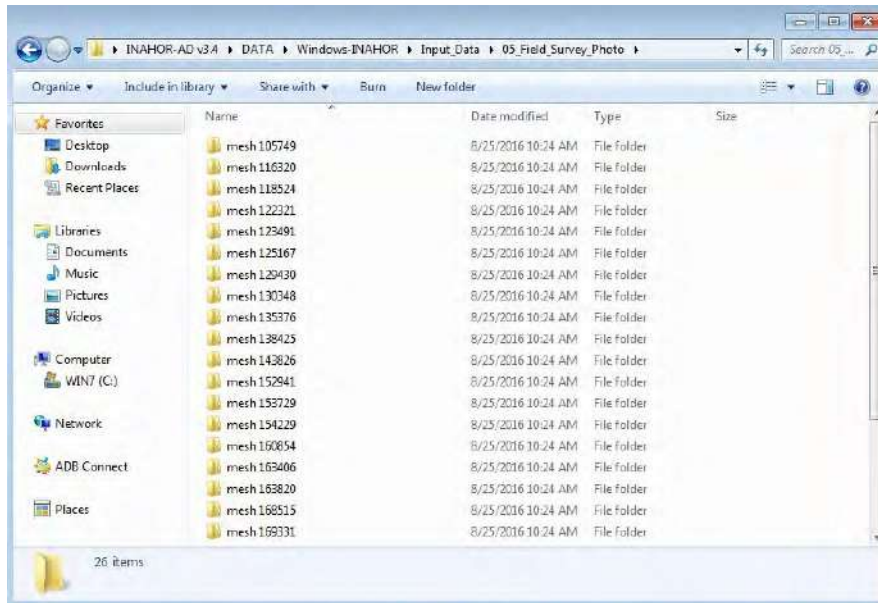
Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.



## 4.7 Field Survey Data Management

After completion of the ground-truthing field survey, the data should be encoded on a data entry program in Microsoft Excel or OpenOffice Calc. Data from the ground-truthing field survey will be used to assess the accuracy of rice area estimates derived using the INAHOR-AD software. Photos taken during the field survey likewise need to be organized for easy referencing during data validation. The photos can be organized such that all field photos taken from one sample mesh are saved in a designated folder identified using the mesh number, as presented in Figure 4.36.

**Figure 4.36: Organizing Field Survey Photos in INAHOR-AD**



Source: Screen shot generated by Asian Development Bank staff, 2016. Manila.

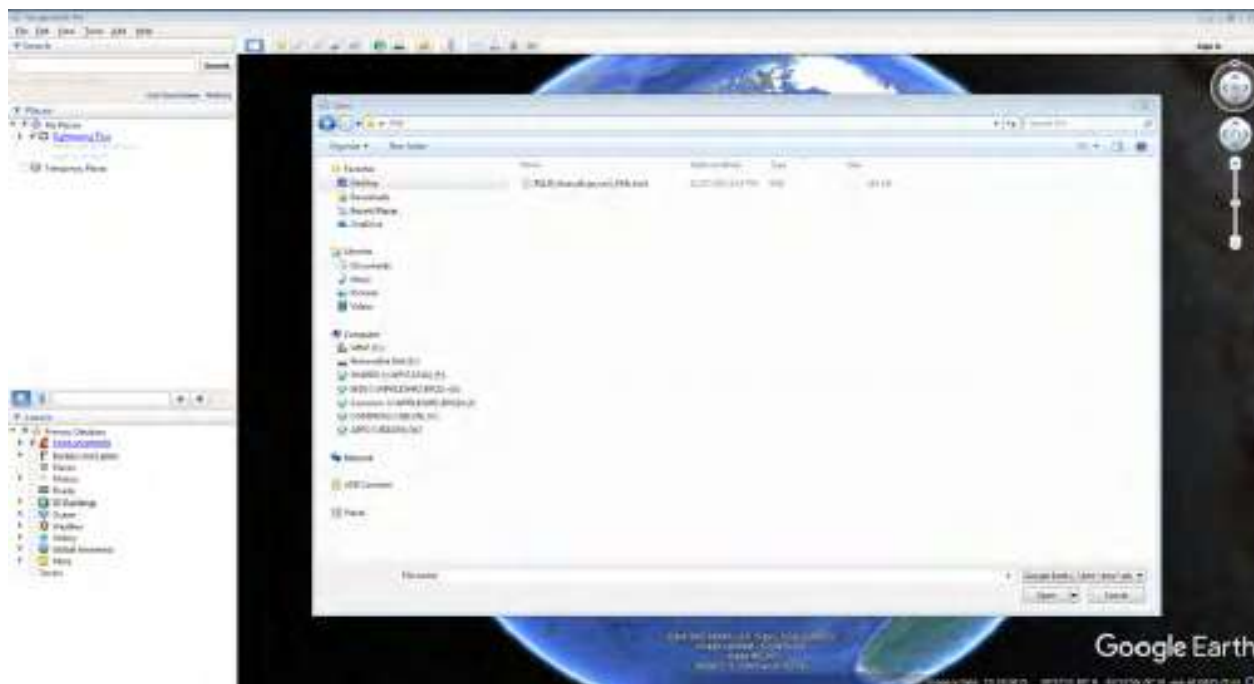
## 4.8 Digitization of Maps for Paddy Area Estimation

Using the information gathered during the ground-truthing field survey, identified paddy areas within the sample meshes are digitized using Google Earth Pro. Field survey personnel should be asked to take note of these areas using the printed field survey maps. Specific paddy areas inside the sample meshes should be marked on the printed maps.

Illustrations presented are from the actual digitization of paddy areas within sample mesh 122581 in Nueva Ecija, Philippines.

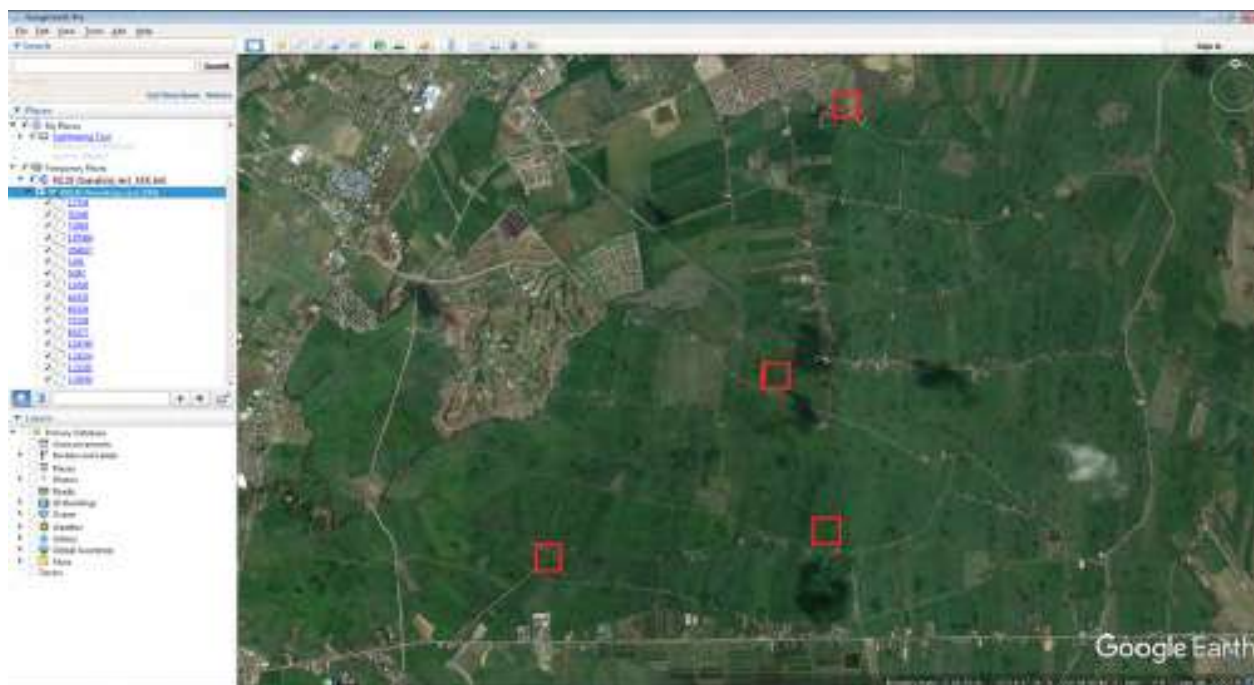
Open the KML file containing the boundaries of 120 sample meshes in Google Earth Pro, as shown in Figure 4.37 and Figure 4.38. Google Earth Pro will zoom in on the target area, in this case, the province of Nueva Ecija, with the sample meshes depicted as red dots. Zooming in on the red dots (by clicking a given dot itself or by clicking its mesh number in the “Places” menu) will show the sample meshes as 200 m x 200 m red squares.

Figure 4.37: Opening the KML File in Google Earth Pro



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Figure 4.38: Zooming In on Target Locations in Google Earth Pro

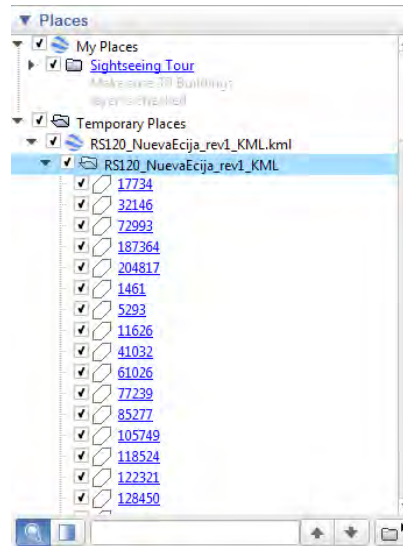


Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.



On the left menu of Google Earth Pro, expand the subfolders to reveal the mesh numbers contained in the opened KML file. Figure 4.39 shows the expanded list of sample meshes in Nueva Ecija. Digitization of the paddy areas within the sample meshes will be done for each sample mesh with identified paddy areas.

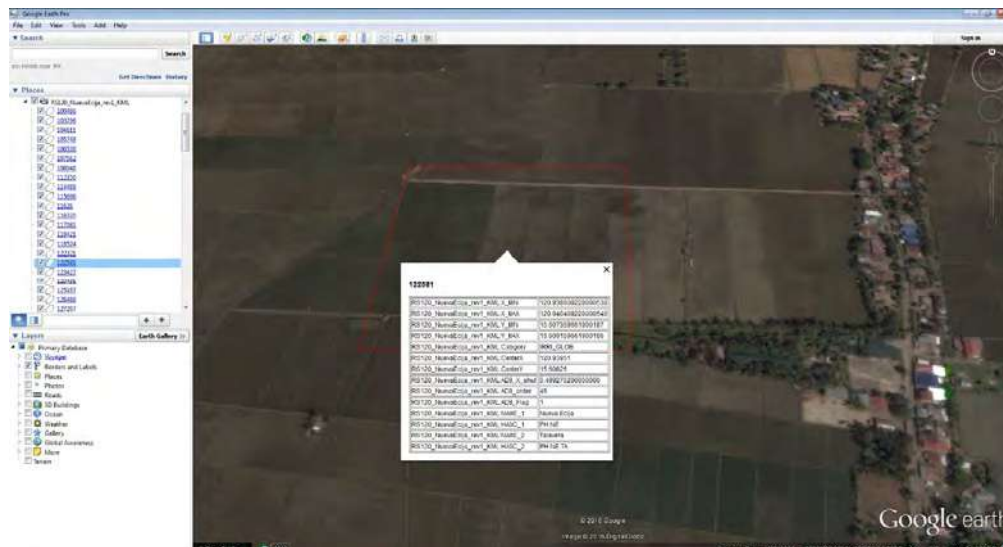
Figure 4.39: Expanding the Places Menu in Google Earth Pro



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

To initiate the digitization process in Google Earth Pro, double-click the sample mesh number for which digitization of paddy area will be done. This will direct Google Earth Pro to zoom in on the selected mesh, an example of which is shown in Figure 4.40.

Figure 4.40: Sample Mesh 122581 in Nueva Ecija, Philippines



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

During the field validation survey, enumerators will have been asked to put notations on the printed survey maps to indicate the specific areas within the mesh that are planted with rice. The notations on the printed survey maps will be used as basis in digitizing the rice areas using Google Earth Pro. Figure 4.41 shows an example of the printed survey map for mesh 122581 in Nueva Ecija, Philippines as used in the field validation survey. The notations “B5-5” indicate that the specific areas are rice areas that are in the “Growing-Maturing stage” as referenced in question B5 of the field survey questionnaire.

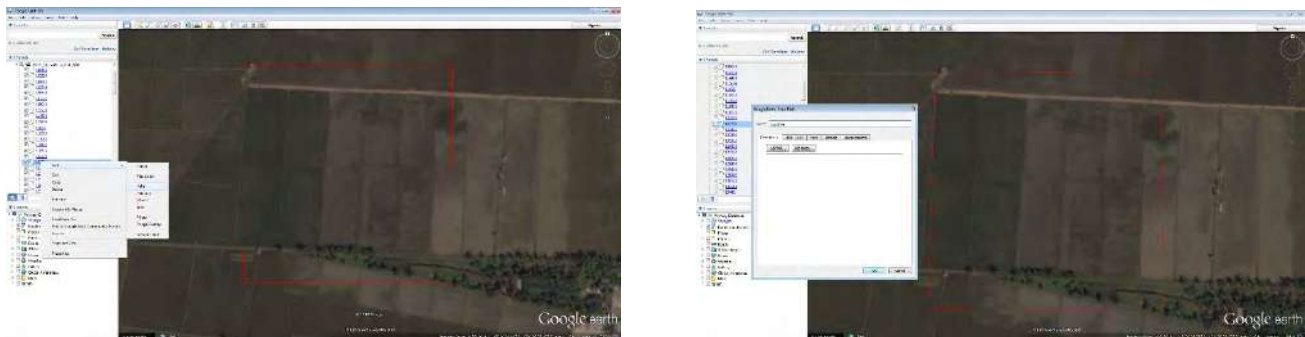
**Figure 4.41: Example of Field Survey Map for Mesh 122581 in Nueva Ecija, Philippines**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

To start the digitization process on Google Earth Pro, right-click on the mesh number of the nominated sample mesh, as shown in Figure 4.42. Select “Add”, then click on “Path”. A “New Path” window pops up, asking for the name of the new path to be created. In the example, the path is given the name “122581-a”. In most cases, several boundaries or paths covering rice areas within one sample mesh will be created, so it is best to assign a path name that includes the mesh number as well as a letter or number as an identifier.

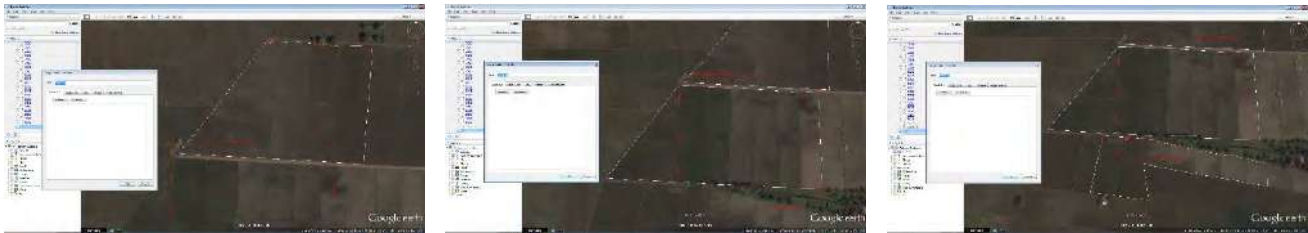
**Figure 4.42: Adding a Path or Boundary of Rice Areas within the Sample Mesh**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Once “OK” is clicked, a new item is created on the menu corresponding to the new path. Right-click on the path name and select “Properties”. An “Edit Path” window pops up, instructing the user to start tracing the rice area boundary. Mark the corners covering the rice area by clicking on the corners and excluding areas such as roads, rivers, or forests. It is best to trace the boundaries including rice areas outside the mesh, ensuring that the rice areas within mesh are covered by the path created. To illustrate, Figure 4.43 shows the digitized rice areas within mesh 122581 covering three separate paths or boundaries. As shown on the images in Figure 4.43, the points or corners on the path are highlighted by red dots while the path is in edit mode.

**Figure 4.43: Three Instances of Digitized Rice Areas Inside Mesh 122581**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

The paths created are saved as individual KML files. To save a specific path, right-click on the path name, then select “Save Place As”. Choose the file type “Kml” and save the path to a specific folder, as shown in Figure 4.45. It is best to create a folder where all the created paths will be saved.

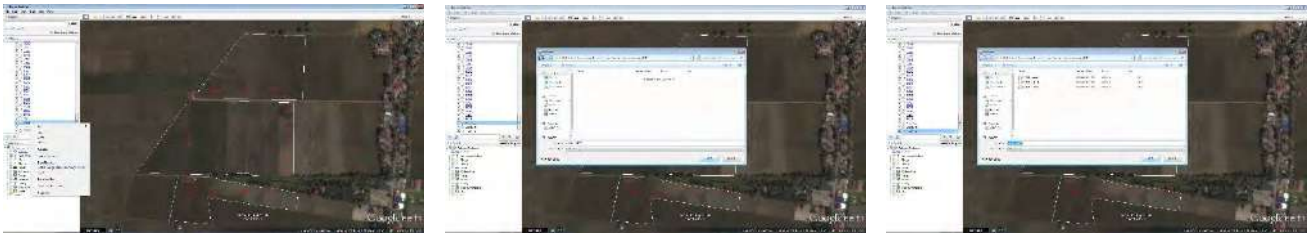
**Figure 4.44: Printed Field Survey Map with Notations, Compared to the Digitized Map**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

After saving all the created paths covering rice-planted areas on the sample meshes as individual KML files, create a compressed (zipped) file containing the saved KML files. The compressed file will be used in calculating the paddy area covered within each mesh.

Figure 4.45: Saving the Created Path as a KML File



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

## 4.9 Estimation of Paddy Areas Using QGIS

The examples presented in this section refer to the estimation of paddy areas in Nueva Ecija, Philippines.

### 4.9.1 Online Conversion to Global Positioning System Exchange Format (GPX) Using GPS Visualizer

Open the zip file “PHL\_track files.zip”. This file refers to the compressed file of all digitized paddy areas covering the sample meshes for Nueva Ecija, Philippines. Choose “.GPX” as the output format. Click “CONVERT”. Download the GPX file. Rename the file as “PHI track files.gpx”.

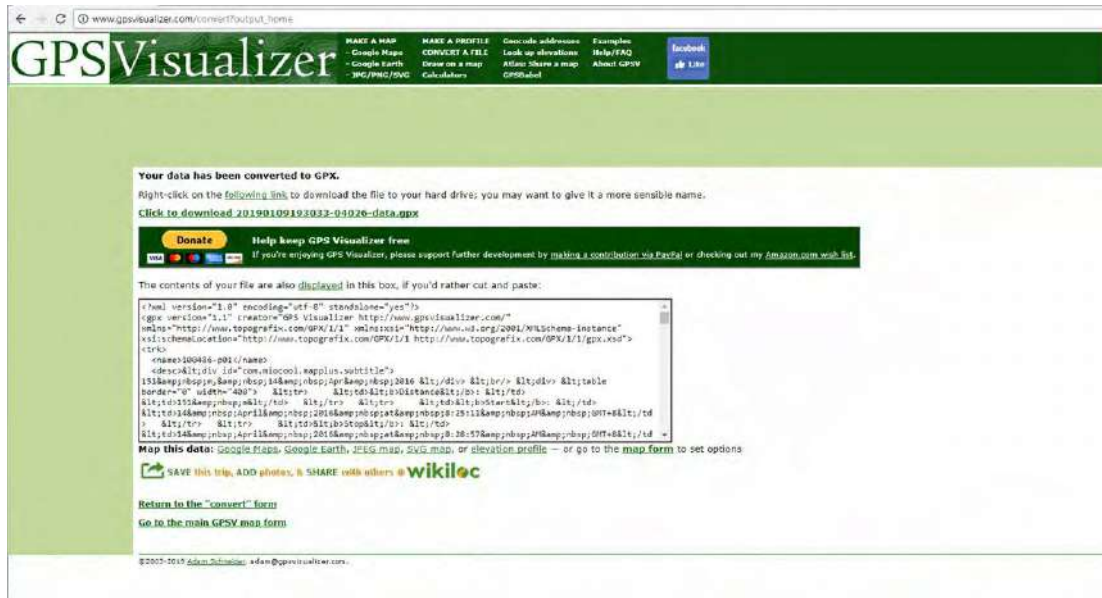
Figure 4.46: Online Conversion of KML files to GPX Using GPS Visualizer



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.



Figure 4.47: Downloading of GPX File

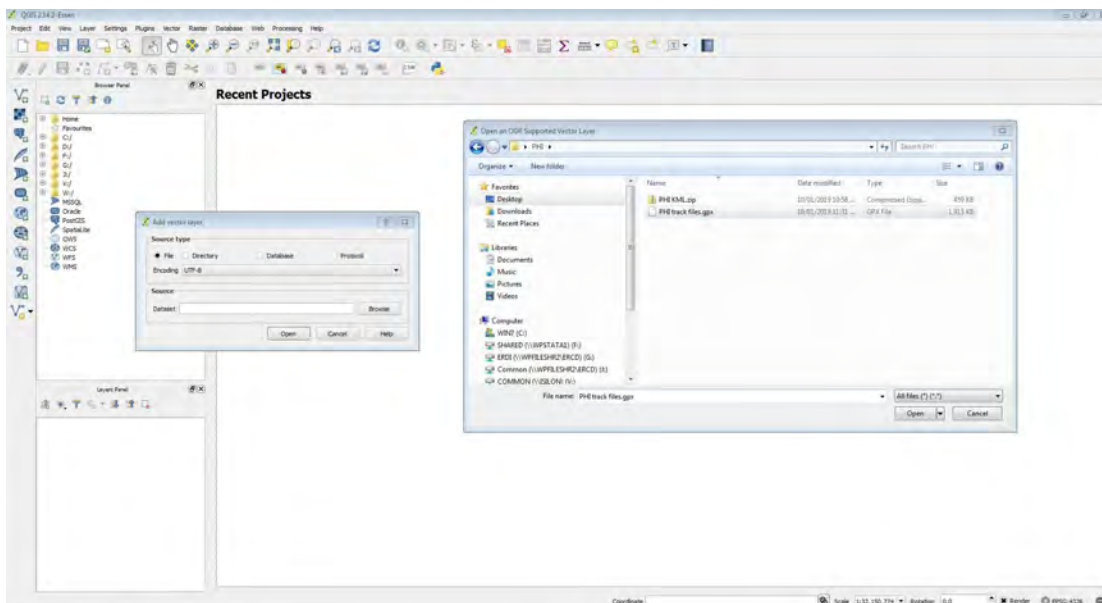


Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

#### 4.9.2 Steps in Area Calculation Using QGIS

Open the GPX file in QGIS, then add as VECTOR layer.

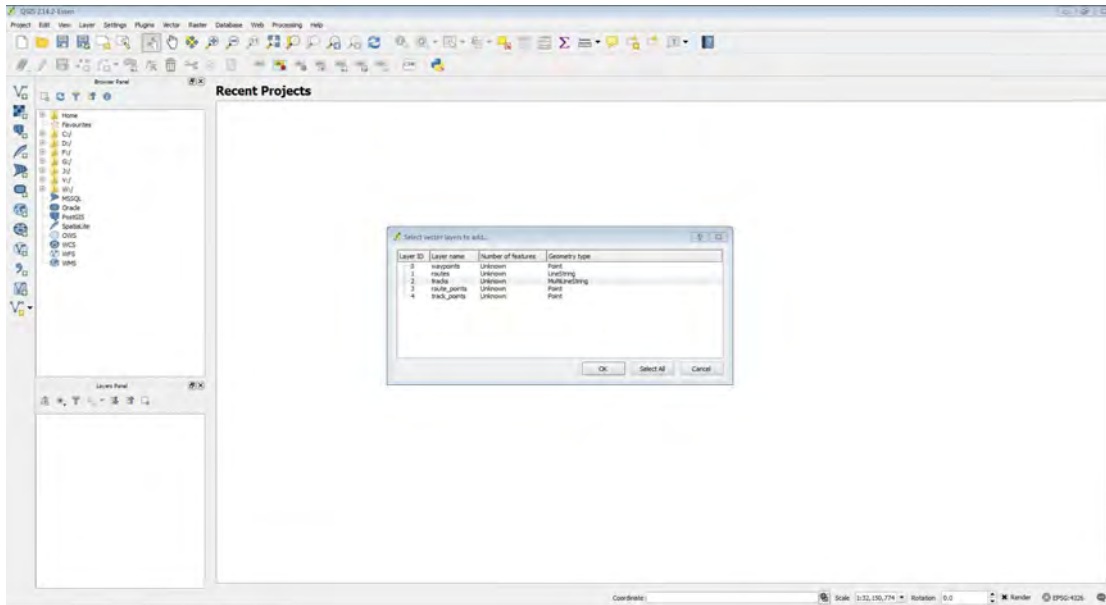
Figure 4.48: Opening a GPX File in QGIS



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Select “Layer ID 2” = “tracks”

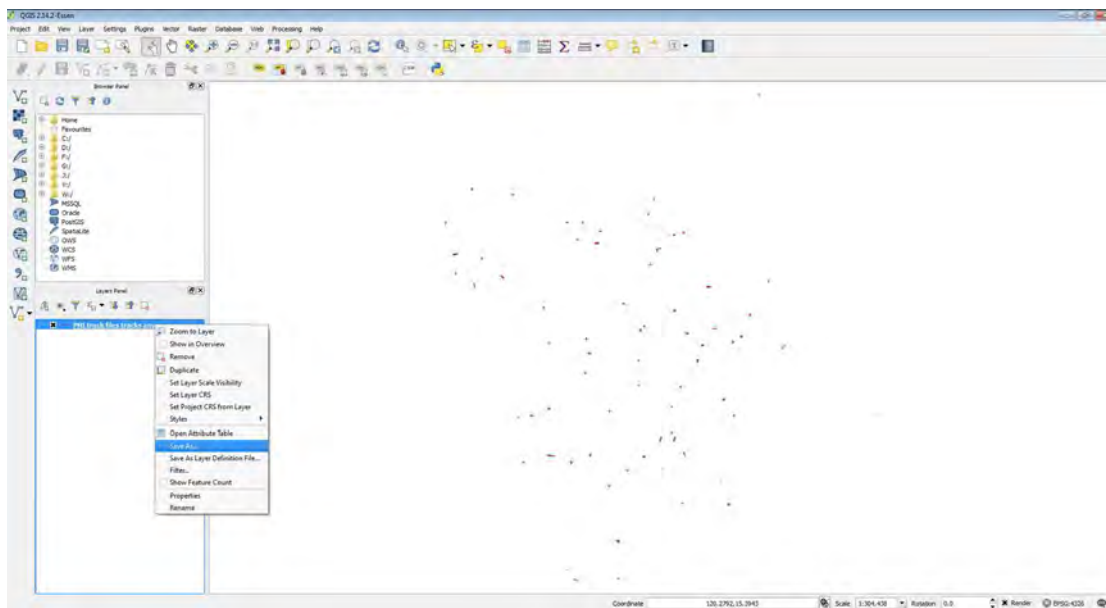
**Figure 4.49: Adding the GPX File as a Vector Layer**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Right-click on the GPX file and save it as a shapefile “PHL\_SHP.shp”

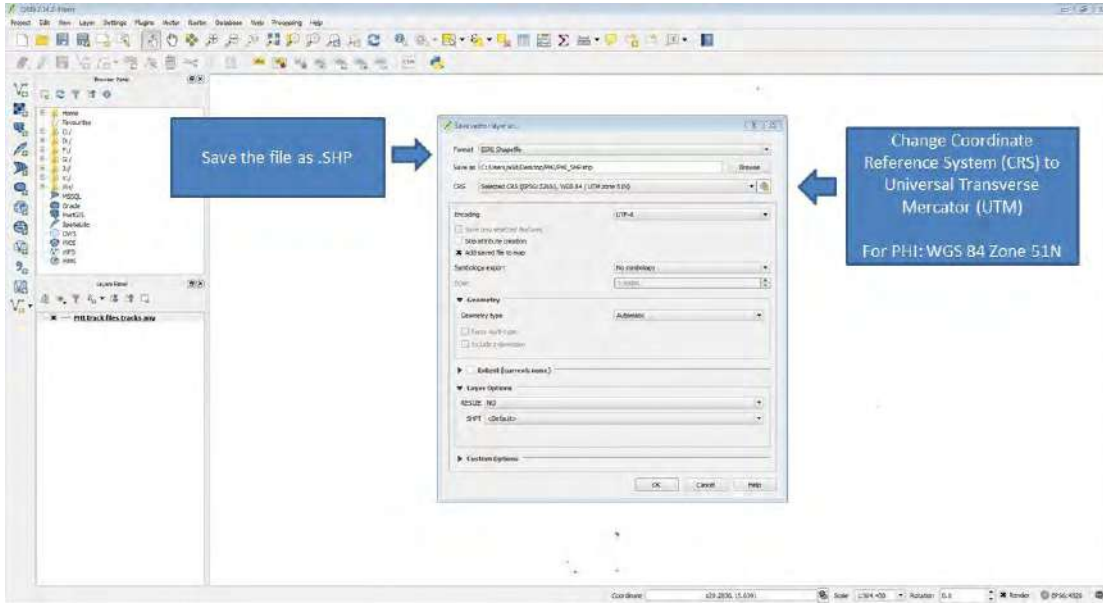
**Figure 4.50: Saving the GPX File as a SHP File**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Change the CRS to the location’s UTM Zone. For Nueva Ecija, Philippines, WGS 84 UTM Zone 51N was used.

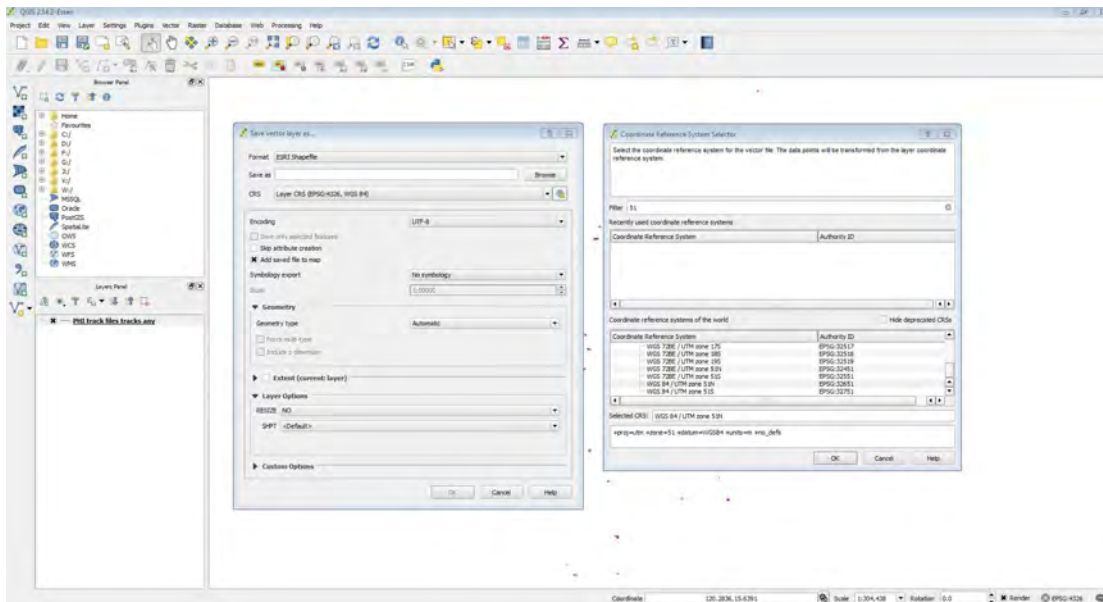
Figure 4.51: Changing the Coordinate Reference System



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

In most cases, browsing through the list of CRS is necessary. Click on the “Globe” icon next to the CRS drop-down menu to select the appropriate CRS.

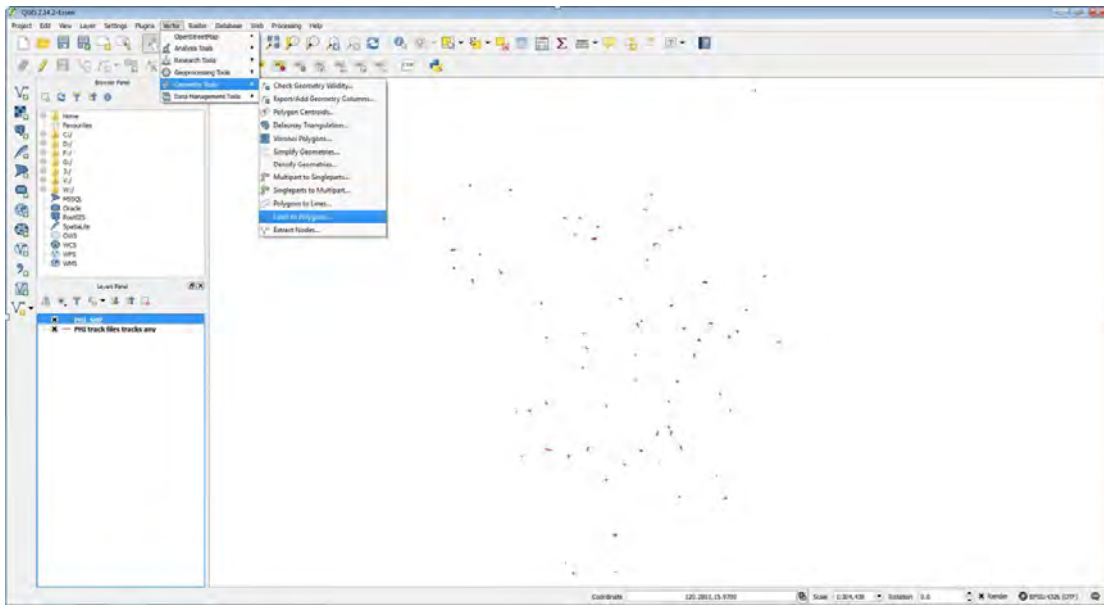
Figure 4.52: Selecting the UTM Zone



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

For batch processing of tracks in QGIS, convert lines to polygons by clicking “Vector”, then “Geometry Tools”, then “Lines to polygons”.

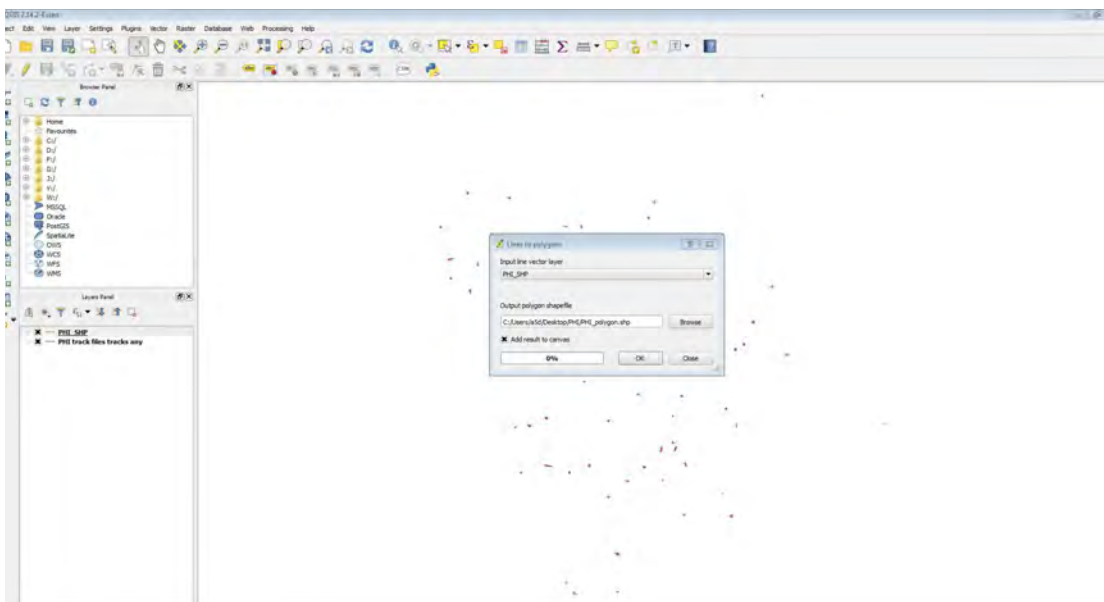
**Figure 4.53: Converting Track Files to Polygons**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

The “Input line vector layer” should be “PHI\_SHP.shp” and the “Output polygon shapefile” should be “PHI\_polygon.shp”.

**Figure 4.54: Specifying Shapefiles as Input Layers**

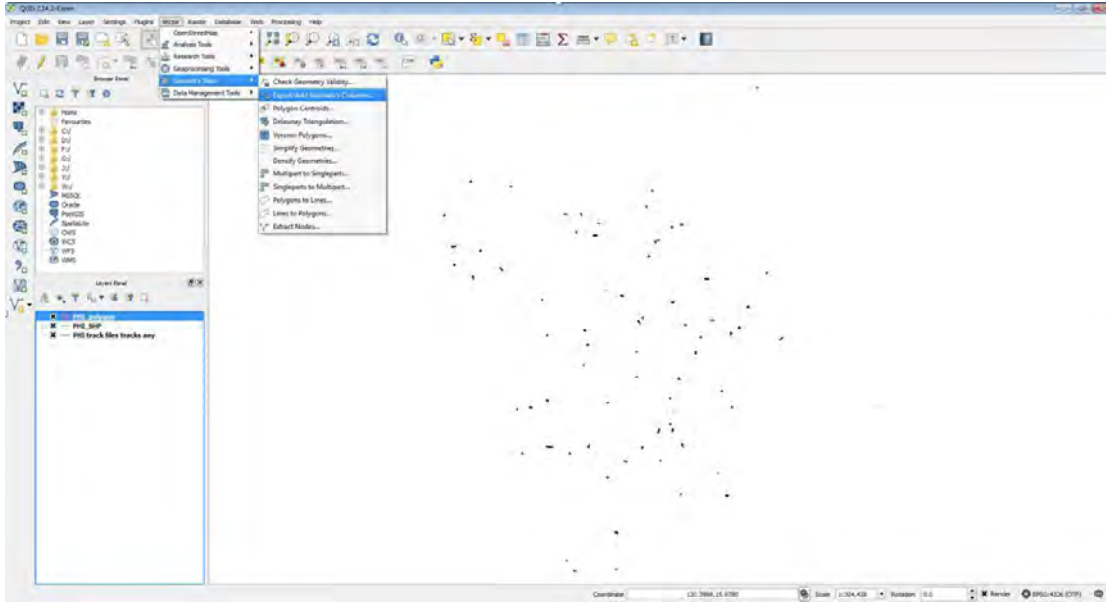


Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.



Add geometry columns to “PHI\_polygon.shp” by click “Vector”, then “Geometry Tools”, then “Export/Add geometry columns”.

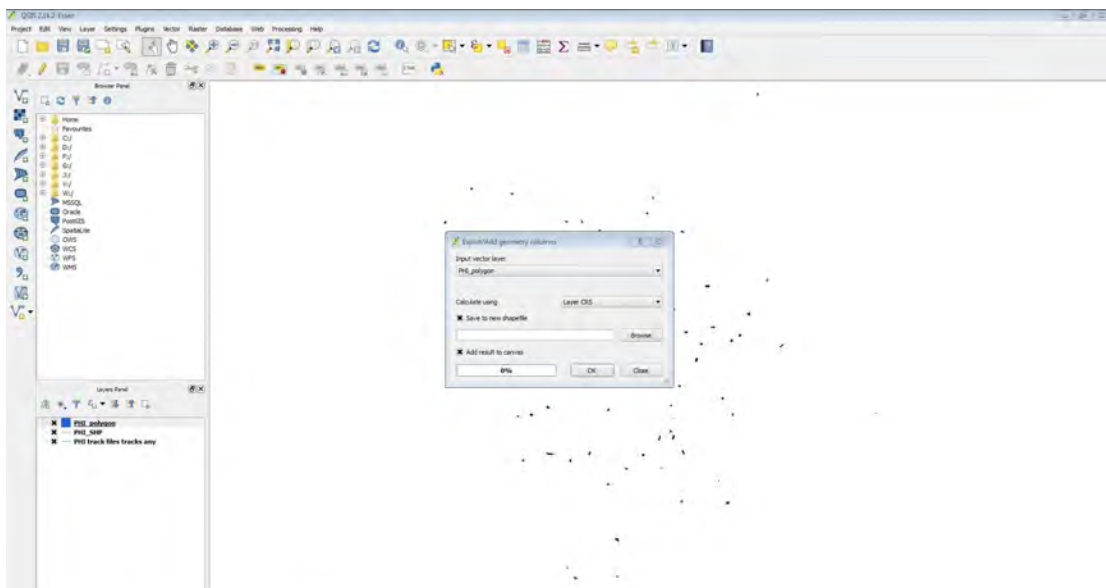
**Figure 4.55: Adding an Attribute Table to Polygons**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Make sure the “Input vector layer” is “PHI polygon”.

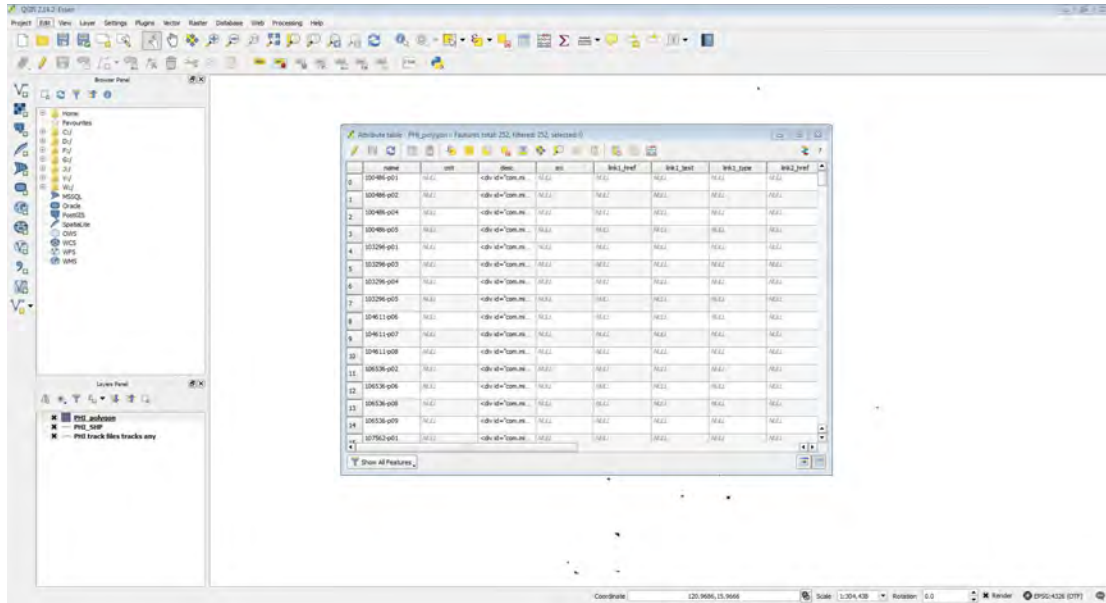
**Figure 4.56: Specifying Polygons as Input Layers**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Right click on “PHI polygon” to view the attribute table.

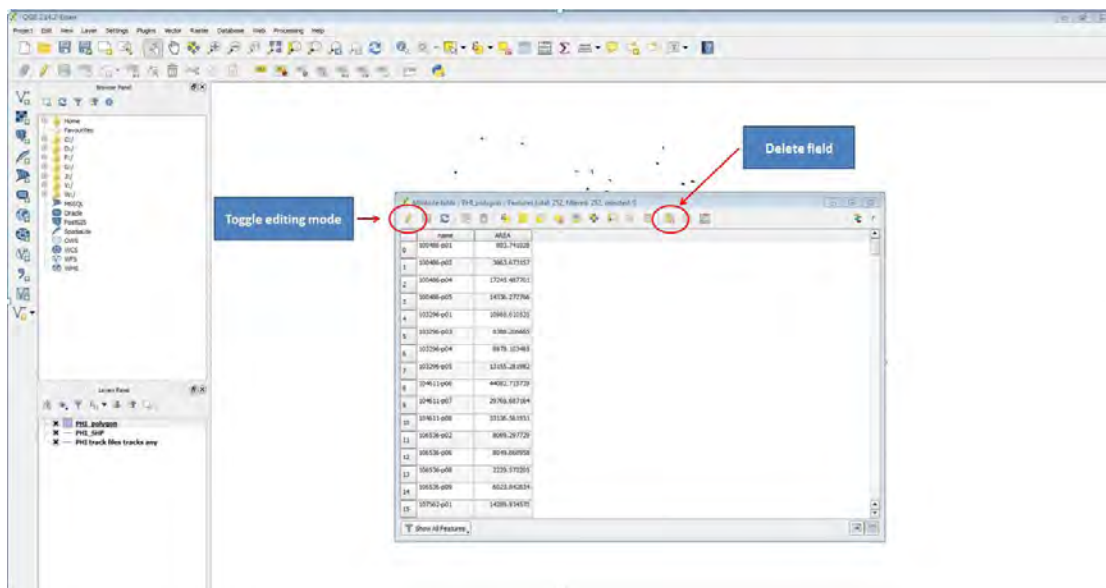
Figure 4.57: Viewing the Polygon Attribute Table



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Retain only relevant attributes = plot name (identification number) and plot area. To do this, turn on the “Toggle editing mode” and tap the “Delete field” icon.

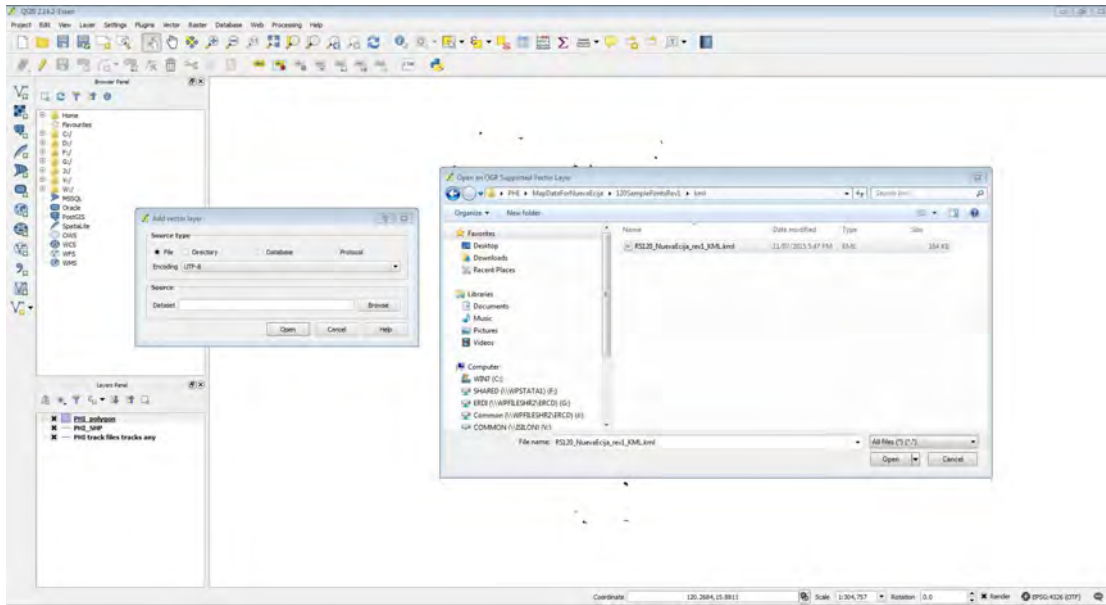
Figure 4.58: Editing the Polygon Attribute Table



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Add another vector layer: 120 Sample Mesh Points = “RS120\_NuevaEcija\_rev1\_KML.kml”

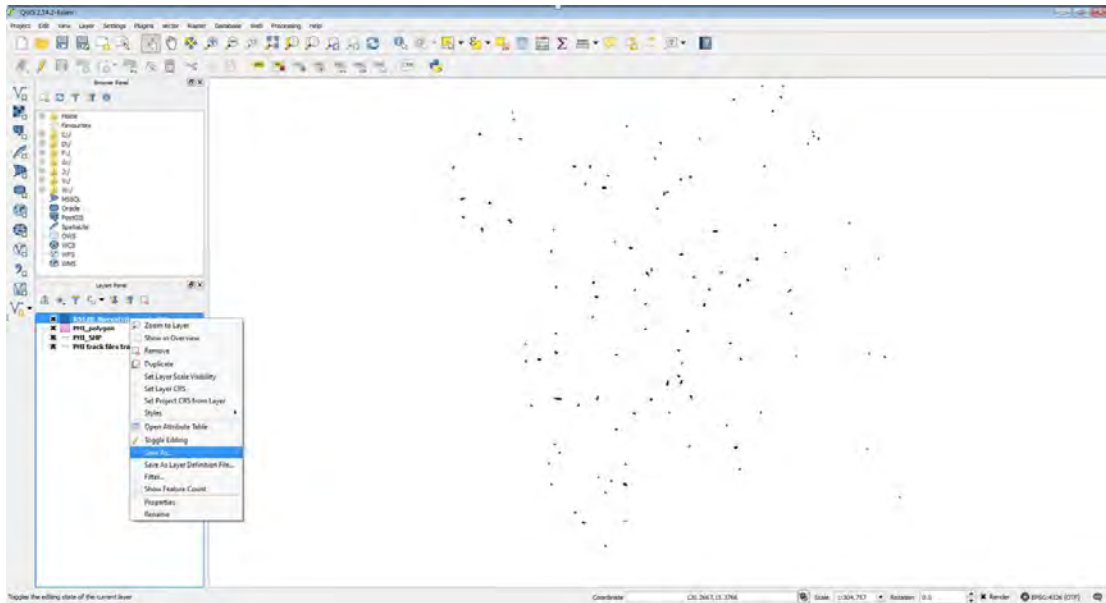
Figure 4.59: Adding the 120 Sample Mesh as a Vector Layer



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

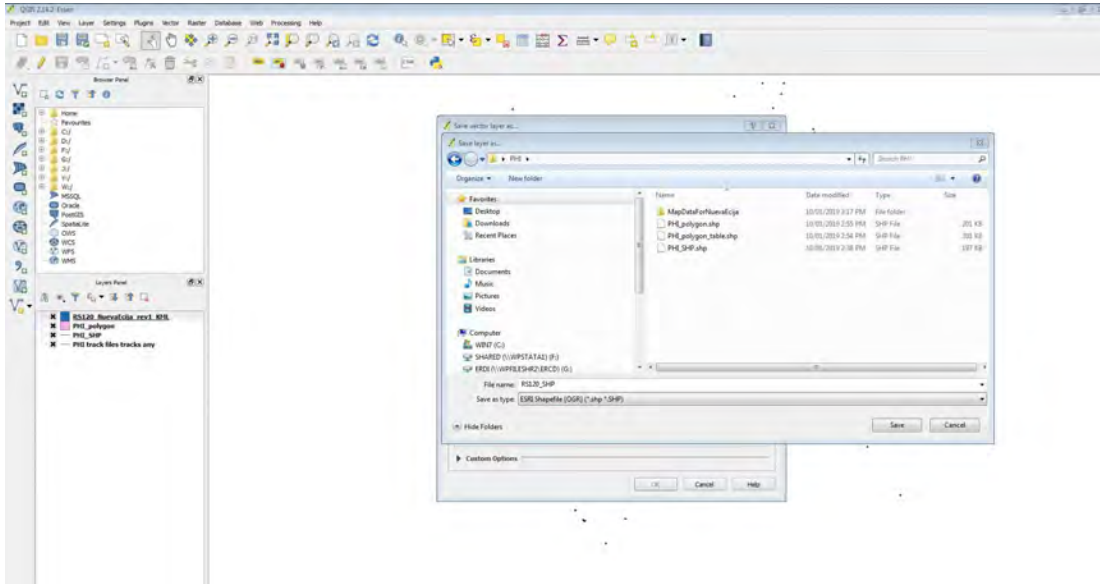
Save the KML file as a shapefile “RS120\_SHP.shp”

Figure 4.60: Saving the KML File to a Shapefile



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

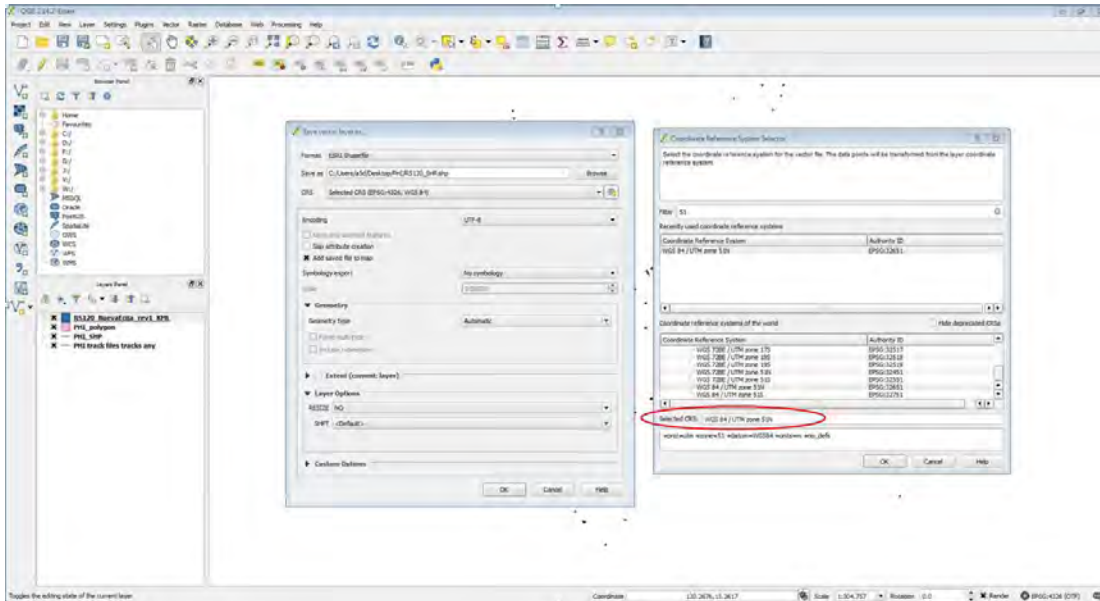
Figure 4.61: Naming Shapefiles



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Change the coordinate reference system to “WGS 84/UTM zone 51N”.

Figure 4.62: Changing the Coordinate Reference System

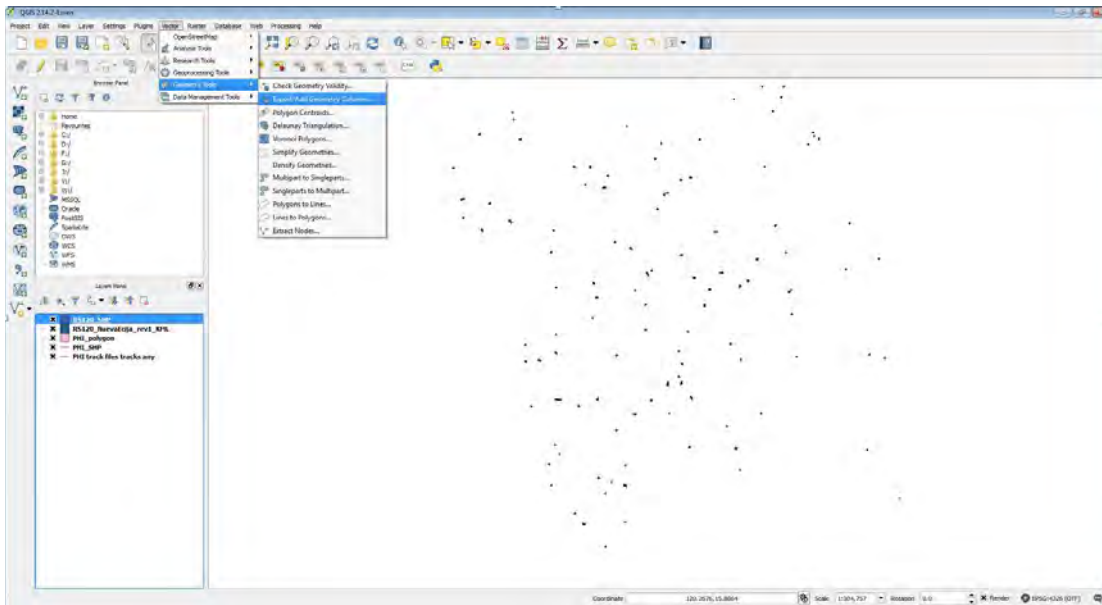


Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.



Add geometry columns to “RS120\_SHP.shp” by clicking “Vector”, then “Geometry Tools”, then “Export/Add geometry columns”.

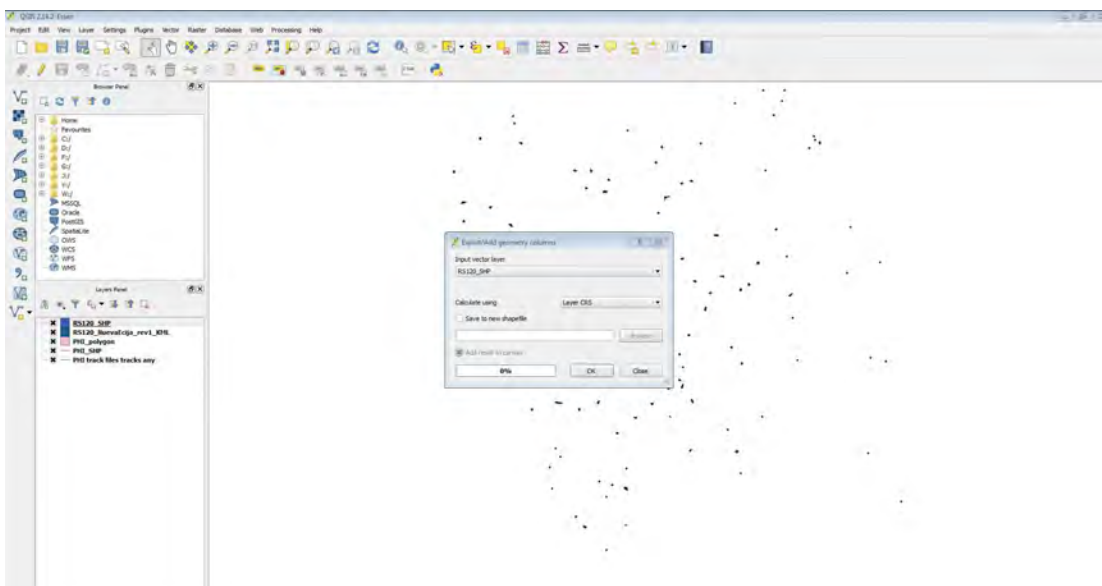
**Figure 4.63: Adding the Attribute Table to the 120 Sample Mesh**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Make sure the “Input vector layer” is “RS120\_SHP.shp”

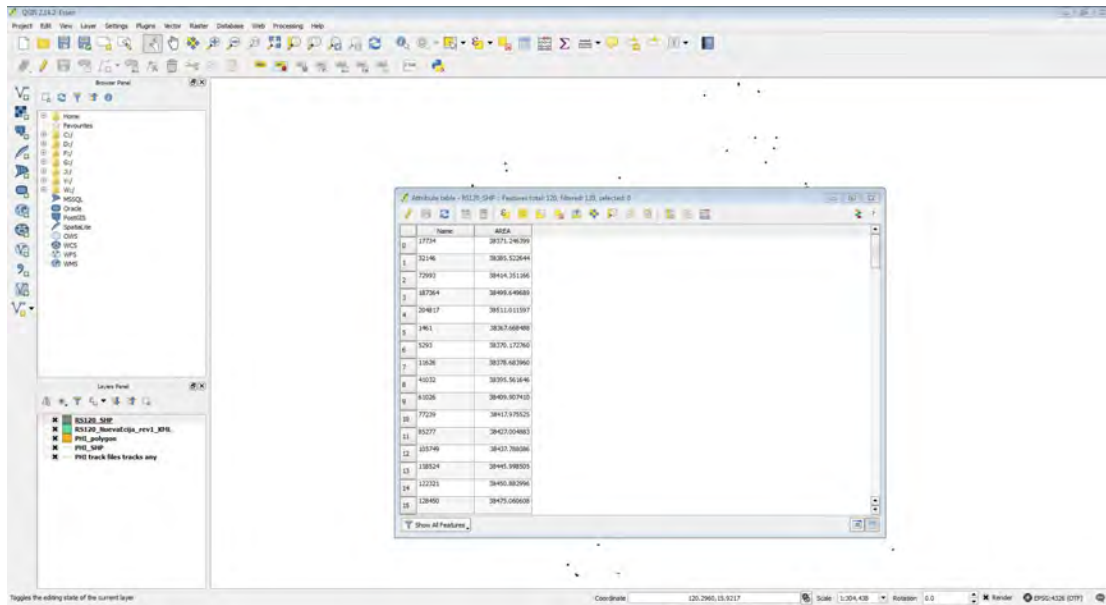
**Figure 4.64: Specifying the 120 Sample Mesh as an Input Vector Layer**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Open the attribute table by right-clicking on “RS\_SHP.shp”. Retain only the relevant attributes = mesh name (identification number) and mesh area.

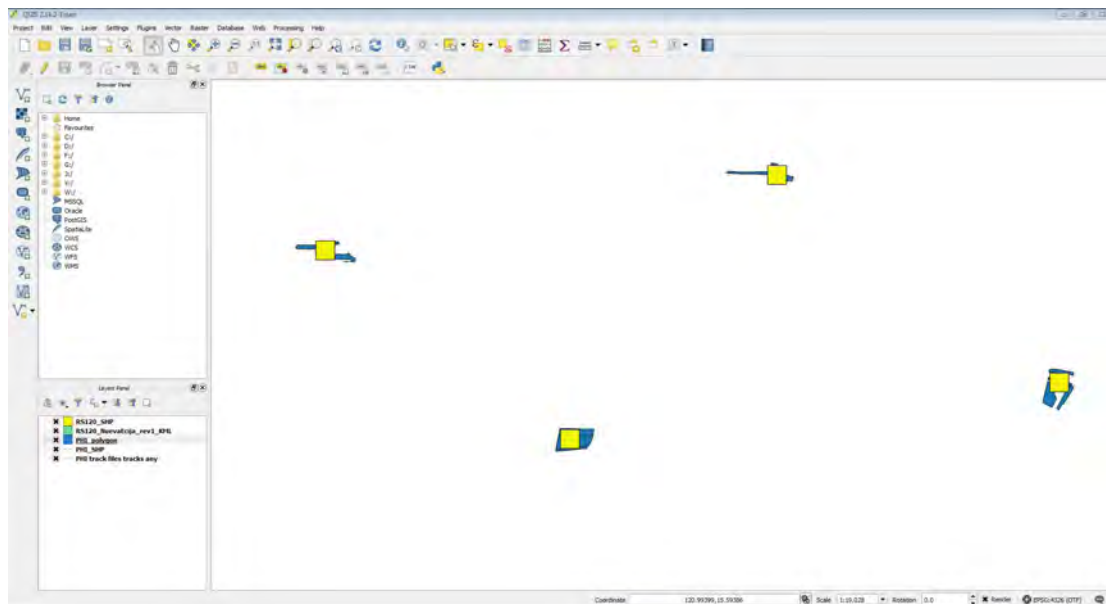
**Figure 4.65: Opening the Attribute Table for the 120 Sample Mesh**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Zoom in to view the overlapping sample mesh and track files.

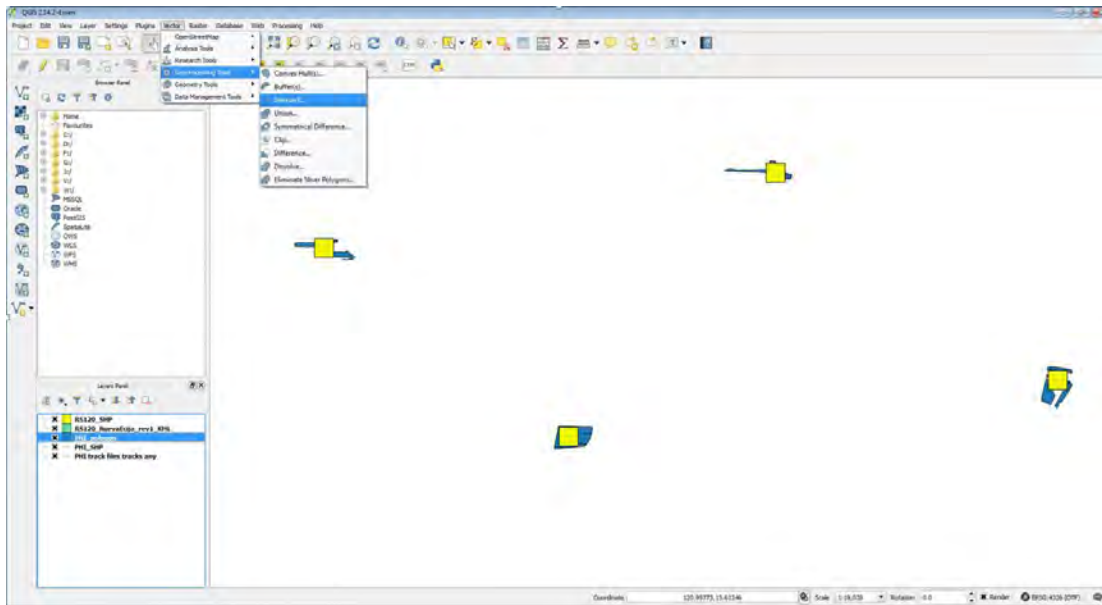
**Figure 4.66: Displaying the Sample Mesh and Track Files Intersection**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Display the area of intersection between mesh and plot by clicking “Vector”, then “Geoprocessing Tools”, then “Intersect”.

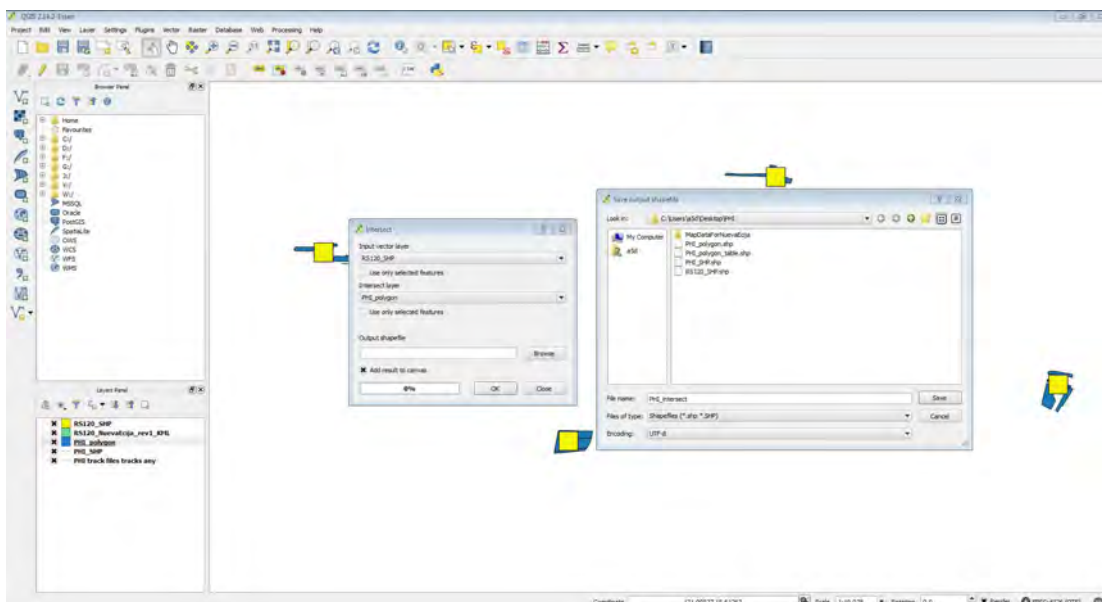
Figure 4.67: Finding the Area Intersection



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

The “Input vector layer” should be “RS120\_SHP.shp’, the “Intersect layer” should be “PHI polygon”, and the “Output shapefile” should be named “PHL\_intersect.shp”.

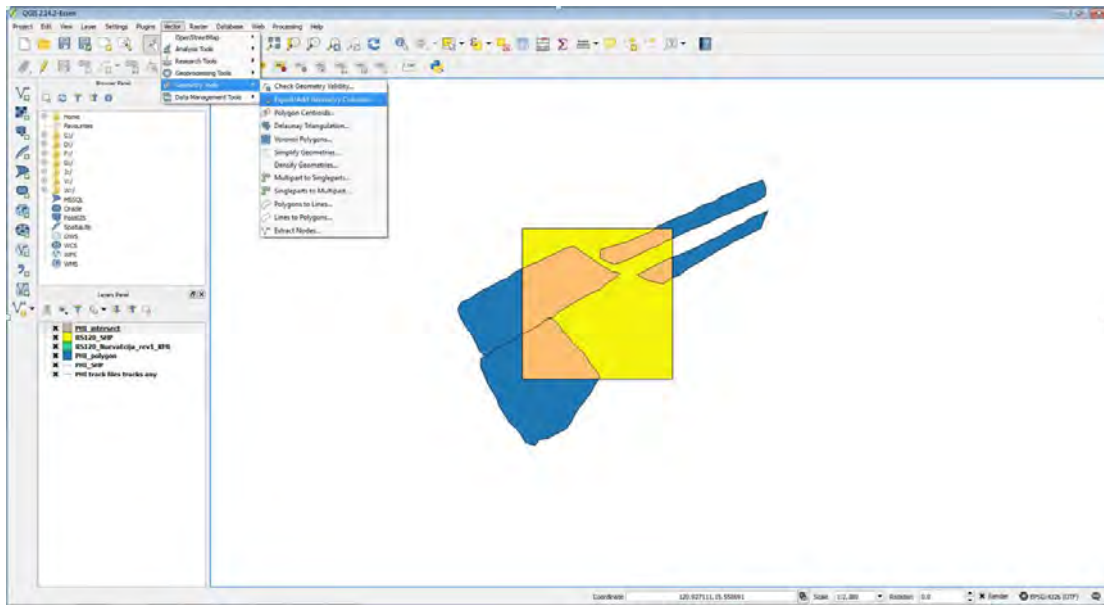
Figure 4.68: Saving the Sample Mesh and Track Files as Input Layers



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

To add geometry columns to “PHI\_intersect.shp”, click “Vector”, then “Geometry Tools”, then “Export/Add geometry columns”.

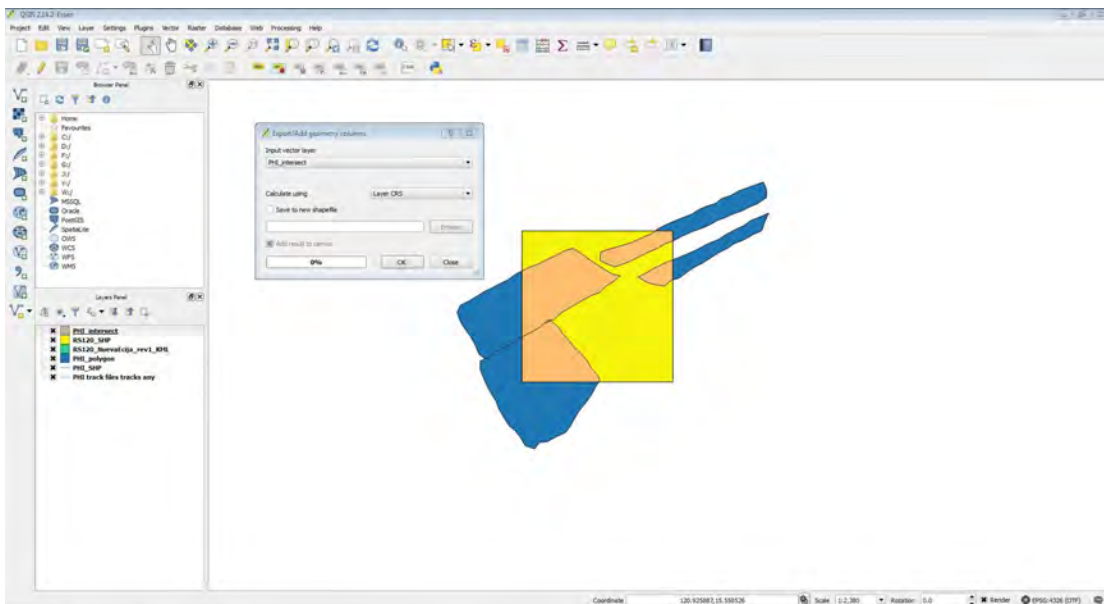
**Figure 4.69: Adding the Attribute Table for the Area Intersection**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

Make sure the “Input vector layer” is “PHI intersect”.

**Figure 4.70: Viewing the Area Intersection**



Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.



The process should result in the “PHI intersect” file shown below, which contains the required area calculations. Note that the final table would display the attributes of the “intersect file”, which in this case is the “PHI\_polygon.shp” file. Make sure to check the other attribute tables for the identification of corresponding area estimates.

Figure 4.71: Assessing the Final Attribute Table

The screenshot displays two attribute tables in QGIS. The left table, titled 'Attribute table - PHI\_polygon', has columns 'Name' and 'AREA'. The right table, titled 'Attribute table - PHI\_intersect', has columns 'Name', 'AREA', 'Name\_1', 'AREA\_2', and 'PHI\_INTERSECT\_1'. The 'PHI\_intersect' table contains data for various polygons, including their names and area values.

Name	AREA
100480-p01	853.742128
100480-p02	2863.873127
100480-p04	17245.467791
100480-p05	14336.272756
100296-p01	30995.632535
100296-p03	8388.266665
100296-p04	8978.103485
100296-p05	13155.281882
104611-p06	44082.713729
104611-p07	20768.687354
104611-p08	31136.361951
104536-p02	8068.287729
104536-p06	4048.868958
104536-p08	2228.572221
104536-p09	6023.842834
107982-p01	14286.934579

Name	AREA	Name_1	AREA_2	PHI_INTERSECT_1
100480	13355.712283	100480-p01	14336.272756	514.545315
100480	187040281	100480-p04	863.742128	59.836986
100296	2440.230420	100296-p05	13155.281882	205.805476
100296	7822.614244	100296-p04	8978.103485	407.258739
100296	8327.639194	100296-p03	8388.266665	423.586742
100296	3036.930513	100296-p01	30995.632535	171.546528
104611	351.732113	104611-p08	31136.361951	108.441289
104611	4641.835120	104611-p07	20768.687354	324.123269
104611	12307.264234	104611-p06	44082.713729	613.576588
104536	2262.137390	104536-p06	4048.868958	286.272211
104536	4680.418304	104536-p02	8068.287729	361.589199
104536	1280.091544	104536-p08	2228.572225	176.238452
104536	283.503966	104536-p09	6023.842834	71.788393
107982	2080.569331	107982-p01	14286.934579	304.548821
112350	135.474121	112350-p01	834.281312	58.437626
112350	3038.226176	112350-p02	3038.226176	128.473276

Source: Screen shot generated by Asian Development Bank staff. 2016. Manila.

## Chapter 5: Crop Cutting Experiments and Farmer Recall Surveys for Paddy Yield Estimation

Two of the most commonly implemented methods for estimating rice crop area, yield, and production are crop cutting experiments (CCEs) and farmer recall surveys. This chapter presents the methodological details for both types of surveys. Discussions include selecting the sample plots and crop cutting subplots, including the use of a listing form to identify plots within a sample mesh; tracking plot boundaries and estimating plot area using Map Plus; crop cutting methodology, materials required, and development of the crop cutting questionnaire; measurement of moisture content in harvested rice using a moisture meter; analysis of crop cutting data to estimate paddy yield; and guidance on creating an accurate farmer recall survey.

### 5.1 Crop Cutting Experiments

Crop cutting is an objective method of determining crop yield. It is a field-based survey wherein farm households or plots are selected using appropriate sampling methodologies, either from a list frame or from an area frame, and involves the actual harvesting of crops from a small area within the farmer's plot. Pioneering work in sampling and survey design to develop methodologies for estimating crop yields based on sampling of small subplots within cultivated fields began in India in the late 1940s. These methods were subsequently adopted as the "gold standard" by the Food and Agriculture Organization of the United Nations (FAO) to measure crop production (FAO 1982; Murphy, Casley, and Curry 1991).

Conducting CCEs requires large financial resources for equipment, field personnel, transportation, and sometimes, farmer incentives. In addition, the whole process of selecting the crop cutting subplot and manually harvesting the crops requires significant planning both from designing the calendar of crop cuts and implementing the

process. Crop cutting may involve measurements in any random portion of the plot of the farmer, which could involve losses to the farmer as the enumerators navigate through the plot. Often the timing of harvesting differs from plot to plot in the same region, and the field teams need to keep clear track of the harvesting calendar and routinely follow up with the farmers harvesting the plots under consideration. There also needs to be a clear understanding of which products are harvestable and which are not. The type of drying and shelling process must also be agreed upon, since drying has an impact on the moisture content of the crop, which ultimately affects the yield calculations. In fact, a standardization of yields based on moisture content is recommended. However, yield measurements derived from objectively designed and well-implemented CCEs will result in reliable and unbiased yield estimates.

Logistically, conducting CCEs may pose challenges because farm households whose plots are randomly selected for the survey may not allow government field personnel to harvest crops from their fields. The refusal of farmers to participate in the study stem from their perceptions of losses incurred when the experiment is conducted. Another difficulty that field personnel may face in implementing CCEs is in terms of the harvest schedule of farmers. Government field personnel may visit the farm after the farmer has already harvested the crops. To address these issues, prior coordination with the sample farm households becomes a key aspect for successful implementation of CCEs.

### 5.2 Crop Cutting Sample Selection

CCEs are conducted to derive rice yield estimates by collecting a sample of rice produced from a small part of a farmer's plot. Thus, CCEs are conducted on plots where rice is grown during the target cropping

season. In addition, farmers or farm operators who own, manage, or work on the plots sampled for crop cutting are interviewed for the farmer recall survey.

To select the sample plots, a list frame or an area frame may be used. In a list frame, which is the standard procedure being implemented in many developing countries, a list of enumeration areas (or the smallest statistical geographic unit within a country) from population and housing census is used as the primary sampling unit. The enumeration areas are typically selected by using systematic random sampling with probability proportional to size, size being the number of households from population and housing census, stratified by type of crop. Subsequent to this, a subset of households within the sampled enumeration areas is chosen as a secondary sampling unit. For this, all households within the sample enumeration areas and owning plots growing the crop under consideration are first listed, out of which a sample of households are selected using a random selection procedure for enumeration. In the tertiary sampling stage, crop cutting will then be conducted on all, or a sample of, plots owned by the households, depending on the sample size requirements and budget allocated for the project. Special care must be taken to account for sampling error, coefficients of variation, design effects, and accuracy of estimates using 95% confidence intervals. Figure 5.1 shows a diagram of the sampling strategy used to select plots for crop cutting using a list frame.

The procedures for list frames are well established, which makes them an attractive sample frame to use for agricultural surveys. They also do not rely on satellite imagery, which may be expensive or unavailable during the period of survey implementation. The disadvantages of a list frame include the time-consuming nature of listing activities; reliance on indirect measures of land size from farmers, rather than from precise global positioning system (GPS) measurement (thereby introducing the possibility of measurement errors); difficulty in supervising and controlling fieldwork;

and increased workload because the third stage of sampling involves crop cutting on all plots owned by the selected household.

On the other hand, in an area frame, remotely sensed data (satellite images) is used to stratify land into different land-use categories as a basis for selecting the sample areas. The methodology for identifying the different stages of sampling differs, based on the availability and richness of the data.

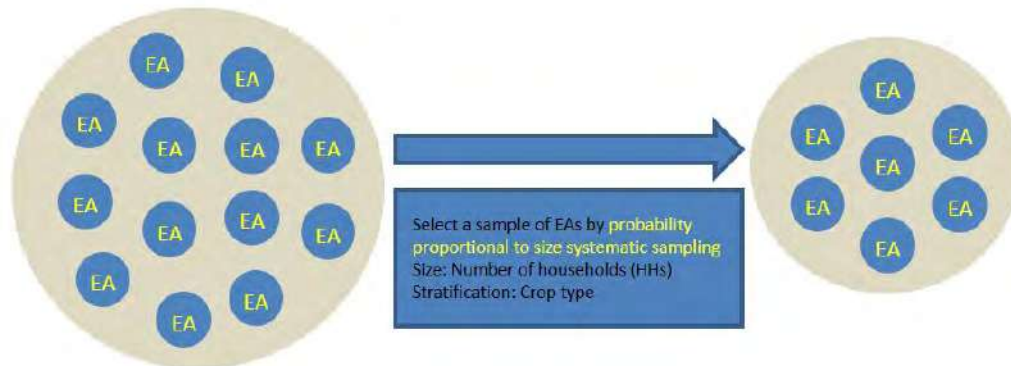
For pilot projects on remote sensing conducted in the Lao People's Democratic Republic (Lao PDR), the Philippines, Thailand, and Viet Nam, an area frame was used to select the sample rice meshes and rice plots, where CCEs and farmer recall surveys were conducted in a three-stage sampling approach. The methodology is explained in detail below and can be adopted or modified for the user's individual settings.

The area sampling frame used for the CCE in each pilot province of the four countries used satellite images as base information, which was stratified into four categories related to the concentration of rice-growing areas as per the following criteria:

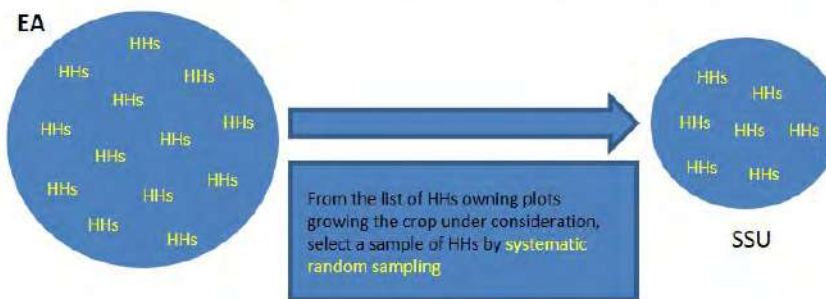
1. Rice area maps obtained by the International Rice Research Institute (IRRI) using 2015 Moderate Resolution Imaging Spectroradiometer data (Nelson and Gumma 2015) and from land-use maps produced by the European Space Agency (ESA) in 2009 under its GlobCover initiative (ESA 2010), which provides the spatial extent of all crops growing in the selected pilot provinces. The ESA-GlobCover Project was jointly initiated in 2005 by the ESA, with partners including the Joint Research Center, the European Environmental Agency, the United Nations Environment Programme, the FAO, Global Observation of Forest and Land Cover Dynamics, and the International Geosphere-Biosphere Programme. The project's objective

Figure 5.1: List Frame Sample Selection for Crop Cutting

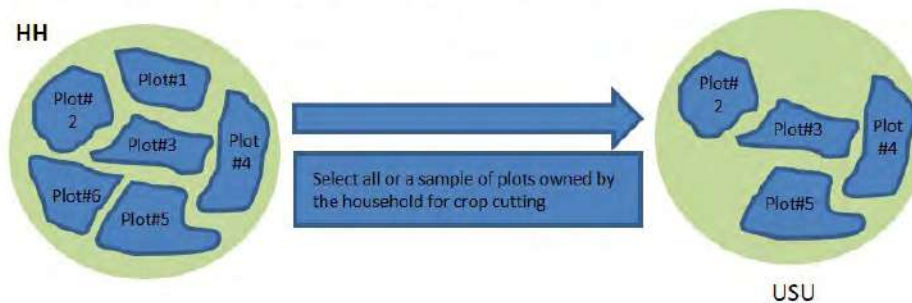
## First stage: Selection of enumeration areas (EAs)



## Second stage: Selection of households within sample enumeration areas



## Third stage: Selection of crop cut plots within a sampled household



EA = enumeration area, HH = household, SSU = secondary sampling unit, USU = ultimate sampling unit.

Source: Asian Development Bank. 2015. PowerPoint presentation developed for a training workshop in crop cutting. Manila.

was mainly “to develop a service capable of delivering global composites and land cover maps using as input observations from the 300 meter (m) Medium Resolution Imaging Spectrometer Instrument (MERIS) sensor on board the ESA Environmental Satellite

(ENVISAT) satellite mission. ESA makes available the land cover maps, which cover 2 periods: December 2004–June 2006 and January–December 2009” (ESA 2010, para1). GlobCover maps used include the following global land cover map classes:



Value	GlobCover global legend
11	Post-flooding or irrigated croplands
14	Rainfed croplands
20	Mosaic Cropland (50-70%) / Vegetation (grassland, shrubland, forest) (20-50%)
30	Mosaic Vegetation (grassland, shrubland, forest) (50-70%) / Cropland (20-50%)

- Rice areas identified from International Rice Research Institute area maps alone.
- Crop areas identified by GlobCover maps alone.
- Remaining areas where presumably rice is not grown (urban, forest, water, etc.).

### 5.2.1 First Stage of Selection: Sample Meshes within Each Strata

Within each of the four strata, the entire area was conceptually divided systematically into 200 m by 200 m meshes using QGIS software. Thus, the primary sampling unit (PSU) in our case is a 200 m by 200 m square “mesh”, which is spatially defined on a digitized satellite image map. The number of meshes in each stratum would then be equal to the total area of the stratum divided by the area of each mesh, i.e.,

40,000 square meters (m<sup>2</sup>). The distribution of the total number of meshes in the frame by stratum for each of the pilot provinces is shown in Table 5.1.

A stratified random sample of 120 meshes was selected for the pilot survey in each province. Table 5.2 presents the allocation of the sample meshes by stratum for each province. A random sample of reserve meshes that could be used for possible replacement was also selected for each stratum, since some meshes could be inaccessible because of unsafe terrain, lack of roads, heavy rain, or other conditions. The distribution of the sample meshes selected as reserves for replacement is also shown in Table 5.2.

All of the sample meshes were first checked in the field to determine whether rice was planted in any plots within the mesh boundaries. Only sample meshes where rice was found to be planted were enumerated for the CCE and farmer recall surveys. The final distribution of the sample meshes with rice planted in each province is shown in Table 5.3.

**Table 5.1: Distribution of Meshes by Stratum in the Sampling Frame for Pilot Provinces**

Stratum	Number of Meshes in Frame			
	Savannakhet, Lao People's Democratic Republic	Nueva Ecija, Philippines	Ang Thong, Thailand	Thai Binh, Viet Nam
IRRI+GlobCover	80,839	68,514	22,105	36,376
IRRI	4,650	157	280	589
GlobCover	154,227	66,127	2,777	4,846
Others	322,391	77,292	34	1,815
<b>Total</b>	<b>562,107</b>	<b>212,090</b>	<b>25,196</b>	<b>43,626</b>

IRRI = International Rice Research Institute.

Source: Asian Development Bank estimates.

**Table 5.2: Allocation of Sample Meshes by Stratum and Number of Sample Meshes Selected as Possible Replacements**

Stratum	Sample Meshes	Replacements	Total
IRRI+GlobCover	80	5	85
IRRI	20	10	30
GlobCover	15	10	25
Others	5	5	10
<b>Total</b>	<b>120</b>	<b>30</b>	<b>150</b>

IRRI = International Rice Research Institute.

Source: Asian Development Bank estimates.

**Table 5.3: Final Distribution of Sample Meshes with Rice, by Stratum**

Stratum	Number of Sample Meshes with Rice			
	Savannakhet, Lao PDR	Nueva Ecija, Philippines	Ang Thong, Thailand	Thai Binh, Viet Nam
IRRI+GlobCover	58	66	50	63
IRRI	8	7	10	2
GlobCover	10	2	6	7
Others	2	0	0	0
<b>Total</b>	<b>78</b>	<b>75</b>	<b>66</b>	<b>72</b>

IRRI = International Rice Research Institute,

Lao PDR = Lao People's Democratic Republic.

Source: Asian Development Bank estimates.

### 5.2.2 Second Stage of Selection: Sample Plots within Each Mesh

The second stage is to select the sample plots within the mesh where the CCE (or the farmer recall survey) will be implemented. In the pilot studies, plot boundaries were defined based on the following definition, adopted from the Living Standards Measurement Study methodology (The World Bank Group 2016):

A “plot” is a continuous piece of land on which:

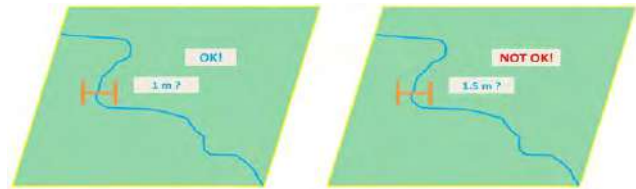
- i) a unique crop or a mixture of crops is grown under a uniform, consistent crop management system;
- ii) is continuous and not split by an obstruction (e.g., river or path, etc.) of more than 1 m in width; and
- iii) farm boundaries are defined according to the crops grown and the operator.

For example, in Figure 5.2, a plot may be planted with one rice variety (on the left) or with a mixture of crops (on the right), which use(s) water from the same irrigation system, and the same type of fertilizer and crop management system are used in either case. In both cases, the plot is classified as one plot (note that there are no significant obstructions, e.g., a river or a road, dividing the plot).

In Figure 5.3, however, it is shown that an obstruction divides the plot. If the obstruction is more than 1 m wide (on the right), based on the

field personnel’s estimation, then the plot needs to be divided into two plots. This is done even if both are owned by the same farmer, or if the plot is otherwise uniform in crop (or crops) planted and crop management. During listing of plots, it is critical to talk to the farmers themselves to get accurate information.

**Figure 5.3: Division of Plot**

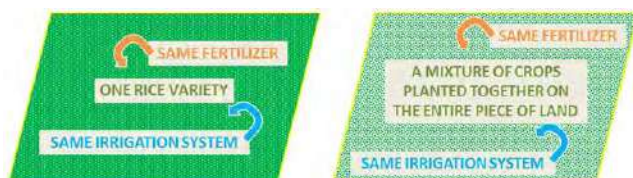


Source: Asian Development Bank. 2015. PowerPoint presentation developed for a training workshop in crop cutting, Manila.

The sample plots are then randomly selected within each sample mesh for the CCE and for the farmer recall survey.

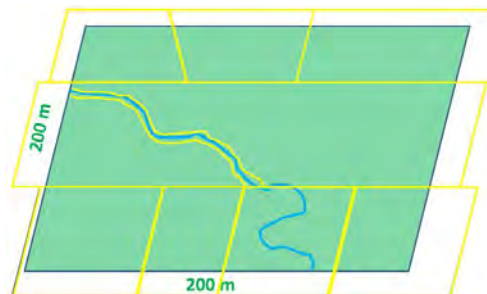
**Use a listing form to identify sample plots.** Initially, start with a printed map of the 200 m x 200 m sample mesh. Try to match any landmark on the printed map with what is actually observed on the field. Boundaries of the mesh can be verified using a GPS app installed on an iPad, which shows the field staff’s current position in the area. Next, draw on the printed map the boundaries of plots that fall within the sample mesh. Talk to a farmer or any person

**Figure 5.2: Illustration of a Plot**



Source: Asian Development Bank. 2015. PowerPoint presentation developed for a training workshop in crop cutting, Manila.

**Figure 5.4: Boundaries of 200 Meter x 200 Meter Sample Mesh**



m = meter.

Source: Asian Development Bank. 2015. PowerPoint presentation developed for a training workshop in crop cutting, Manila.

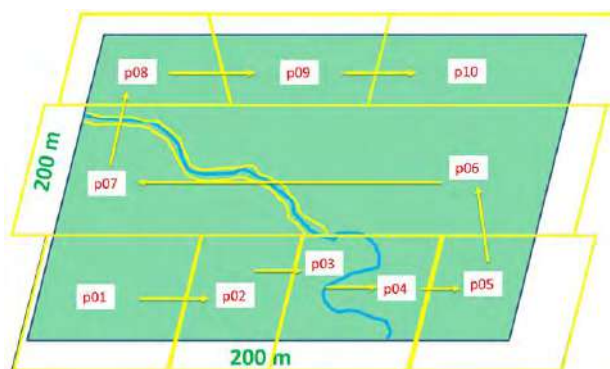
knowledgeable about the area, e.g., a village or commune head, to help identify the plot boundaries and, if possible, the owners of the plots.

Once the boundaries of all the plots are identified and delineated on the printed map, number each plot in a serial and geographically serpentine manner, as shown in Figure 5.5. The first plot (p01) can be assigned arbitrarily.

The next step is to transfer information of all plots within a sample mesh from the printed map onto a listing form, which helps identify the total number of plots covering the extent of the sample mesh. An example of a listing form is shown in Appendix 2. Even if a plot is partially within the mesh, it will still be included in the listing process. The list and the printed map should match in terms of the total number of plots. One listing form should be sufficient for each sample mesh.

Figure 5.6 shows how to fill out the listing form. In Figure 5.5, a total of 10 plots were listed, with at least some portion of each plot falling inside the 200

Figure 5.5: Sample Mesh with Assigned Plot Number



m = meter.

Source: Asian Development Bank. 2015. PowerPoint presentation developed for a training workshop in crop cutting. Manila.

**HELPFUL HINT:** Consider the definition of the plot discussed above. As long as a portion of the plot falls within the boundaries of the sample mesh, that plot should be included in the listing form. It is very likely that the plots may (and probably will) extend outside the boundaries of the mesh, as illustrated in Figure 5.4. Include all plots that are both fully and partially inside the mesh.

Figure 5.6: Sample Listing Form with Plot Details

PROVINCE	CODE 4 9		NAME NUEVA ECIIA					
MUNICIPALITY	0 3 0		TALAVERA					
BARANGAY	0 2 2		DINARAYAT					
MESH/PIXEL ID	1 3 4 9 0 1		Pattern #1: Y Y N Y Pattern #2: Y Y N N W/MM/YYYY					
SNO	PLOT NUMBER	NAME OF FARMER	AREA (USING GPS) in m <sup>2</sup>	1 WAS RICE PLANTED ON THIS PLOT, THIS SEASON? (Y/N) YES...Y → go to Question 2 NO...N → next plot	2 WILL RICE BE HARVESTED DURING THIS SEASON? (Y/N) YES...Y → go to Question 3 NO...N → next plot	3 HAS THE RICE ALREADY BEEN HARVESTED? (Y/N) YES...Y → next plot NO...N → go to Question 4	4 IS THE RICE READY FOR HARVEST? (Y/N) YES...Y → next plot NO...N → go to Question 5	5 WHEN WILL THE RICE BE READY FOR HARVEST? use W/MM/YYYY format
1	p01	Hermogenes de Vera	4,000	Y	Y	N	Y	
2	p02	Carlos Avila	3,333	Y	Y	N	Y	
	p03	Aquelino Santos	1,667	N				
3	p04	Leila Mendoza	1,667	Y	Y	N	Y	
	p05	Eugenia dela Cruz	3,333	Y	Y	Y		
4	p06	Marcelo Amador	8,667	Y	Y	N	N	4/10/2015
	p07	Edwin Guzman	4,000	N				
5	p08	Teodoro Rivera	4,000	Y	Y	N	Y	
	p09	Jenny Castro	4,000	Y	N			
6	p10	Jesse Cuevas	5,333	Y	Y	N	N	1/11/2015

GPS = global positioning system, m<sup>2</sup> = square meter, SNO = serial number.

Source: Asian Development Bank. 2015. PowerPoint presentation developed for a training workshop in crop cutting. Manila.

m x 200 m mesh. These have been appropriately recorded in the sample listing form (Figure 5.6).

Once all plots have been listed, a criterion needs to be established to determine whether or not a particular plot qualifies to be crop cut.

In the pilot studies, the selection criterion was whether rice was planted on a plot with the intention of harvesting in the rainy season of 2015, since the objective was to only obtain estimates for one season. If rice was not being grown on a plot for the harvesting season under consideration, it did not qualify for selection because crop cutting cannot be accomplished. Therefore, in Figure 5.6, only plots p01, p02, p04, p06, p08, and p010 qualified for crop cutting. Although they were not yet ready for harvest during the first visit, plots p06 and p010 were still considered for crop cutting because the crops were scheduled to be harvested within the target period.

Once a list of all plots that meet the criteria of qualifying for crop cutting is prepared, a sample of four of these plots should be randomly selected for crop cutting. The selection of four plots is driven by the need to ensure sufficient sample size within a mesh to capture variability in rice yields across plots and budgetary constraints. If there are fewer than four plots within the mesh that are eligible for selection, crop cutting should be done in all plots. The random selection of eligible plots can be accomplished in multiple ways. In the pilot studies, a random number generator, as presented in Table 5.4 was used. The sample plots are selected from the total number of plots listed as eligible for crop cutting (based on the listing form) through a systematic random sampling approach.

Track the boundaries and estimate the area of the selected sample plots using the GPS application Map Plus (Geographical Information System Editor + Offline Map + GPS Recorder), and record the information on the crop cutting questionnaire. An

example of a crop cutting questionnaire from the Philippines is included in Appendix 3.

Section 5.3 and Section 5.4, respectively, will describe how to use Map Plus to track boundaries and estimate the area of the sample plots.

**Table 5.4: Random Number Table for Systematic Selection of Plots**

Number of plots listed in the sample segment	Main sample of plots				Replacement plots	
	1	2	3	4		
5	1	2	4	5	3	
6	1	2	4	5	3	6
7	1	2	4	5	3	6
8	1	4	5	8	2	6
9	2	5	6	9	3	8
10	1	3	6	8	4	9
11	3	5	8	10	1	7
12	2	4	8	10	6	12
13	3	6	10	12	1	8
14	4	6	11	13	2	9
15	5	7	12	15	2	10
16	5	8	13	16	2	10
17	2	4	10	13	7	16
18	3	6	12	15	9	18
19	6	10	16	19	3	13
20	2	5	12	15	9	19
21	1	4	11	15	8	18
22	1	9	12	20	5	16
23	7	11	19	23	3	15
24	3	7	15	19	11	23
25	2	6	14	18	10	23
26	6	11	19	24	2	15
27	4	13	18	27	9	22
28	3	8	17	22	13	27
29	9	14	23	28	4	19
30	2	7	17	22	12	27
31	7	12	23	28	2	17
32	7	13	23	29	2	18
33	5	16	22	33	11	27
34	1	7	18	24	13	30
35	2	13	19	31	7	25
36	1	13	19	31	7	25
37	4	10	22	28	16	34
38	12	18	31	37	5	24
39	10	17	30	36	4	23
40	6	13	26	33	20	40
41	9	16	30	37	3	23
42	13	20	34	41	6	27
43	1	15	22	36	8	29
44	4	11	26	33	18	40
45	2	17	25	40	10	32
46	13	21	36	44	6	29
47	7	23	31	46	15	38
48	5	21	29	45	13	37
49	10	18	35	43	2	27
50	9	25	34	50	17	42

Source: Asian Development Bank. 2015. PowerPoint presentation developed for a training workshop in crop cutting. Manila.



### 5.2.3 Third Stage of Selection: Selection of Crop Cutting Subplot

Once the maximum of four random plots per sample mesh are selected as part of the second stage, the third stage is implemented, whereby one 2.5 m by 2.5 m subplot is randomly selected within each sample plot for the rice crop cutting. Many studies have been done to determine the relative efficiency of different plot sizes and shapes, as compared with the yield rates. The subplots could be circular, square, or even triangular in shape and could vary in size as well. In the case of the pilot studies, square subplots of 2.5 m x 2.5 m were chosen and considered manageable.

To start, create a copy of the plot on a blank sheet of paper. Identify and count the total number of corners of the plot, then identify the northwestern-most corner and label it “1”. Next, label all the remaining corners, going clockwise, as illustrated in Figure 5.7.

Use a random number table, as shown in Table 5.5, to determine a random starting point that

identifies the corner of the plot where the field staff will start the crop cutting activity.

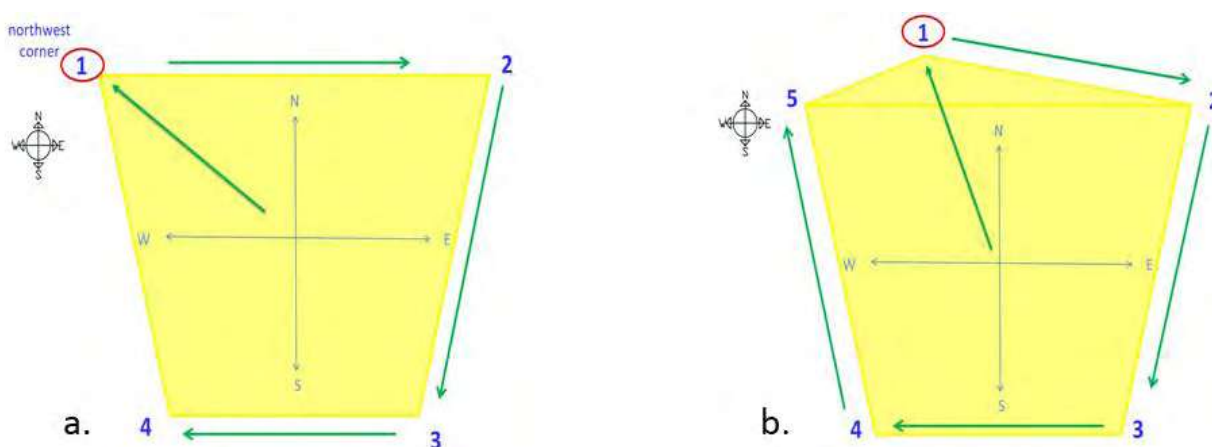
The random selection of a plot corner, from which the identification of the subplot starts, utilizes Random Number Table 1: Crop Cutting START CORNER SELECTION. This random number table can easily be recreated in Microsoft Excel using the command “=RANDBETWEEN(1,20)”, which will generate random numbers between 1 and 20. Here, it is assumed that a plot could have a maximum of 20 corners.

Use the first number in the random number table that matches one of the numbered corners of the field, i.e., the first number less than or equal to the total number of corners of the plot. Suppose that the sample plot has four corners (as in part “a” of Figure 5.7) and Random Number Table 1 is as follows:

Random Number Table 1: Crop Cutting Start Corner Selection									
7	15	16	20	18	16	10	7	3	14

The starting point will therefore be the third corner of the plot.

Figure 5.7: Identifying Plot Corners



**Table 5.5: Random Number Tables for Crop Cutting Subplot Selection**

This section contains random number tables which should be used to randomly select the crop cutting sub-plot in each farm.

Use **Table 1** to randomly select the **starting corner** for crop cutting. Circle the first number that is less than or equal to the total number of corners on the field. Starting from the North Western corner, this number should be the corner that you walk to and is the "start corner".

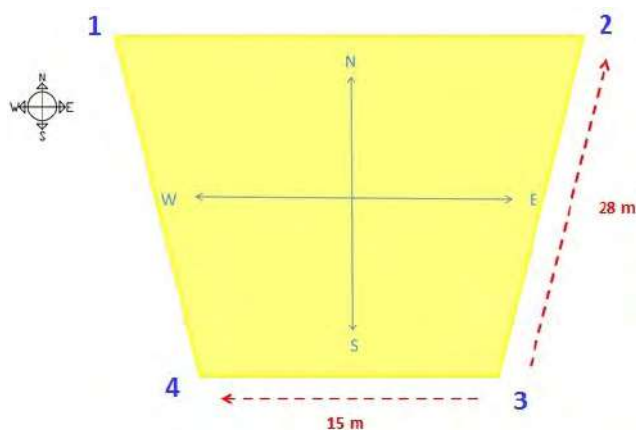
Use **Table 2** to select the **crop cutting area from the start corner** which you are currently at. Measure the length of both sides of the field adjacent to the "start corner" you are standing at.

FULL IDENTIFICATION: MESH + PLOT ID	Random Number Table 1: Crop Cutting START CORNER SELECTION										Random Number Table 2: Crop Cutting SUB-PLOT SELECTION																								
	7	15	16	20	18	16	10	7	3	14	96	158	43	20	151	195	232	123	171	84	185	48	81	151	87	162	30	221	5	64	53	205	123	15	205
	9	8	15	1	8	5	9	20	15	17	191	241	101	4	126	236	201	103	217	207	193	250	244	3	67	82	34	223	123	82	121	120	64	173	175
	4	10	11	7	3	10	8	2	17	14	14	248	198	215	250	70	186	203	34	9	162	129	85	185	203	226	73	19	227	98	87	169	139	222	216
	4	3	2	12	4	12	11	9	16	1	173	105	214	128	206	172	72	92	218	200	166	231	12	133	242	159	192	28	17	92	54	132	73	110	98
	14	3	2	10	20	3	4	6	16	19	166	100	55	124	74	195	94	214	110	97	159	84	16	37	114	98	222	3	178	65	120	230	162	194	229
	8	7	4	1	12	13	18	13	8	6	184	99	95	106	102	236	58	110	102	27	152	212	201	185	170	75	191	76	121	205	203	208	79	214	119
	13	13	11	14	13	8	1	20	18	12	45	229	62	225	128	219	229	53	153	68	247	117	71	182	180	144	168	37	147	29	149	170	128	3	158
	19	7	19	17	18	7	9	13	8	2	19	128	131	247	231	239	73	24	150	145	130	92	171	189	232	202	126	205	107	67	210	144	130	136	45
	4	20	18	11	1	18	15	12	17	18	217	245	148	242	54	141	5	42	80	162	162	95	120	67	18	181	97	249	43	94	151	199	172	133	138
	11	5	10	17	16	8	10	15	12	9	42	160	172	214	29	117	228	111	204	51	201	157	221	200	64	15	232	215	120	203	180	78	213	241	181
	3	8	1	19	1	4	14	9	19	13	99	176	68	223	111	73	31	194	174	149	145	59	111	125	120	75	41	166	75	26	151	41	124	178	88
	12	4	4	13	18	14	6	12	4	7	8	42	145	155	237	183	31	164	214	82	246	230	146	67	21	35	221	177	39	245	48	14	68	214	64
	5	12	5	15	9	8	17	7	5	3	85	102	34	95	183	121	45	182	246	138	212	182	8	162	79	176	152	88	161	247	213	167	192	247	128
	20	5	15	12	13	1	11	16	19	9	50	90	229	96	104	92	108	163	86	231	6	47	37	86	110	90	160	61	57	166	36	230	83	189	17
	10	2	1	18	10	20	5	15	15	18	13	13	211	144	221	168	224	3	239	91	24	26	200	157	41	28	88	54	162	38	178	50	204	37	195

Source: Asian Development Bank. 2015. PowerPoint presentation developed for a training workshop in crop cutting, Manila.

Once the random start corner is identified, use measuring tape or an iPad to measure the distance of the two sides along the selected corner. Identify which is the longer side and which is the shorter side. Record the side measurements on the printed map or on a separate piece of paper. In Figure 5.8, starting from the third corner of the plot, the shorter side is on the south side of the plot, while the longer side is on the east side.

Figure 5.8: Measuring the Long and Short Sides of a Sample Plot



m = meter.

Source: Asian Development Bank. 2015. PowerPoint presentation developed for a training workshop in crop cutting. Manila.

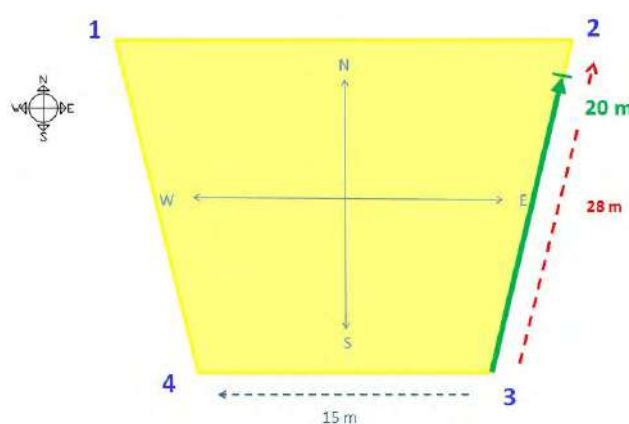
After taking the measurements of the two adjacent sides, take the bearing from the start corner down the longer side. The field personnel will need to walk a certain distance along the length of the longer side. To determine this distance, use Random Number Table 2: Crop Cutting SUBPLOT SELECTION, which presents random distances in meters. Similarly, this random number table can be easily reproduced in Microsoft Excel using the command “=RANDBETWEEN(3,250)”. The first number should be the number of meters that the field staff will walk along the length of the longer side of the field. If the first number is larger than the length of the side, choose the next random number (and so on, until a number that is less than the length

of the longer side is found). Suppose the length of the longer side is 28 m (as in Figure 5.8) and Random Number Table 2 is as follows:

Random Number Table 2: Crop Cutting Sub-Plot Selection									
96	158	43	20	151	195	232	123	171	84

Beginning at the starting point (i.e., the random start corner) and continuing along the longer side of

Figure 5.9: Walking Along the Long Side of a Sample Plot



m = meter.

Source: Asian Development Bank. 2015. PowerPoint presentation developed for a training workshop in crop cutting. Manila.

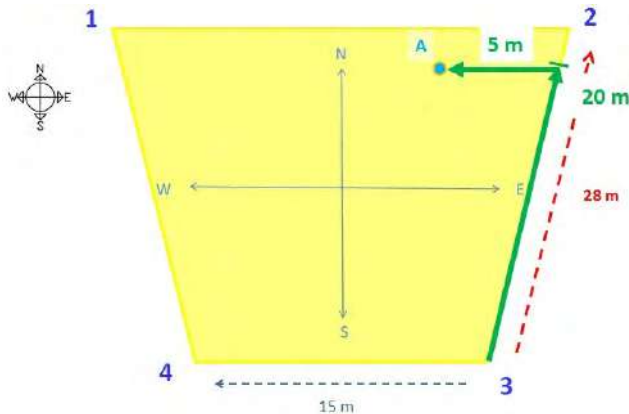
the plot, walk the number of meters indicated by the random number (Figure 5.9).

Turn into the field so that the bearing of the field staff is the same as the bearing of the shorter side of the field. This means that the field staff will enter the plot parallel to the shorter side. Choose the next random number from Random Number Table 2 that is lower than the length of the shorter side, then walk the number of meters indicated by this second random number. Supposing the next random number that is less than the length of the shorter side is “5”, as in the example below, field staff would walk 5 meters into the plot, parallel to the short side.

Random Number Table 2: Crop Cutting Sub-Plot Selection																								
96	158	43	20	151	195	232	123	171	84	185	48	81	151	87	162	30	221	5	64	53	205	123	15	205

Field staff will then arrive at “Point A” of the crop cutting subplot, which is the blue dot presented in Figure 5.10.

**Figure 5.10: Identifying the Crop Cutting Subplot**

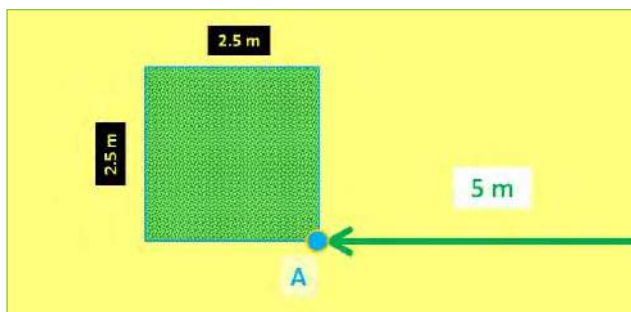


m = meter.

Source: Asian Development Bank. 2015. PowerPoint presentation developed for a training workshop in crop cutting. Manila.

Place the 2.5 m x 2.5 m crop cutting frame at the upper right corner of Point A, as shown in Figure 5.11. Insert sticks at the four corners of the square to keep the frame firmly fixed to the ground. This is the subplot on which crop cutting will take place. Proceed with the crop cutting of the rice on the subplot. Make sure that the GPS measurements are taken for the crop cutting subplot and recorded on the crop cutting questionnaire.

**Figure 5.11: Placing the Crop Cutting Frame**




m = meter.

Source: Asian Development Bank. 2015. PowerPoint presentation developed for a training workshop in crop cutting. Manila.

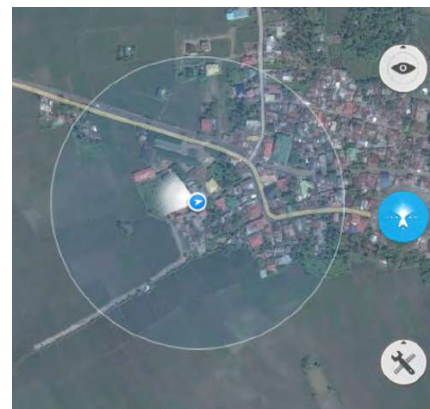
### 5.3 Tracking Plot Boundaries Using Map Plus

Information on the total area covered by the sample plots, as well as the area of those sample plots that fall within the mesh, is important for calculating the weights and, eventually, in estimating rice yield. It is critical that plot boundaries are measured on the field, where the field personnel actually walk around the sample plots using a handheld device installed with an application (or “app”) that can record the boundaries of the plot. In the pilot studies, iPad mini 3 devices were installed with the Map Plus application developed by Miocool Inc. The app can be downloaded from the Apple Inc. website (<https://itunes.apple.com/us/app/map-plus/id438868200?mt=8>). Remember to load and update the map downloaded onto the device to be able to use the app offline. Note that there is no version yet of Map Plus available for Android devices.

Map Plus is not only used to record plot boundaries, but also to first to locate the mesh where the sample plot for crop cutting is located. The screenshots following this procedure are given in the following figures.

To use Map Plus to locate the mesh and the sample plot, tap the location button  to start tracking the target location. Wait for a few seconds until the current position icon is shown on the map (Figure 5.12) and the location becomes stable.

**Figure 5.12: Current Position Indicator in Map Plus**

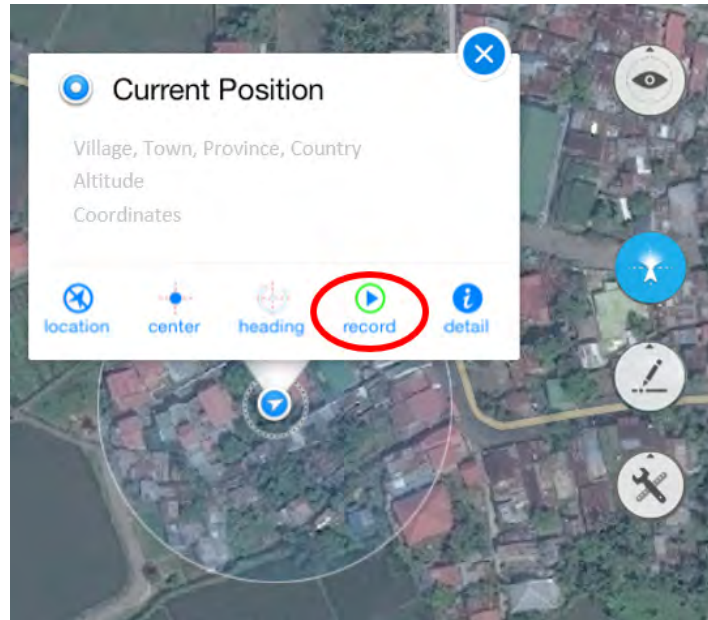


Source: Asian Development Bank. 2015. PowerPoint presentation developed for a training workshop in crop cutting. Manila.



When the sample plot is reached and the field personnel are ready to record the plot boundaries, use the “GPS Track Recording” function of Map Plus. Tap the “record” button on the operation bar, as shown in Figure 5.13, and start walking around the boundaries of the plot. During recording, the current track is displayed and an annotation for the starting point is indicated.

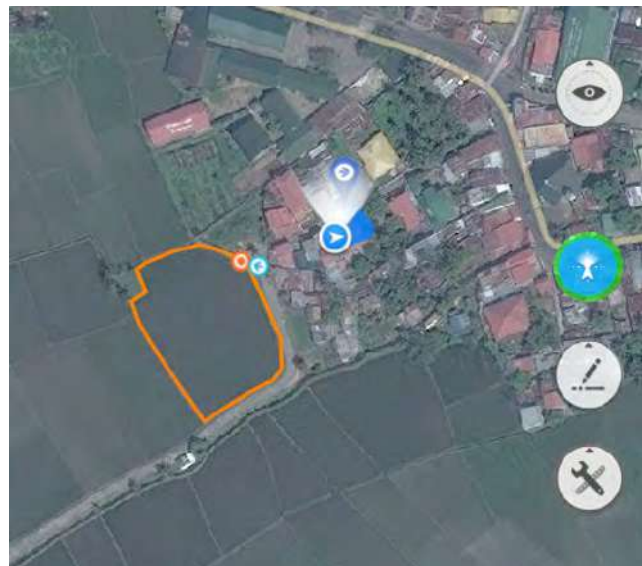
**Figure 5.13: Using the Record Function in Map Plus**



Source: Asian Development Bank. 2015. PowerPoint presentation developed for a training workshop in crop cutting. Manila.

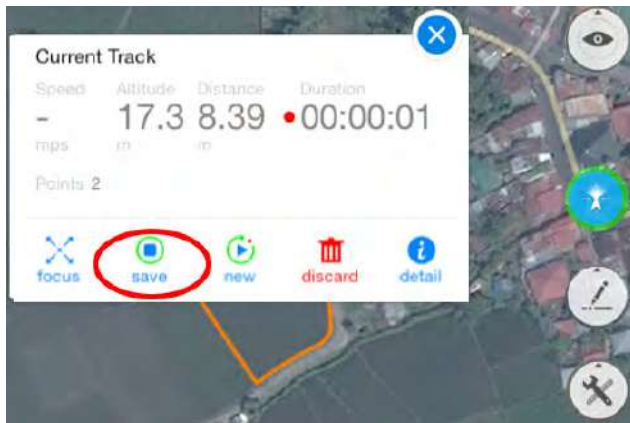
**Figure 5.14: Example of a Recorded Track in Map Plus**

Figure 5.14 shows an example of a track, depicted by the orange polygon. The starting point is indicated by the orange dot on the polygon. When the start point is reached, indicating that the whole area of the plot has been covered, tap the “save” button (as shown in Figure 5.15) to stop recording. A file copy of the track is saved on the root folder of the device. By default, the track is named “my track” on the root folder. Replace the track’s filename by tapping the “detail” button.



Source: Asian Development Bank. 2015. PowerPoint presentation developed for a training workshop in crop cutting. Manila.

Figure 5.15: Saving the Recorded Track in Map Plus



Source: Asian Development Bank. 2015. PowerPoint presentation developed for a training workshop in crop cutting. Manila.

Another window pops up, showing relevant information about the saved track file, including its default filename, the total distance traveled or the perimeter of the polygon, the total time it took to walk around the boundary, and others, as Figure 5.16 shows. To edit the filename, tap the “Edit” button located at the lower right side of the window. Edit

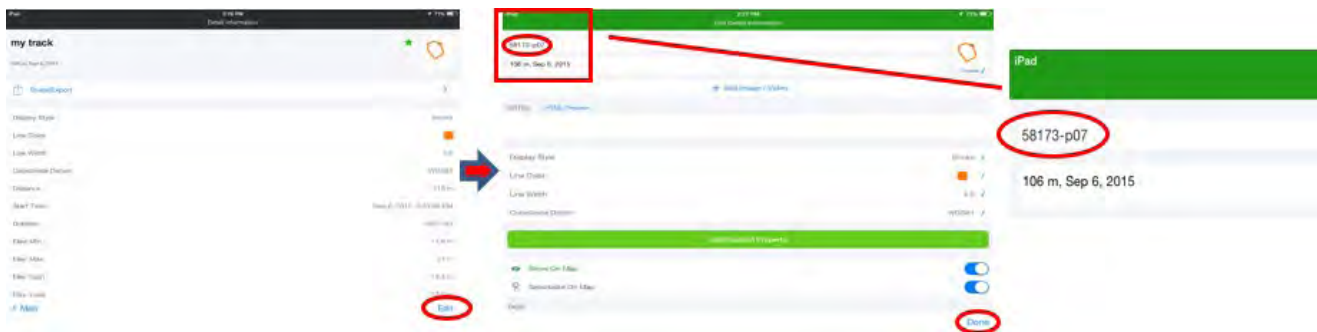
the filename on the new window, following the recommended plot-naming convention. Ideally, the plot name should include the mesh ID and the plot number, e.g. “58173-p07”. Tap the “Done” button when finished. The track is saved as a Keyhole Markup Language (KML) file, which is an XML-based file format used to display geographic data in an Earth browser such as Google Earth, Google Maps, etc.

#### 5.4 Estimating Plot Area Using Map Plus

Apart from the search and GPS tracking functions of Map Plus, it also has area measuring capabilities. After saving the track file of the sample plot, Map Plus can be used to estimate the sample plot’s area.

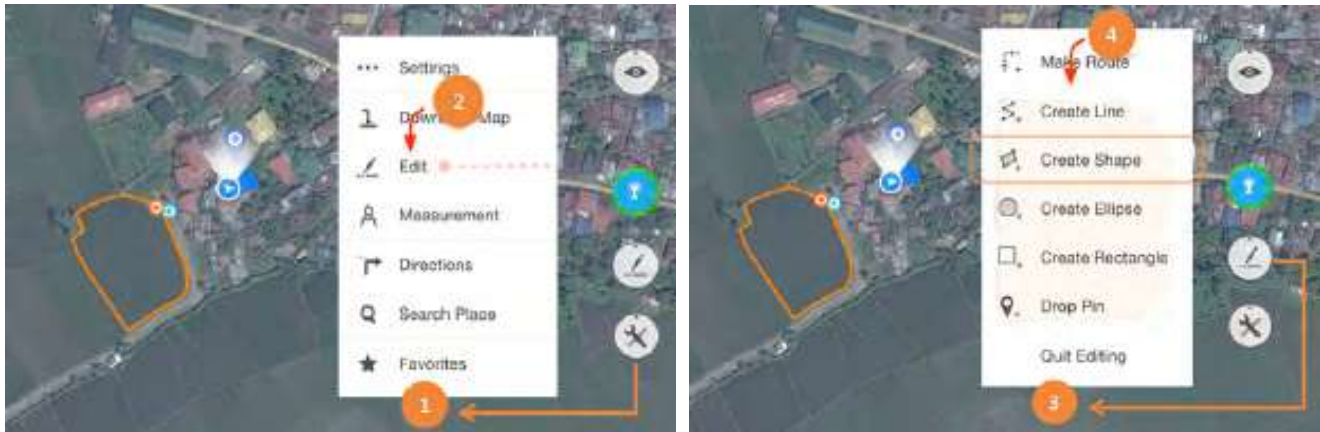
Tap the TOOLS icon to open the menu, then select “Edit”, as shown in Figure 5.17. Tapping the EDIT icon opens the edit menu containing several functions such as creating lines, shapes, etc. on the map. Tap “Create Shape” to create a polygon that will match the track created by walking around the sample plot.

Figure 5.16: Editing Recorded Track Filename in Map Plus



Source: Asian Development Bank. 2015. PowerPoint presentation developed for a training workshop in crop cutting. Manila.

Figure 5.17: Accessing the Editing Functions in Map Plus



Source: Asian Development Bank. 2015. PowerPoint presentation developed for a training workshop in crop cutting. Manila.

Long press on any of the corners of the orange-colored polygon and drag it to move the point of the polygon to the corners of the plot. The polygon must completely cover the original track of the sample plot to be based on the created polygon (Figure 5.18).

After completely covering the track with the polygon, tap the “save” button on the menu to save

the created polygon. Notice that the area of the polygon is shown on the top left corner of the pop-up window. Record this information on the crop cutting questionnaire. By default, the polygon is named ‘My Polygon’. Edit the filename using the recommended plot-naming convention, and following the same procedure as in Figure 5.16 in Section 5.3. There are now two files saved for the specific sample plot: the track file and the polygon.

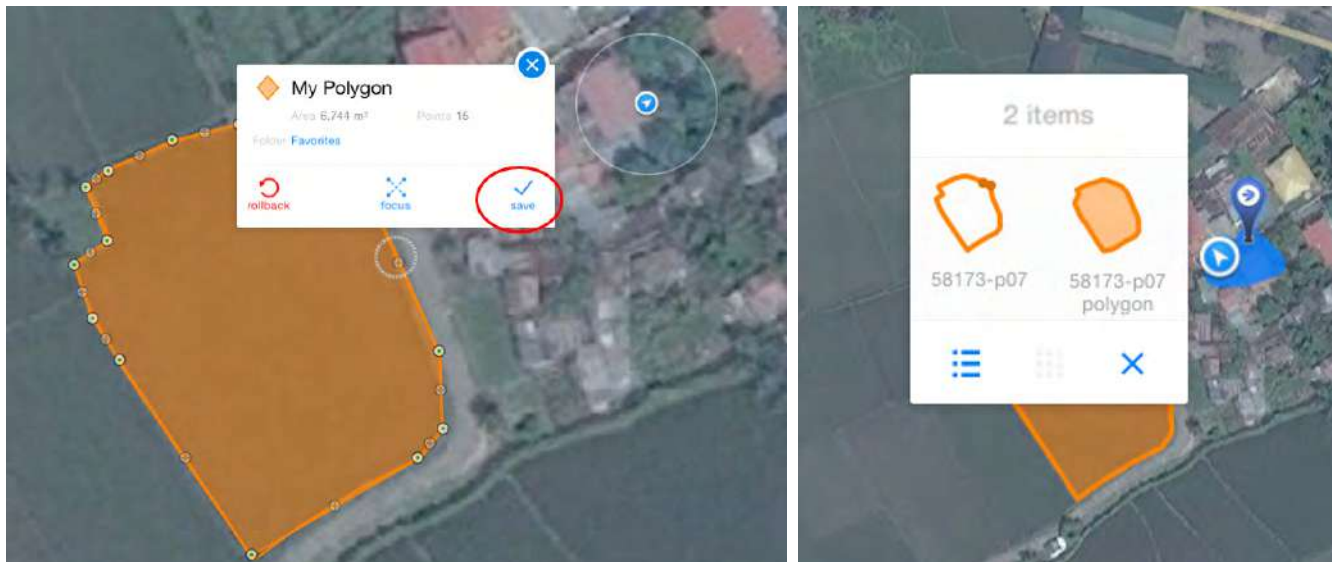
Figure 5.18: Creating a Polygon to Match the Recorded Track in Map Plus



Source: Asian Development Bank. 2015. PowerPoint presentation developed for a training workshop in crop cutting. Manila.



**Figure 5.19: Saving the Polygon and Recording the Plot Area Estimate in Map Plus**

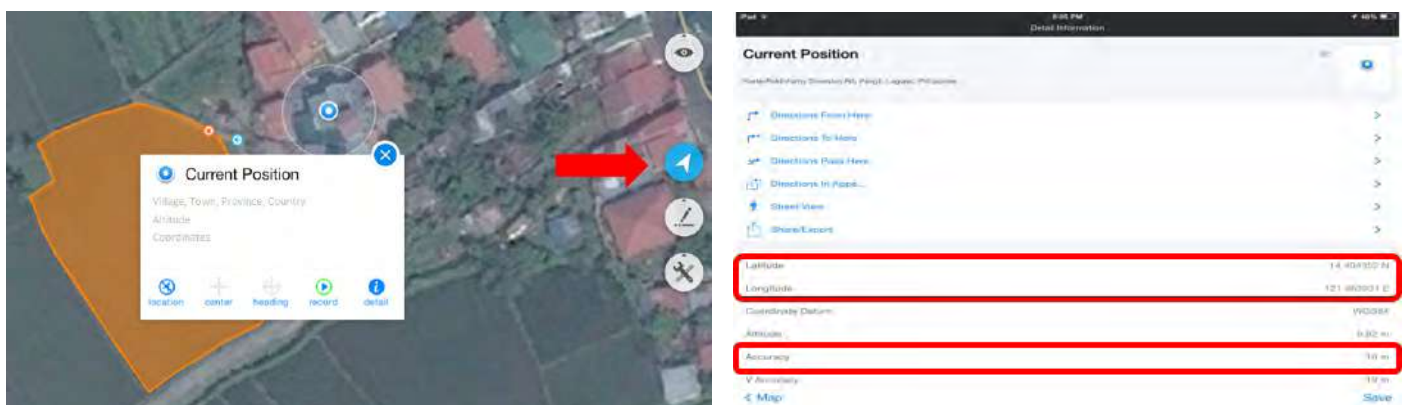


Source: Asian Development Bank. 2015. PowerPoint presentation developed for a training workshop in crop cutting. Manila.

Information on GPS accuracy and GPS coordinates of the crop cutting subplot random corner are recorded in the crop cutting questionnaire. To get the information, the person holding the iPad must be at the random corner of the crop cutting subplot, tap the location button on the map, and get

the coordinates of the location (Figure 5.20). Tapping the “detail” button opens the detailed information of the person’s current position. Here, the GPS coordinates and the GPS accuracy are shown. Record this information on the crop cutting questionnaire.

**Figure 5.20: Locating Position Coordinates and Accuracy in Map Plus**



Source: Asian Development Bank. 2015. PowerPoint presentation developed for a training workshop in crop cutting. Manila.

## 5.5 Crop Cutting Methodology

### 5.5.1 Crop Cutting Materials Required

To successfully implement a CCE, the following materials must be prepared:

1. **Crop cutting frame** (to mark the subplot to be cropped cut)
2. **Sickle** (to harvest the rice)
3. **Bags** (to store the grain)



Photo credit: Center for Agricultural Statistics, Lao People's Democratic Republic, 2016.



Photo credit: J.A.D. TOOLS s.r.o., 2016.



Photo credit: Center for Informatics and Statistics, Viet Nam, 2016.

4. **Mesh bags** (for threshing)



Photo credit: Asian Development Bank, 2015.

5. **Mat** (for threshing and cleaning)



Photo credit: Center for Informatics and Statistics, Viet Nam, 2016.

6. **Winnowing basket** (to clean the threshed rice)



Photo credit: Etsy, Inc., 2015.

7. **Pot or pan, stove or mini gas cookers, spoon** (for drying using the parching method)



Photo credit: Asian Development Bank, 2015.

8. **Moisture meter** (to measure the moisture content)



Photo credit: Asian Development Bank, 2015.

9. **Weighing scale** (to weigh the rice sample)



Photo credit: Asian Development Bank, 2015.

10. **Measuring tape** (to measure distance towards the crop cutting sub-plot)



Photo credit: Fjcaldera, 2008.

The pictures above illustrate equipment and tools needed to conduct the crop cutting survey.



### 5.5.2 Crop Cutting Procedure



The image above showcases how the 2.5m x 2.5 m square is placed in a plot as a final step to implementing rice crop cutting in Savannakhet, Lao PDR.  
Photo credit: Center for Agricultural Statistics, Lao People's Democratic Republic, 2016.

Be sure to get the farmer's consent before proceeding with the harvesting of rice samples from the farmer's plot. Indicate on the crop cutting questionnaire the date crop cutting is being conducted. Proceed by using the sickle to manually harvest all the rice contained within the crop cutting subplot area, covered by the 2.5 m x 2.5 m crop cutting frame. Before placing the harvested rice sample in the bags, count the total number of "hills" from which the harvested rice came, and record this information on the crop cutting questionnaire.

A hill of rice is a single shoot (often made up of a number of stems) growing out of the ground. For transplanted rice, calculate the total number of hills by multiplying the number of hills on the length and width of the crop cutting subplot. For direct-seeding or ratooning, physically count the total number of hills. Place the harvested rice sample in the mesh bag and transport it to a safe place, making sure there are no losses.

**HELPFUL HINT:** Counting the number of hills is much easier after harvesting rice.

The next step is to thresh the harvested rice sample to separate the grains from the straw. In the pilot studies, samples were threshed manually by impact, beating the mesh bags containing the rice against a mat or platform. However, one could also use friction or a combing action to separate the rice grains from the straw. Threshing rice by friction involves trampling or stomping on a pile of harvested rice to separate the grains from the straw, while in a combing method a tool similar to a rake is used to manually comb the rice from the straw. Images showing these threshing methods are presented in Figure 5.21.

**Figure 5.21: Methods of Threshing Harvested Paddy Rice**



Photo credit: Asian Development Bank, 2015.



Photo credit: Asian Development Bank, 2015.



Photo credit: Angelina Earley, 2008.

The images above highlight the various methods that can be adopted for threshing including impact, friction, and combing.

Collect the grains and using a digital weighing scale, take the fresh weight of the paddy after threshing, including the husk and other impurities. Ensure that the scale is set to “0.00” (tare any container used). Weigh up to just under the maximum capacity of the digital weighing scale. For example, if the maximum capacity of the weighing scale is 3 kilograms (kg), weigh amounts slightly less than 3 kg. Record the weight measurements on the crop cutting questionnaire. If multiple weighing is done due to the capacity of the weighing scale, record all weight measurements to get the total weight. Ideally, weighing scales used will have a maximum weight capacity of up to 3 kg, gradation of 0.01 kg, and precision of 0.01 kg.



The images above showcase the various methods that can be implemented to separate small and large rice grains, a process also known as winnowing. Photo credit: Center for Agricultural Statistics, Lao People's Democratic Republic, 2016.

Clean the rice sample by removing any unwanted materials from the grain such as leaves, straw, rocks, and other nongrain materials. Place the threshed sample in a winnowing basket and separate the impurities, then sort the grains to remove the damaged and empty grains. After cleaning, take the weight of the cleaned paddy. Record the weight measurements on the crop cutting questionnaire. Again, if multiple weighing is done, record all weight measurements.

Measure the moisture content of the fresh, cleaned paddy using a moisture meter. Do three moisture content measurements and take the average of the three moisture content readings. Record the average moisture content of the fresh paddy onto the crop cutting questionnaire. In between readings, shake and stir the rice so that the samples taken are more random, and the reading will be more accurate. A more detailed description of how to use a moisture meter is presented in Appendix 3 (Annex 4 of the crop cutting enumerator's manual).

Rice needs to be dried so that it can be milled or safely stored without going bad. Reduce the moisture content to about 12%–14%, which is the level that is safe for storage or milling. Ideally, drying should be done immediately, or within 24 hours, after harvesting. After taking the initial moisture content of the sample, proceed to dry the sample either by sun-drying or by parching. Indicate the drying method in the crop cutting questionnaire. The traditional method for drying rice in many countries in Asia is sun-drying because it is low in cost and easy to manage. An alternative methodology is to use mechanical drying systems such as heated air-drying, low-temperature drying, grain-cooling or solar-drying. In the pilot studies, due to time limitations for enumerators, parching was used as a drying method.

### 5.5.3 Crop Cutting Questionnaire

To record all information about the sample plot, its owner or operator, and all observations and measurements gathered during the CCE, a crop cutting questionnaire should be designed. One questionnaire needs to be completed for each sample plot where crop cutting is conducted. Hence, in one sample mesh, a maximum of four crop cutting questionnaires should be completed.

A sample of the crop cutting questionnaire used in the Philippines is presented in Appendix 3. A crop cutting enumerator's manual, which presents detailed instructions related to completing the questionnaire as well as a description of the crop cutting methodology, should accompany the crop cutting questionnaire. The enumerator's manual used in the Philippines is presented in Appendix 3.

It is important for the enumerators to be well trained in all activities involved in the conduct of the CCE. Both in-house and field training were implemented for the pilot studies. In the 2-day classroom training, all topics relevant to the crop cutting preparations were discussed. Actual practice of the crop cutting methodology was done during 3 days of field training. This included a crop cutting field demonstration and a pre-test of the crop cutting questionnaire.

## 5.6 Using a Grain Moisture Meter

Moisture content is a measure of the amount of water found within a sample at any given time, expressed as a percentage. Moisture content is defined as follows:

$$MC(\%) = \frac{\text{Weight of water}}{\text{Total weight of sample}} \quad (1)$$

In rice production, accurate measurement of the moisture content is important in managing and marketing paddy and rice. There are different levels of rice moisture contents that are ideal for harvesting and for storage or milling. Rice is usually harvested at 20%–25% moisture content. Farmers could incur harvest losses if paddy are harvested at higher moisture contents than the ideal level. Rice that is harvested with higher moisture requires more time to dry, which might result in increased drying costs. For safe storage, rice grains must be dried to 12%–14% moisture content to avoid deterioration. Drying reduces grain moisture content to a safe level for storage.

Inaccurate measurement of rice moisture content during harvest may lead to, as mentioned, extra drying costs and harvest losses. If stored rice grains are too wet, there is a higher rate of spoilage and loss. Farmers also lose profits when the grains sold are too dry, because the rice weighs less at this point. In addition, if farmers decide to mill the rice at an incorrect moisture reading, there is the tendency to have lower head rice when milled (IRRI n.d.). Therefore, milling paddy at the proper moisture content is essential to obtain the highest head rice yield. Paddy is at its optimum milling potential at moisture content of 14% wet-weight basis. If grains are milled with high moisture contents, the grains are still too soft to withstand hulling pressure, which results in grain breakage and possibly pulverization of the grain. On the other hand, if the grains are too dry, they become brittle and are more prone to breakage when milled (Badi 2013).

Rice moisture is usually measured using a grain moisture meter. There are several types and brands of grain moisture meters on the market. For the pilot studies, the Scientific and Handy Equipment for Gintong Ani version III (SHEGA III) moisture meter was used. The SHEGA III moisture meter was the result of more than 5 years of research and development done by the Philippine Bureau of Post-Harvest Research and Extension. It can be used to measure the moisture content of rice and corn, and has a variety of features. Detailed instructions on how to use the SHEGA III moisture meter are presented in Appendix 3 (Annex 4 of the crop cutting enumerator's manual).

## 5.7 Sampling Weights Calculation

The weight for each sampling unit is based on the inverse of its overall probability of selection, taking into account all sampling stages. In the case of the sample meshes in each stratum, the probability of selection was calculated as follows:

$$p_{1h} = \frac{n_h}{N_h} \quad (2)$$

where:

$p_{1h}$  = first stage probability of selection of each sample mesh in stratum h,

$n_h$  = number of sample meshes selected and visited in stratum h,

$N_h$  = total number of meshes in frame for stratum h.

The second stage probability of selection for the sample plots is calculated as the number of sample plots selected in the mesh (generally four) divided by the total number of plots with rice planted during the season and totally or partly within the mesh. This probability is expressed as follows:

$$p_{2hi} = \frac{n_{hi}}{N_{hi}} \quad (3)$$

where:

$p_{2hi}$  = second stage probability of selection of each sample plot with rice within the i-th sample mesh in stratum h,

$n_{hi}$  = number of sample plots selected for crop cutting in the i-th sample mesh in stratum h (generally equal to four),

$N_{hi}$  = total number of plots with rice planted this season that are at least partly located within the boundaries of the i-th sample mesh in stratum h (including those that had already been harvested and those where the crop was lost for any reason).

While a number of plots for which the rice had already been harvested, or where rice was planted but lost pre-harvest, were excluded from the second-stage selection of plots (no crop cutting), these plots were still represented in the estimates and included in the denominator of this probability.

At the third stage, one 2.5 m x 2.5 m subplot is selected within each of the maximum of four sample plots in the mesh for the rice paddy crop cutting. In this case, the probability will depend on the total area

of the plot. The third stage probability of selection was calculated as follows:

$$p_{3hij} = \frac{6.25m^2}{a_{hij}} \quad (4)$$

where:

$p_{3hij}$  = third stage probability of selection of the sample subplot in the j-th sample plot with rice within the i-th sample mesh in stratum h,

$a_{hij}$  = total area (in m<sup>2</sup>) of the j-th sample plot with rice within the i-th sample mesh in stratum h.

The weight for the sample mesh could be calculated as the inverse of the first stage probability of selection as follows:

$$W_{1h} = \frac{1}{p_{1h}} = \frac{N_h}{n_h} \quad (5)$$

where:

$W_{1h}$  = basic weight for each sample mesh in stratum h.

The weight for the sample plots in each sample mesh was based on the inverse of the overall probability of selection. This involved both the first- and second-stage probabilities of selection. In the case where part of the sample plot is located outside the mesh boundaries, the weight was adjusted based on the proportion of the plot that is inside the mesh boundaries. The reason for this adjustment is that the plot can be selected if either of the two adjacent meshes is selected. The weighted total area would be overestimated at the stratum level if no adjustment were done. The general expression for the weight of a sample plot is defined as follows:

$$W_{2hij} = \frac{1}{p_{1h} \times p_{2hi}} \times \frac{a'_{hij}}{a_{hij}} = \frac{N_h}{n_h} \times \frac{N_{hi}}{n_{hi}} \times \frac{a'_{hij}}{a_{hij}} \quad (6)$$



where:

$W_{2hij}$  = basic weight for the j-th sample plot with rice within the i-th sample mesh in stratum h,  
 $a'_{hij}$  = area of the j-th sample plot with rice inside the boundaries of the i-th sample mesh in stratum h.<sup>4</sup>

If the area of the sample plot is completely within the boundaries of the sample mesh,  $a'_{hij} = a_{hij}$ . Hence, the last component of this weight would be equal to 1. It should be noted that the weight of the plot expressed above is applied to the data for the entire plot, including the area outside the sample mesh. The formula for the total area planted in rice can be expressed as follows:

$$\hat{A} = \sum_h \sum_i \sum_j W_{2hij} \times a_{hij} = \sum_h \sum_i \sum_j \frac{N_h}{n_h} \times \frac{N_{hi}}{n_{hi}} \times \frac{a'_{hij}}{a_{hij}} \times a_{hij} = \sum_h \sum_i \sum_j \frac{N_h}{n_h} \times \frac{N_{hi}}{n_{hi}} \times a'_{hij} \quad (7)$$

Since the pilot study researchers also had information on the area of rice planted in the part of the plot inside the mesh ( $a'_{hij}$ ), they could use a simpler expression to calculate the total area of rice. In the case of the sample subplot in each sample plot, the weight will include probability components from all three sampling stages. The weight for each subplot can be expressed as follows:

$$W_{3hij} = \frac{1}{p_{1h} \times p_{2hi} \times p_{3hij}} = \frac{N_h}{n_h} \times \frac{N_{hi}}{n_{hi}} \times \frac{a'_{hij}}{a_{hij}} \times \frac{a_{hij}}{6.25m^2} = \frac{N_h}{n_h} \times \frac{N_{hi}}{n_{hi}} \times \frac{a'_{hij}}{6.25m^2} \quad (8)$$

where:

$W_{3hij}$  = basic weight for the sample subplot in the j-th sample plot within the i-th sample mesh in stratum h.

The estimate of the average yield is based on the weighted mean of subplot area (in m<sup>2</sup>) and production (in kg) data from crop cutting. The estimated yield

was converted to tons per hectare to compare with estimates from administrative data.

## 5.8 Farmer Recall Survey Methodology

Data from farmer recall surveys can be compared with rice area, production, and yield estimates derived from CCEs. Likewise, information on other crops, agricultural methods, and household economics and demographics are gathered to better understand the context of the data collected. Ideally, the farmer recall survey should be conducted within 2 months after the harvest period of the reference cropping season.

Sample plots included in the farmer recall survey are the same plots where crop cutting was conducted. However, in cases where a farmer may own two or more plots within the sample mesh, the farmer will be interviewed only once, but will be asked about information on the other plots he or she owns within the sample mesh, as well as all other plots he or she may own that are outside of the sample mesh.

Farmer recall surveys were conducted to estimate rice yield and production in the four pilot provinces studies. The farmer recall survey questionnaire used in Nueva Ecija, Philippines, along with the accompanying enumerator's manual, is presented in Appendix 4. The reference period for the questions asked was the 2015 rainy season, for comparability of results with the CCE. The farmer recall survey questionnaire was developed based on the Agriculture Questionnaire of the Third Malawi Integrated Household Survey (The World Bank Group 2012), refined in consultation with the agriculture statistics offices in each of the pilot countries, and translated into the local language, for ease of implementation by enumerators.

4 The ratio  $\frac{a'_{hij}}{a_{hij}}$  is also known as the weighted segment estimator because the estimator is based on the ratio of the area of the plot in the mesh to the land area in the entire plot.

In order for enumerators to have a clear understanding of the questions included in the farmer recall survey questionnaire, and to guide them in properly conducting the survey, 3 days of in-house training was conducted. Each question was thoroughly explained and discussed with the enumerators. In addition, 2 days of field work was conducted among rice farmers to test the questionnaire. This provided additional information to the enumerators on how to improve their interviewing strategies. The questionnaire asked for some very detailed information on farm inputs, production, and sales

information. The interviews took approximately 1 hour and 30 minutes to complete, with importance placed on the objectives of the survey being properly explained to the respondent, and that rapport with the respondent was built at the onset of the interview process.

After the completion of the farmer recall survey in each pilot province, encoding of the surveyed data was done using the Census and Survey Processing System (CSPro). The encoded data were converted to STATA data files and checked for consistency.

## Chapter 6: Assessing Accuracy, Revising INAHOR Outputs, and Estimating Paddy Production

In many applications of remote sensing—whether it is paddy area estimation, damage assessment, forest monitoring, or other areas—conducting field validation is essential to properly assess the accuracy of estimates or other information derived from remote sensing data. Remote sensing experts agree that there are limitations to the results derived from analyzing remote sensing data, and that these results need to be supported by observations made on the ground. In this regard, proper evaluation of paddy area estimates generated by analyzing remote sensing data using the advanced version of INternational Asian Harvest mOnitoring system for Rice (INAHOR-AD) software is an essential step in ensuring that the estimates are accurate and truly reflect the actual paddy cultivation areas.

This chapter discusses how to revise INAHOR-AD settings to improve the software’s output; calculating zonal statistics; determining optimal threshold values; and the INAHOR-AD module for estimating paddy production. The chapter also addresses the importance of comparing results from the INAHOR-AD software with a variety of informational sources. Paddy area estimates from INAHOR-AD are compared not only with the results and observations made during the ground-truthing field validation activity, but also with farmer’s estimates of paddy area based on the crop cutting experiments and farmer recall surveys, as well as with official statistics from government statistical agencies.

### 6.1 Methods for Revising INAHOR-AD Settings for Improved Output

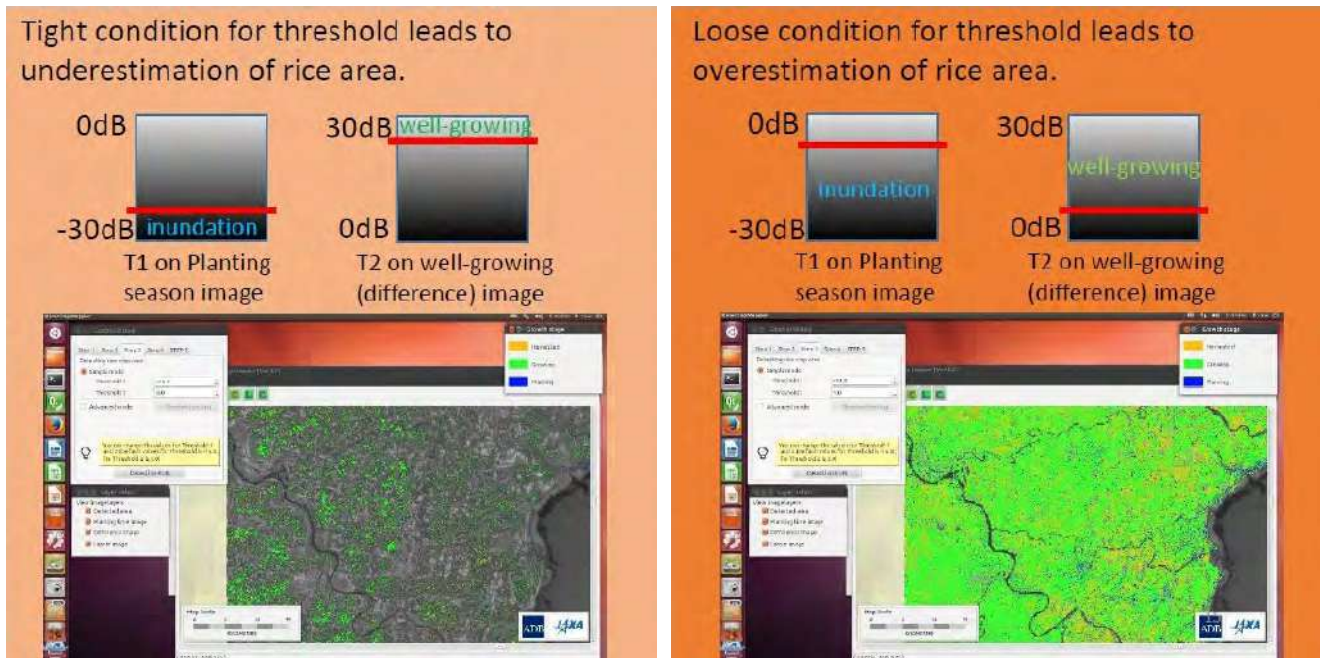
As discussed in Chapter 3 of this handbook, two threshold values (Threshold 1 and Threshold 2) are required in the INAHOR-AD software for paddy area detection. These threshold values are used by the INAHOR-AD software to analyze the backscatter

coefficients of the satellite images used in paddy area detection. Specification of correct threshold values is critical in properly identifying the inundation areas during the planting stage and the healthy areas during the growing stage. With the correct threshold values specified, the INAHOR-AD software will be able to detect paddy areas with increased accuracy.

Figure 6.1 presents scenarios in which threshold values 1 and 2 are inaccurately specified in INAHOR-AD, and how these affect paddy area detection. The green areas on the map depict detected paddy areas in the growing stage. In one case, tight conditions for the threshold values may lead to underestimation of paddy area. As illustrated on the left of Figure 6.1, Threshold 1 (the minimum backscatter value) is set at -25.0, while Threshold 2 (the difference between the maximum and minimum backscatter values) is set at 6.0. Using these threshold values leads to underestimation of paddy areas, which means there is very low detection of areas in the inundation or planting stage and the healthy growing stages. On the other hand, loose conditions for the threshold values may lead to overestimation of paddy area, as illustrated on the right of Figure 6.1. Threshold 1 is set at -10.0, while Threshold 2 is set at 1.0. The illustration shows that large areas in the inundation or planting stage and the healthy growing stages are detected, leading to the detection of a large part of the area as paddy area in the growing stage (shown by the green area on the map).

Table 6.1 shows the optimal threshold values used in INAHOR-AD for pilot studies on remote sensing conducted in the provinces of Savannakhet, Lao People’s Democratic Republic; Nueva Ecija, Philippines; Ang Thong, Thailand; and Thai Binh, Viet Nam for the 2015 wet-cropping season. These threshold values were determined based on the tuning process done during the course of the studies.

Figure 6.1: Importance of Appropriately Specifying Threshold Values



dB = decibel, T1 = Threshold 1, T2 = Threshold 2.

Source: Remote Sensing Technology Center of Japan. 2015. PowerPoint presentation developed for a training workshop in INAHOR-AD. Tokyo.

Table 6.1: Optimal Threshold Values for Paddy Area Detection

Pilot Province	Threshold 1	Threshold 2
Savannakhet, Lao PDR	-17.74	4.77
Nueva Ecija, Philippines	-17.86	8.13
Ang Thong, Thailand	-17.58	3.58
Thai Binh, Viet Nam	-17.46	5.99

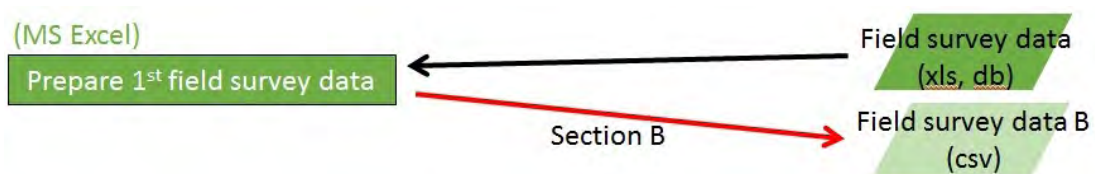
Lao PDR = Lao People's Democratic Republic

Source: Remote Sensing Technology Center of Japan. 2015. PowerPoint presentation developed for a training workshop in INAHOR-AD. Tokyo.

### 6.1.1 Adjusting Threshold Parameters

It is important that threshold values 1 and 2 are optimized to get the most-precise estimates of paddy area using the INAHOR-AD software, and that is why threshold parameter tuning is necessary. To determine the optimal threshold values for paddy area detection, data derived from the ground-truthing field survey are needed (Figure 6.2). Specifically, data on rice area rates or mixcel ratios will be used (Section B of the ground-truthing field survey questionnaire in Appendix 1). Data from the ground-truthing field survey are available at the mesh level.

Figure 6.2: Preparing the Ground-Truthing Field Survey Data



csv = comma-separated values, dB = decibel, xls = Excel Spreadsheet.

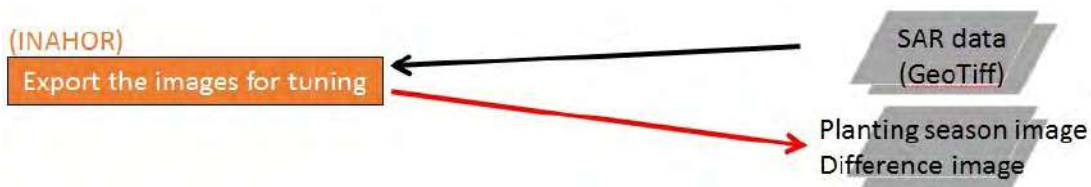
Source: Remote Sensing Technology Center of Japan. 2015. PowerPoint presentation developed for a training workshop in INAHOR-AD. Tokyo.



Section 3.12 of Chapter 3 presents the steps in using INAHOR-AD’s Rice Crop Mapper module to generate paddy area maps. Using the Rice Crop Mapper (Step 3), generate the preliminary set of paddy area maps by specifying initial values for thresholds 1 and 2. Based on studies conducted by the Remote Sensing Technology Center of Japan, preliminary or initial values of -15.0 for threshold 1 and 3.0 for threshold 2 can be used to detect paddy area. However, considering the results of the pilot

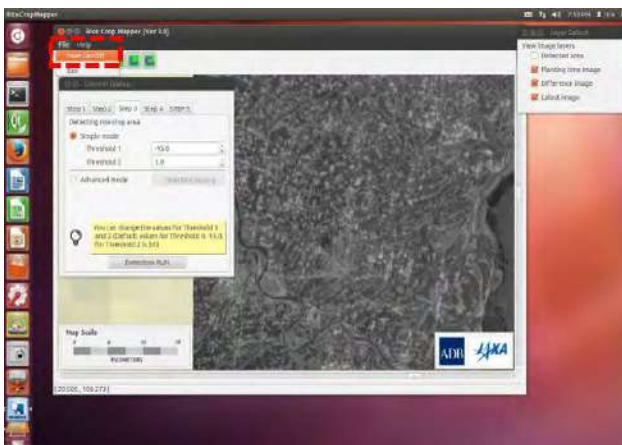
studies, the optimal threshold values presented in Table 6.1 may be used as initial values in subsequent paddy area detections using INAHOR-AD. Images to be used in the threshold tuning process are then exported using INAHOR-AD. After paddy area detection, and while still at Step 3 tab of the Rice Crop Mapper, export the images by clicking “File”, then “Save GeoTiff”, as presented in Figures 6.3 to 6.6.

Figure 6.3: Overview of Exporting Map Images Using INAHOR-AD



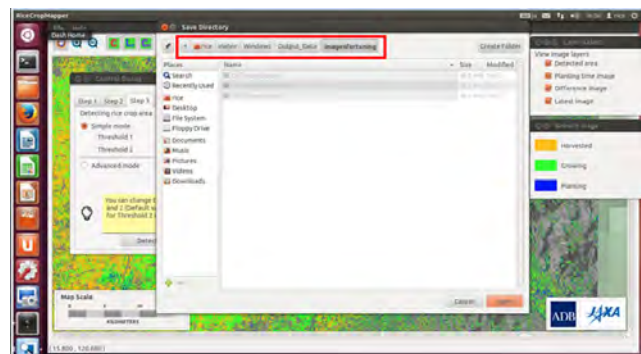
Source: Remote Sensing Technology Center of Japan. 2015. PowerPoint presentation developed for a training workshop in INAHOR-AD. Tokyo.

Figure 6.4: Exporting Map Images Using INAHOR-AD, Step 1



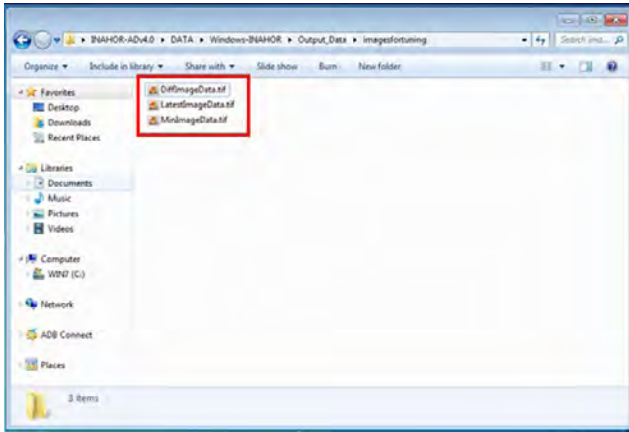
Source: Remote Sensing Technology Center of Japan. 2015. PowerPoint presentation developed for a training workshop in INAHOR-AD. Tokyo.

Figure 6.5: Exporting Map Images Using INAHOR-AD, Step 2



Source: Remote Sensing Technology Center of Japan. 2015. PowerPoint presentation developed for a training workshop in INAHOR-AD. Tokyo.

**Figure 6.6: Exporting Map Images Using INAHOR-AD, Step 3**



Source: Remote Sensing Technology Center of Japan. 2015. PowerPoint presentation developed for a training workshop in INAHOR-AD. Tokyo.

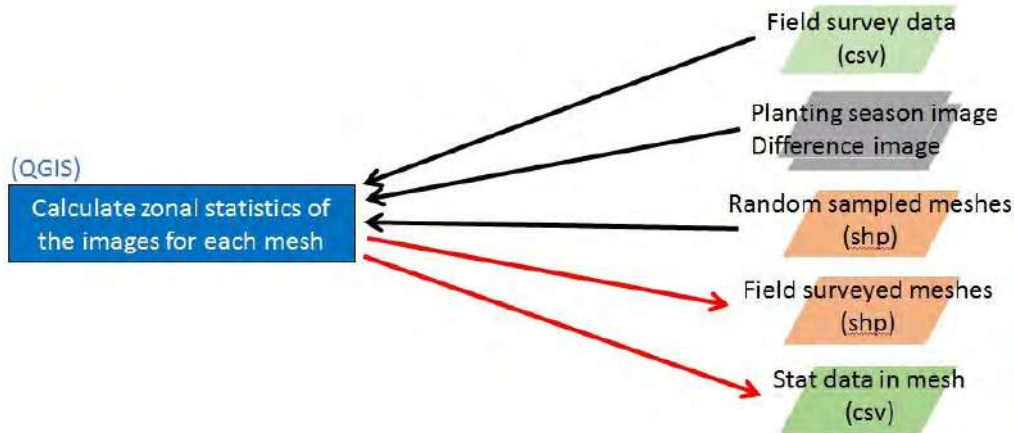
Save the images in the folder “Windows-INAHOR/Output\_Data/images\_for\_tuning/” folder, in the “DATA” folder located inside the “INAHOR-AD” main folder. Three images are

saved on the Windows shared folder, including (i) “MinImageData.tif” – the planting season image; (ii) “DiffImageData.tif” – the difference image; and (iii) “LatestImageData.tif” – the latest image. The images saved will subsequently be used in QGIS to derive zonal statistics, which will be used as basis in determining the optimal values for thresholds 1 and 2.

Inputs required in calculating zonal statistics in QGIS—which include the ground-truthing field survey data, images of detected paddy area exported from INAHOR-AD, and the shapefile of the randomly selected sample meshes—are presented in Figure 6.7. The specific steps for calculating zonal statistics using QGIS are presented in Section 6.2.

Using the zonal statistics (“ZoneStat.csv”) calculated from the initial set of paddy area maps, as described in Section 6.2, revised values for thresholds 1 and 2 can be calculated.

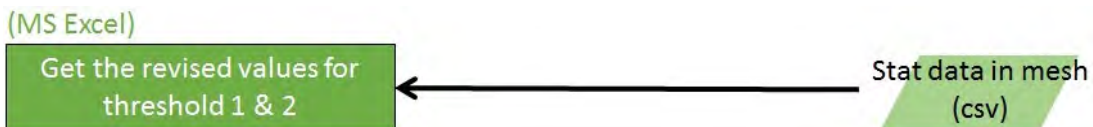
**Figure 6.7: Calculating Zonal Statistics Using QGIS**



csv = comma-separated values, shp = shapefile.

Source: Remote Sensing Technology Center of Japan. 2015. PowerPoint presentation developed for a training workshop in INAHOR-AD. Tokyo.

**Figure 6.8: Generating Threshold Values 1 and 2**



csv = comma-separated values.

Source: Remote Sensing Technology Center of Japan. 2015. PowerPoint presentation developed for a training workshop in INAHOR-AD. Tokyo.

Ground-truthed field survey data, specifically indicators in Section B of the field validation questionnaire, will also be used in the calculation. For illustration purposes, Table 6.2 presents the indicators in Section B of the field validation questionnaire used in Nueva Ecija, Philippines; and the corresponding variable names used to identify the indicators. Categories for land status or stage of development varied among the four pilot studies. For example, in Nueva Ecija, Philippines, specific growing stages (vegetative, reproductive, and maturing) are included in the questionnaire, as presented in Appendix 1. The detailed calculation procedure and screenshots of the Excel spreadsheet illustrating the process of determining the revised threshold values 1 and 2 are shown in Section 6.3.

**Table 6.2: Indicators in Section B of the Field Validation Questionnaire Used in Nueva Ecija, Philippines**

Indicator	Variable name
1. Whether or not there is rice on the sample mesh	B_1RiceFlag
2. Whether or not the rice mesh is a mixcel	B_2MixFlag
3. Rice area rate/Mixel ratio from first impression	B_3RiceRate
4. Rice area rate/Mixel ratio from 16 submeshes	B_4RiceRate
5. Land status/stage of development	
Land preparation	B_5ST1
Planting/Transplanting   Planted/Transplanted	B_5ST2
Growing – Vegetative stage	B_5ST3
Growing – Reproductive stage	B_5ST4
Growing – Maturing stage	B_5ST5
Harvesting/Harvested	B_5ST6
Rice field but left fallow	B_5ST7

Source: Asian Development Bank. 2015. PowerPoint presentation developed for a training workshop in field validation. Manila.

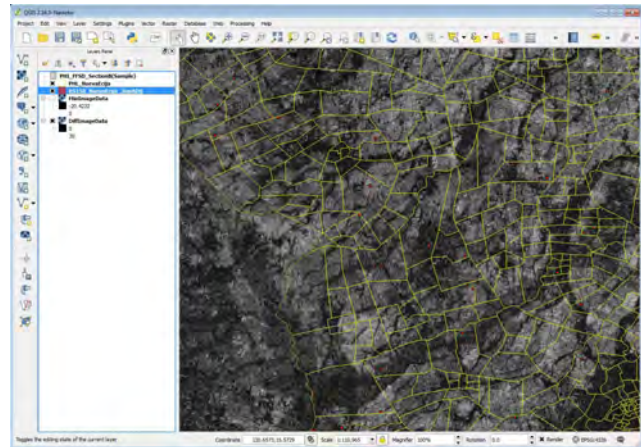
## 6.2 Calculating Zonal Statistics Using QGIS

Start the QGIS program and open the following input files:

- i) ground-truthing field survey data exported as a CSV file (STEP 1), by clicking the “Add Vector Layer” button;
- ii) “MinImageData.tif” and “DiffImageData.tif” saved in the “Windows-INAHOR/Output\_Data/images\_for\_tuning/” folder (STEP 2), by clicking the “Add Raster Layer” button; and

- iii) the shapefile containing the 150 randomly selected sample meshes, which include the 120 sample and 30 replacement meshes (refer to Section 4.1 of Chapter 4), by clicking the “Add Vector Layer” button.

**Figure 6.9: Data Inputs in QGIS for Zonal Statistics Calculation**

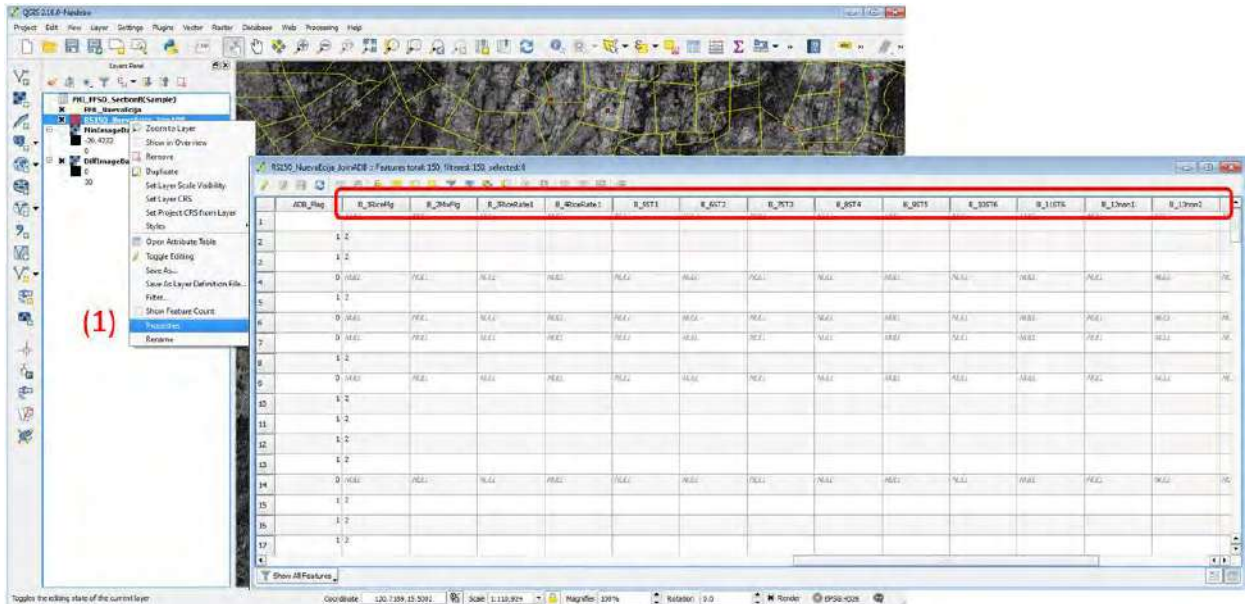
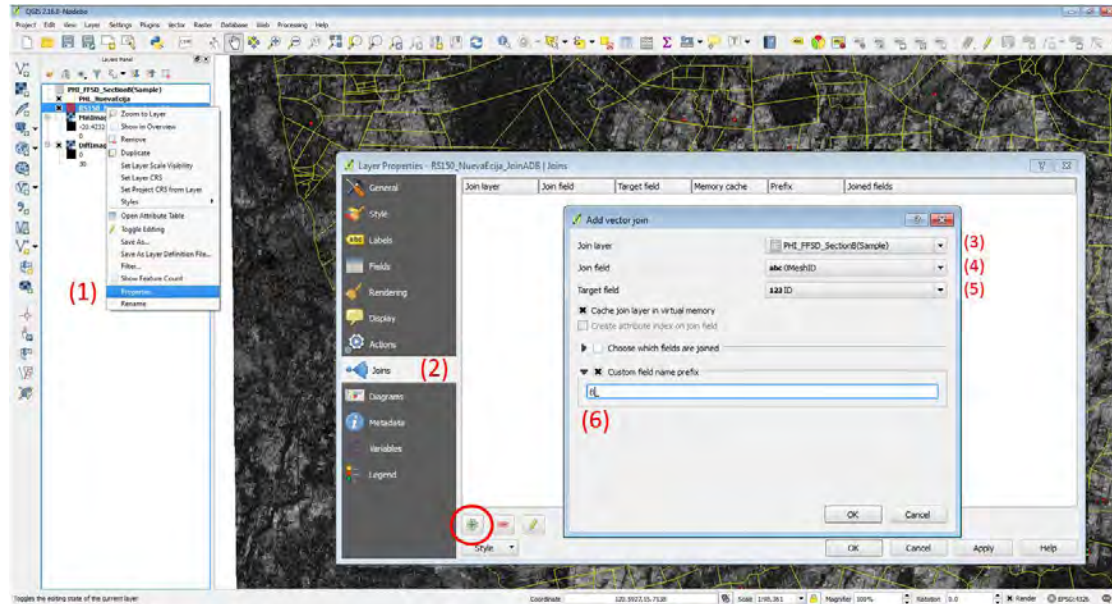


Source: Screen shot generated by Remote Sensing Technology Center of Japan staff. 2015. Tokyo.

Merge the ground-truthing field survey data with the attribute data of the 150 randomly selected sample and replacement meshes. As illustrated in Figure 6.10, right-click the shapefile of the 150 sample and replacement meshes, then click “Properties” to open the “Layer Properties” window. Select the “Joins” option, then click the green plus symbol located at the lower left of the “Layer Properties” window to open the “Add vector join” window. Select as “join layer” the ground-truthing field survey data file. Select as “join field” the mesh number on the ground-truthing field survey data file. Select as “target field” the mesh number on the sample mesh shapefile, which can be identified by opening its attribute table. Likewise, tick the options “Cache join layer in virtual memory” and “Custom field name prefix”, then specify a unique code as identifier, say “B\_”, referring to data from Section B of the ground-truthing field survey. To verify that variables from the two files are joined, open the attribute table of the 150 sample and replacement meshes. The attribute table should include variables from the ground-truthing field survey data file.



Figure 6.10: Merging Field Survey Data with Attributes of the Sample Meshes in QGIS



Source: Screen shots generated by Remote Sensing Technology Center of Japan staff. 2015. Tokyo.

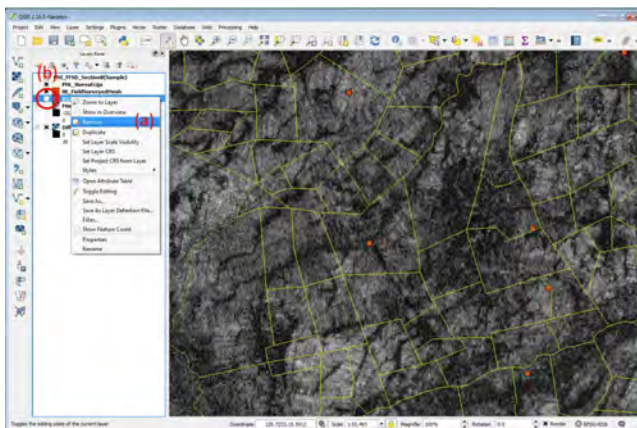
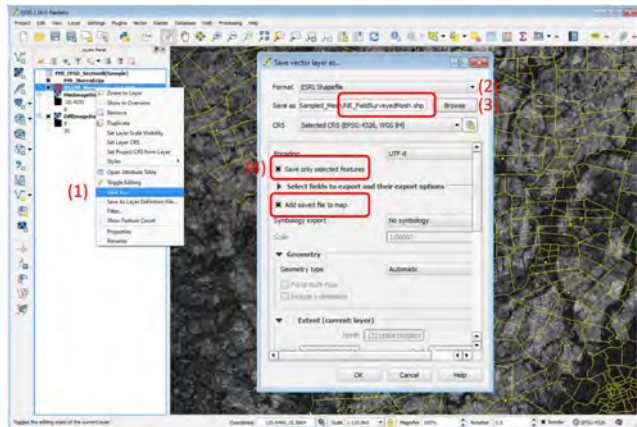
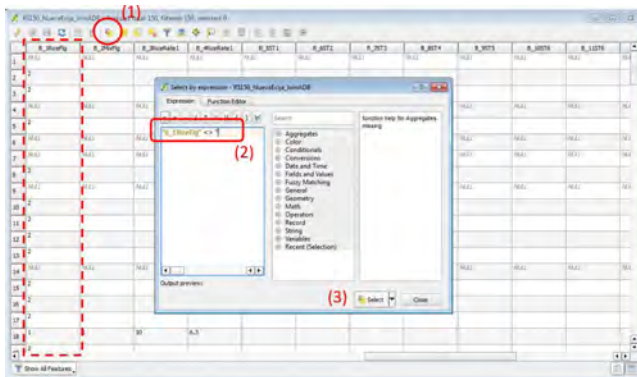
From the opened attribute table of the sample and replacement meshes, select only the sample meshes that were actually visited during the field validation survey. Do not select meshes that have blank or “NULL” values for variable B1. To do this, open the “Select by expression” window by clicking , and then specify the expression, as illustrated in Figure 6.11. For example, if variable B1 was assigned

the variable name “B\_1RiceFlag”; write the expression as “B\_1RiceFlag” <> ‘ , then click “Select” to include the relevant meshes. Save the selected meshes as a new shapefile by right-clicking the sample mesh shapefile; selecting the “Save As” option; choosing as format “ESRI Shapefile”; and clicking “Browse” to specify the filename (for example, “Field\_Surveyed\_Mesh.shp”) and the folder where the shapefile will



be saved. Remember to tick the options “Save only selected features” and “Add saved file to map”. Next, remove the shapefile containing the 150 randomly selected sample and replacement meshes.

**Figure 6.11: Selecting Visited Sample Meshes and Saving as a New Shapefile in QGIS**



By using the “Zonal Statistics” function in QGIS (click “Raster”, then “Zonal statistics”, then “Zonal statistics”), calculate zonal statistics using the planting season image (MinImageData.tif) for Threshold 1 and the difference image (DiffImageData.tif) for Threshold 2.

For Threshold 1, specify the following information:

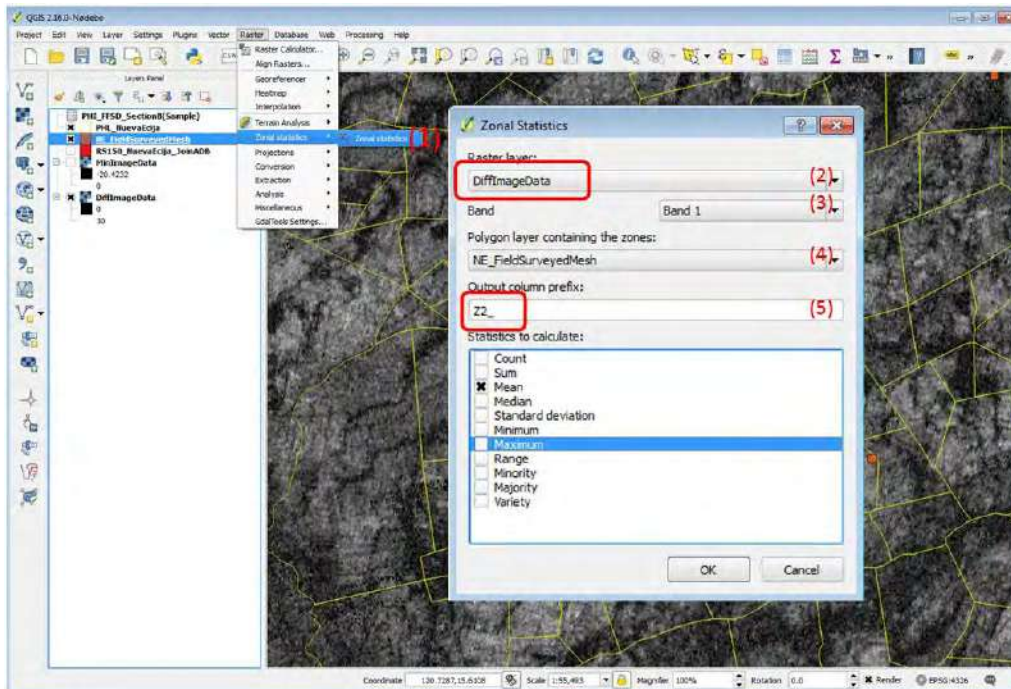
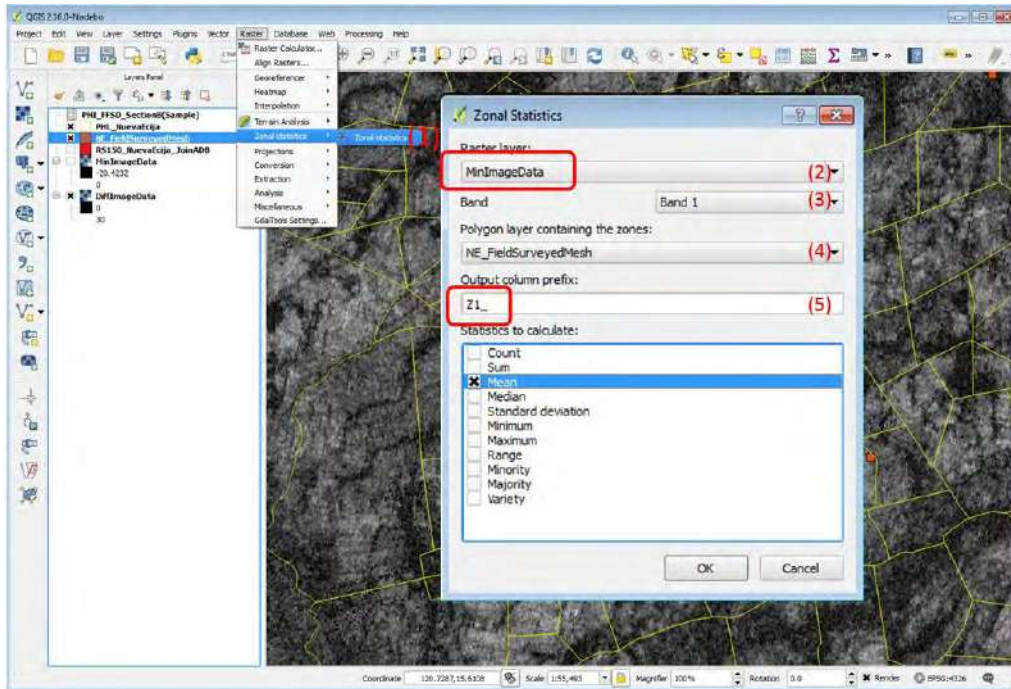
- i) Raster layer = “MinImageData”;
- ii) Band = “Band 1”;
- iii) Polygon layer containing the zones = Shapefile of the sample meshes actually visited during the field validation survey (Field\_Surveyed\_Mesh.shp); and
- iv) Output column prefix = “Z1\_”.

For Threshold 2, specify the following information:

- i) Raster layer = “DiffImageData”;
- ii) Band = “Band 1”;
- iii) Polygon layer containing the zones = Shapefile of the sample meshes actually visited during the field validation survey (Field\_Surveyed\_Mesh.shp); and
- iv) Output column prefix = “Z2\_”.

Calculate only the “Mean”. These statistics will be labeled as “Z1\_mean” and “Z2\_mean”, and should appear on the attribute table for “Field\_Surveyed\_Mesh.shp”, as shown in Figure 6.12.

Figure 6.12: Calculating Zonal Statistics in QGIS Using the Planting Season Image and Difference Image



Source: Screen shots generated by Remote Sensing Technology Center of Japan staff. 2015. Tokyo.



After calculating the zonal statistics for the planting season image and the difference image, export the results as a CSV file, as shown in Figure 6.13. To do this, right-click the shapefile of the sample meshes actually visited during the field validation survey (Field\_Surveyed\_Mesh.shp); select the “Save As” option; choose as format “Comma Separated Value [CSV]”; and click “Browse” to specify the filename (for example, “Zone\_Stat.csv”) and the folder where the shapefile will be saved. Remember to tick the option “Add saved file to map”.

Figure 6.14: Spreadsheet of Sample Mesh Attributes, Ground-Truthing Data, and Computed Zonal Statistics

ID	Category	CenterX	CenterY	NAME_O	Province	B_1RiceFlg	B_2MixFlg	B_3RiceRate	B_4RiceRate	B_5ST1	B_6ST2	B_7ST3	B_8ST4	B_9ST5	B_10ST6	B_11ST7	Z1_mean	Z2_mean_2	
2	34681	IRRI	121.07451	15.98086	Philippines	Nueva Ecija	1	1	10	12.5								-15.34635426	10.6142073
3	39803	IRRI_GLOB	121.11411	15.95926	Philippines	Nueva Ecija	1	1	70	68.8	1	1	1					-16.13864043	6.479248725
4	70710	IRRI_GLOB	120.90171	15.82786	Philippines	Nueva Ecija	1	1	70	62.5								-16.13485323	6.793200365
5	72560	IRRI_GLOB	120.67671	15.81526	Philippines	Nueva Ecija	1	1	50	56.3								-16.16981273	4.505962624
6	73295	IRRI_GLOB	120.73971	15.80808	Philippines	Nueva Ecija	1	1	80	68.8	1							-15.76133944	8.932595693
7	76689	IRRI_GLOB	120.95391	15.80266	Philippines	Nueva Ecija	1	1	60	62.5		1						-15.45666405	6.071005434
8	82209	IRRI_GLOB	120.94491	15.77926	Philippines	Nueva Ecija	1	1	95	93.8								-18.51343531	8.303349823
9	85115	IRRI_GLOB	120.82071	15.76666	Philippines	Nueva Ecija	1	1	95	93.8		1						-15.87253159	11.55884539
10	85129	IRRI_GLOB	120.84591	15.76666	Philippines	Nueva Ecija	1	2	100	100								-18.52117165	9.796814782
11	85277	GLOB	121.11231	15.76666	Philippines	Nueva Ecija	1	1	10	6.3								-16.26130543	4.032327376
12	85438	IRRI_GLOB	120.63711	15.76486	Philippines	Nueva Ecija	1	1	50	43.8	1		1	1				-17.48455669	1.716715949
13	88344	IRRI_GLOB	120.87291	15.75226	Philippines	Nueva Ecija	1	2	100	100								-18.70258328	13.368116
14	89039	IRRI_GLOB	120.99891	15.75046	Philippines	Nueva Ecija	1	2	100	100	1	1	1					-19.44615289	12.79013097
15	89881	IRRI_GLOB	120.98451	15.74686	Philippines	Nueva Ecija	1	1	95	93.8								-17.41199231	12.14441322
16	91500	IRRI_GLOB	120.83871	15.73966	Philippines	Nueva Ecija	1	2	100	100		1						-19.28446953	13.72435306
17	94967	IRRI_GLOB	120.95931	15.72526	Philippines	Nueva Ecija	1	2	100	100	1	1	1					-21.36580342	12.3471791
18	96496	IRRI_GLOB	120.65151	15.71806	Philippines	Nueva Ecija	1	1	65	62.5	1	1						-17.76414795	6.989589185
19	98219	IRRI_GLOB	120.69291	15.71086	Philippines	Nueva Ecija	1	1	90	93	1	1	1	1				-17.91381681	6.189902867
20	100486	IRRI_GLOB	120.94851	15.70386	Philippines	Nueva Ecija	1	1	90	87.5	1	1	1					-16.08784519	6.641345799
21	103296	IRRI_GLOB	120.65151	15.68926	Philippines	Nueva Ecija	1	1	95	93.8		1	1	1				-20.66700659	10.48772086
22	104611	IRRI_GLOB	120.72351	15.68386	Philippines	Nueva Ecija	1	1	85	87.5								-18.55693488	7.315550923
23	106536	IRRI_GLOB	121.12851	15.67666	Philippines	Nueva Ecija	1	1	35	37		1	1					-16.60914992	3.734576568
24	107582	IRRI_GLOB	120.68031	15.67126	Philippines	Nueva Ecija	1	2	100	100	1							-21.40104243	13.44259885
25	108048	IRRI_GLOB	120.79011	15.66946	Philippines	Nueva Ecija	1	2	100	100			1					-19.76261984	12.51133849
26	112350	IRRI_GLOB	120.88971	15.65146	Philippines	Nueva Ecija	1	1	20	18.8								-18.08256499	3.62265272
27	114488	IRRI_GLOB	120.90711	15.64246	Philippines	Nueva Ecija	1	1	98	93.8		1	1	1				-19.82573274	10.533788948
28	115696	IRRI_GLOB	120.78651	15.63706	Philippines	Nueva Ecija	1	2	100	100		1	1					-20.33479171	10.37707905
29	117081	IRRI_GLOB	120.98451	15.63166	Philippines	Nueva Ecija	1	2	70	70	1	1						-17.11753215	13.14665146
30	118421	IRRI_GLOB	121.10151	15.62626	Philippines	Nueva Ecija	1	1	95	100		1	1					-19.83544138	8.133629605
31	122581	IRRI_GLOB	120.93951	15.60826	Philippines	Nueva Ecija	1	1	90	87.5								-14.07448074	5.034808092
32	123427	IRRI_GLOB	120.93231	15.60466	Philippines	Nueva Ecija	1	2	100	100								-16.04413621	7.167271338
33	123491	IRRI_GLOB	121.04751	15.60466	Philippines	Nueva Ecija	1	1	60	56.3	1		1					-12.84045473	7.056860626
34	125167	IRRI_GLOB	121.00431	15.59746	Philippines	Nueva Ecija	1	1	90	87.5								-14.80004046	6.398450293
35	126488	IRRI_GLOB	121.08711	15.59206	Philippines	Nueva Ecija	1	1	95	93.8	1	1	1					-18.22660356	10.15690751
36	127207	IRRI_GLOB	120.85131	15.58846	Philippines	Nueva Ecija	1	1	95	93.8								-16.54858901	6.670416534
37	128181	IRRI_GLOB	121.07451	15.58486	Philippines	Nueva Ecija	1	1	95	93.8	1	1						-16.8998522	14.26542412
38	128450	GLOB	120.79371	15.58306	Philippines	Nueva Ecija	1	1	60	56.3								-18.17873245	6.484567463

Source: Screen shot generated by Remote Sensing Technology Center of Japan staff. 2015. Tokyo.

### 6.3 Determining Optimal Threshold Values

Figure 6.14 shows a screenshot of the spreadsheet, “ZoneStat.csv”, containing the sample mesh attributes, ground-truthing field survey data, and computed zonal statistics. The optimal threshold values, T1 and T2, will be derived based on this information.

Firstly, open the CSV file with Microsoft Excel or OpenOffice Calc. Using the filter function

(shown here for Excel) “Data”, then “Filter”; select all sample meshes identified as 100% rice area using the indicator “B\_4RiceRate”. Next, among the filtered sample meshes, identify and select only the sample meshes identified to have rice crops that are in the land preparation, planting, or growing stages. Eliminate from the selected set any sample mesh whose rice grown is in the harvesting or harvested stage, and those identified as rice area but left fallow, because these sample meshes are not suitable for estimating the threshold values. The reason is that the paddy area being estimated is for those meshes

that were planted during the month that the ground-truthing field validation survey was conducted, i.e., during the target planting period. Shown in Figure 6.15 are data from the field validation survey in Nueva Ecija, Philippines, filtered using the criteria “B\_4RiceRate=100%”.

Figure 6.15: Identifying 100% Rice Area Meshes in Nueva Ecija, Philippines

ID	Category	CenterX	CenterY	NAME_0	Province	B_1RiceFlg	B_2MixFlg	B_3RiceRat	B_4RiceRat	B_5ST1	B_6ST2	B_7ST3	B_8ST4	B_9ST5	Z1_mean	Z2_mean
10	IRRI_GLOB	120.84591	15.76666	Philippines	Nueva Ecija	1	2	100	100						-19.52117165	9.796814782
13	88544	IRRI_GLOB	120.87291	15.75226	Philippines	Nueva Ecija	1	2	100	100					-18.70258326	13.368116
14	89039	IRRI_GLOB	120.99891	15.75046	Philippines	Nueva Ecija	1	2	100	100	1	1	1	-19.44615289	12.79013097	
16	91500	IRRI_GLOB	120.83871	15.73966	Philippines	Nueva Ecija	1	2	100	100				-19.28446953	13.72435306	
17	94967	IRRI_GLOB	120.95931	15.72526	Philippines	Nueva Ecija	1	2	100	100	1	1	1	-21.36580342	12.3471791	
24	107562	IRRI_GLOB	120.68031	15.67126	Philippines	Nueva Ecija	1	2	100	100	1			-21.40104243	13.44299895	
25	108048	IRRI_GLOB	120.79011	15.66946	Philippines	Nueva Ecija	1	2	100	100				-19.76261984	12.51133849	
28	115696	IRRI_GLOB	120.78651	15.63706	Philippines	Nueva Ecija	1	2	100	100				-20.33479171	10.37707909	
30	118421	IRRI_GLOB	121.10151	15.62626	Philippines	Nueva Ecija	1	1	95		1	1		-19.83544138	8.133629605	
41	132310	IRRI_GLOB	120.85671	15.56686	Philippines	Nueva Ecija	1	2	100	100				-20.63085791	12.47149482	
50	152250	IRRI_GLOB	120.79371	15.48226	Philippines	Nueva Ecija	1	2	100	100	1	1	1	-23.16845495	16.59450373	
51	153151	IRRI_GLOB	120.88551	15.47866	Philippines	Nueva Ecija	1	2	100	100				-21.44926967	9.338652357	
62	169331	IRRI_GLOB	120.93951	15.41026	Philippines	Nueva Ecija	1	2	100	100				-17.86250834	13.73705869	
64	171393	IRRI	120.82611	15.40126	Philippines	Nueva Ecija	1	2	100	100	1			-19.30914488	9.541578203	
65	171394	IRRI	120.82791	15.40126	Philippines	Nueva Ecija	1	2	100	100				-21.31621951	12.81782132	
70	199909	IRRI	120.89991	15.28066	Philippines	Nueva Ecija	1	2	100	100				-20.38583979	13.64260979	

Source: Screen shot generated by Remote Sensing Technology Center of Japan staff. 2015. Tokyo.

After identifying the sample meshes with 100% rice area and with rice crops in the land preparation, planting, or growing stages, refer to the mean values generated, i.e., “Z1\_mean” and “Z2\_mean”. Select Threshold 1 to be the maximum mean pixel value in zonal statistics 1. For Threshold 2, select the minimum mean pixel value in zonal statistics 2. As shown in Figure 6.13, the optimum value for Threshold 1 for Nueva Ecija, Philippines is -17.86, while the optimum value for Threshold 2 is 8.13.

Figure 6.16: Optimal Threshold Values 1 and 2 for Nueva Ecija, Philippines

ID	Category	CenterX	CenterY	NAME_0	Province	B_1RiceFlg	B_2MixFlg	B_3RiceRat	B_4RiceRat	B_5ST1	B_6ST2	B_7ST3	B_8ST4	B_9ST5	Z1_mean	Z2_mean
10	IRRI_GLOB	120.84591	15.76666	Philippines	Nueva Ecija	1	2	100	100						-19.52117165	9.796814782
13	88544	IRRI_GLOB	120.87291	15.75226	Philippines	Nueva Ecija	1	2	100	100					-18.70258326	13.368116
14	89039	IRRI_GLOB	120.99891	15.75046	Philippines	Nueva Ecija	1	2	100	100	1	1	1	-19.44615289	12.79013097	
16	91500	IRRI_GLOB	120.83871	15.73966	Philippines	Nueva Ecija	1	2	100	100				-19.28446953	13.72435306	
17	94967	IRRI_GLOB	120.95931	15.72526	Philippines	Nueva Ecija	1	2	100	100	1	1	1	-21.36580342	12.3471791	
24	107562	IRRI_GLOB	120.68031	15.67126	Philippines	Nueva Ecija	1	2	100	100	1			-21.40104243	13.44299895	
25	108048	IRRI_GLOB	120.79011	15.66946	Philippines	Nueva Ecija	1	2	100	100				-19.76261984	12.51133849	
28	115696	IRRI_GLOB	120.78651	15.63706	Philippines	Nueva Ecija	1	2	100	100				-20.33479171	10.37707909	
30	118421	IRRI_GLOB	121.10151	15.62626	Philippines	Nueva Ecija	1	1	95		1	1		-19.83544138	8.133629605	
41	132310	IRRI_GLOB	120.85671	15.56686	Philippines	Nueva Ecija	1	2	100	100				-20.63085791	12.47149482	
50	152250	IRRI_GLOB	120.79371	15.48226	Philippines	Nueva Ecija	1	2	100	100	1	1	1	-23.16845495	16.59450373	
51	153151	IRRI_GLOB	120.88551	15.47866	Philippines	Nueva Ecija	1	2	100	100				-21.44926967	9.338652357	
62	169331	IRRI_GLOB	120.93951	15.41026	Philippines	Nueva Ecija	1	2	100	100				-17.86250834	13.73705869	
64	171393	IRRI	120.82611	15.40126	Philippines	Nueva Ecija	1	2	100	100	1			-19.30914488	9.541578203	
65	171394	IRRI	120.82791	15.40126	Philippines	Nueva Ecija	1	2	100	100				-21.31621951	12.81782132	
70	199909	IRRI	120.89991	15.28066	Philippines	Nueva Ecija	1	2	100	100				-20.38583979	13.64260979	

Source: Screen shot generated by Remote Sensing Technology Center of Japan staff. 2015. Tokyo.



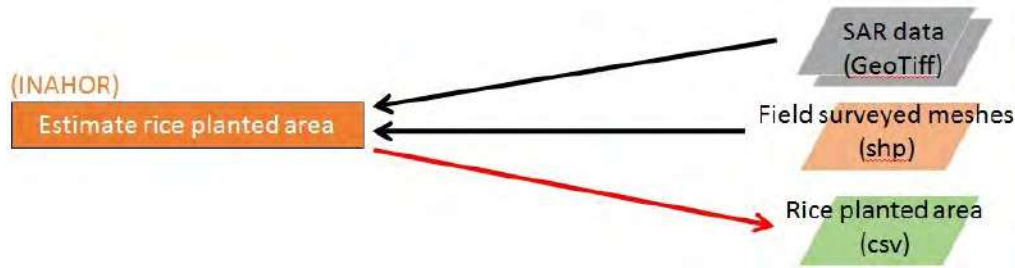
## 6.4 Producing Revised Output of Paddy Field Area Using INAHOR-AD

After the revised threshold values are identified, these threshold values will be used in generating the paddy area map using INAHOR-AD following the steps outlined in Section 3.12 of Chapter 3. The paddy area map generated in INAHOR-AD in this step will be used in estimating paddy area in INAHOR-AD for validation and comparison with the ground-truthing field survey data. Remember, when saving the generated paddy area map, to include a reference that the paddy area map will be used for tuning or validation purposes, as shown in Figure 6.18, where the rice area map for Nueva Ecija is saved as “NuevaEcija2015WetForTuning”. Since the field survey data is available at the mesh level, paddy area estimates from INAHOR-AD should also be generated at the mesh level. Hence, to validate paddy

area estimates using the Rice Production Calculator module of INAHOR-AD, the “Field\_Surveyed\_Mesh.shp”, which refers to the shapefile of the sample meshes visited, will be used as boundary data, instead of the usual provincial shapefile.

Launch the Rice Production Calculator module of INAHOR-AD and create a new project for tuning, as shown in Figure 6.19. Detailed steps for this process are available in Section 3.13 of Chapter 3. Open the paddy area map generated in the Rice Crop Mapper using the revised threshold values (Figure 6.18). Next, open “Field\_Surveyed\_Mesh.shp” as boundary data. At this point, since the interest is only to validate the estimate for paddy area, there is no need to input yield values in the Rice Production Calculator module. Calculate planted area, which will be computed in INAHOR-AD by mesh, and save the results as a comma-separated values (CSV) file.

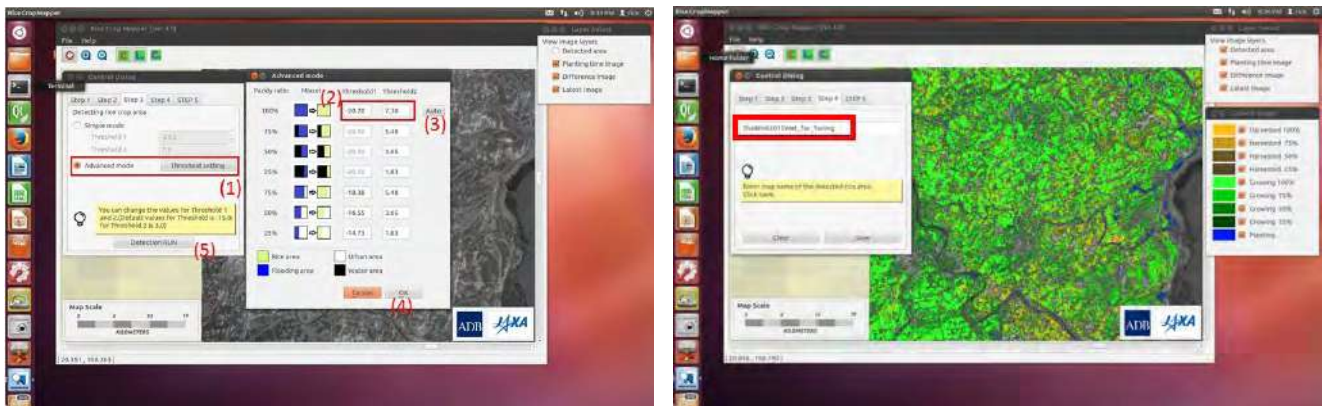
Figure 6.17: Estimating Paddy Area in INAHOR-AD Using the Revised Threshold Values



csv = comma-separated values, shp = shapefile.

Source: Remote Sensing Technology Center of Japan. 2015. PowerPoint presentation developed for a training workshop in INAHOR-AD. Tokyo.

Figure 6.18: Generating Paddy Area Maps in INAHOR-AD Using the Revised Threshold Values



Source: Remote Sensing Technology Center of Japan. 2015. PowerPoint presentation developed for a training workshop in INAHOR-AD. Tokyo.

**Figure 6.19: Generating and Saving Paddy Area Estimates in INAHOR-AD for Validation**

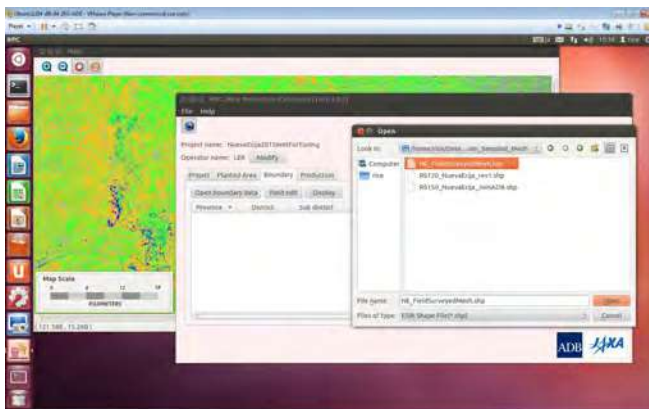
Step 1: Creating a new project in INAHOR-AD



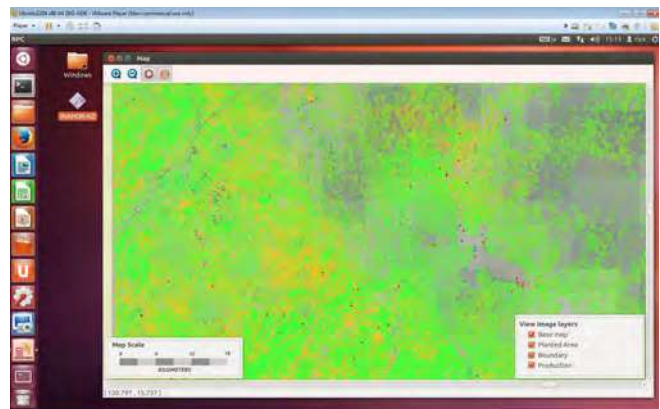
Step 2: Opening the planted area map generated in INAHOR-AD, e.g., “NuevaEcija2015WetForTuning.tif”



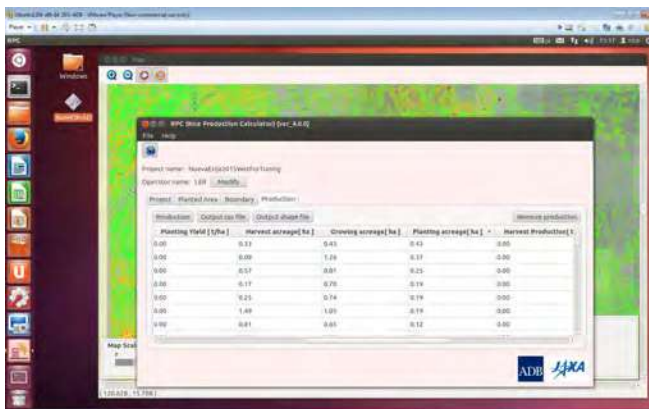
Step 3: Opening “Field\_Surveyed\_Mesh.shp” as boundary data



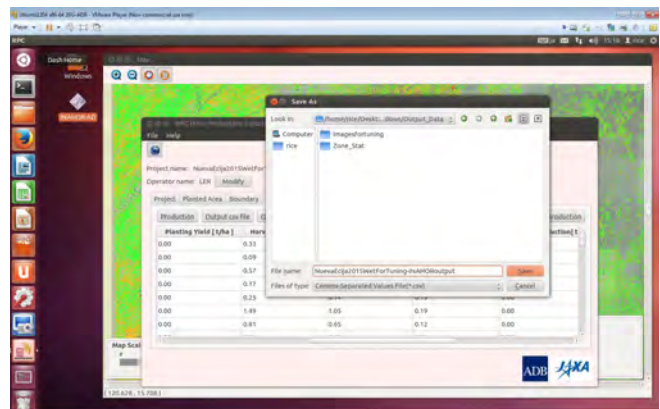
Step 4: View of the planted area map and the field surveyed meshes



Step 5: Planted area estimates using INAHOR-AD



Step 6: Saving the paddy area estimates as a CSV file



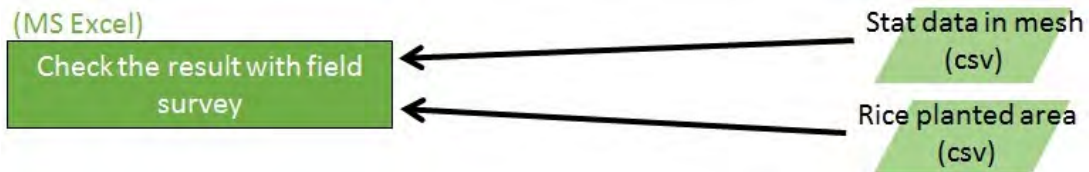
Source: Remote Sensing Technology Center of Japan. 2015. PowerPoint presentation developed for a training workshop in INAHOR-AD. Tokyo.

## 6.5 Validating INAHOR-AD Paddy Area Estimates with Ground-Truthing Field Survey Data

Create a new worksheet in Microsoft Excel for the validation of results. From the CSV file containing

the INAHOR-AD estimates of paddy area by mesh, as discussed in Figure 6.19 under Section 6.4, copy the “Mesh\_ID”, “HarvestAcreage”, and “GrowingAcreage”. As Figure 6.21 shows, sort the data by mesh number, then calculate rice planted area in square meters (m<sup>2</sup>) in each sample mesh as

Figure 6.20: Validating INAHOR-AD Paddy Area Estimates



csv = comma-separated values, shp = shapefile.

Source: Remote Sensing Technology Center of Japan. 2015. PowerPoint presentation developed for a training workshop in INAHOR-AD. Tokyo.

Figure 6.21: Calculating Total Paddy Area from INAHOR-AD Estimates

Mesh_ID	HarvestAcreage [ha]	GrowingAcreage [ha]	Rice Area (m <sup>2</sup> )
1461	0.29	0.7	9900
5293	0.28	0.39	6700
11626	0.28	0.26	5400
13442	0.26	1.64	19000
13867	0.25	0.74	9900
17734	0.23	2.32	31500
22797	0.19	2.57	27600
32146	0.19	0.47	6600
34681	3.29	0	32900
36811	0.19	0.43	6200
37236	0.17	0.98	11500
39803	3.21	0.36	35700
41032	0.17	0.7	8700
56375	0.16	2.3	24600
60216	0.14	3.35	34900
61026	0.11	0.62	7300
65309	0.09	1.26	13500
68064	0.09	0.62	7100
70710	2.85	0.23	30800
72993	0.06	3.58	36400
73560	2.16	0.96	31200
74269	0.06	0.88	9400
75123	0.05	3.06	31100
75295	2.11	1.64	37500
75447	0.03	0.36	3900
75548	0	0.25	2500
76689	1.78	0.47	22500
77239	0	0.22	2200

Source: Screen shot generated by Remote Sensing Technology Center of Japan staff. 2015. Tokyo.



follows:

Total planted area (in m2) = [harvest acreage (in hectares) + growing acreage (in hectares)] \* 10,000

From the “ZoneStat.csv” Excel file, copy the “Mesh\_ID”, “B\_1RiceFlag” and “B\_4RiceRate”. Likewise, as shown in Figure 6.22, calculate the rice-planted area in square meters in each sample mesh as follows:

$$Total\ planted\ area\ (in\ m2) = \frac{200 \times 200 \times Rice\ area\ rate\ based\ on\ 16\ submeshes}{100}$$

After calculating the rice-planted area in each mesh from both the INAHOR-AD estimates and the field survey data, calculate the sum of rice planted area for both data sources. Next, use these figures to calculate the accuracy of the INAHOR-AD rice area estimate, which is calculated as:

$$INAHOR - AD\ Accuracy\ Rate = \frac{Total\ Rice\ Area\ (from\ INAHOR - AD)}{Total\ Rice\ Area\ (from\ field\ survey)} \times 100\%$$

If the accuracy rate calculated is not satisfactory, repeat the process of tuning the threshold values until the optimum values for Threshold 1 and Threshold 2 are achieved (Section 6.1.1). Calculated accuracy rates

Figure 6.22: Calculating Total Paddy Area from Ground-Truthing Data

	A	B	C	D	F	G	H	I	J	K
	Mesh_ID	HarvestAcreage [ ha ]	GrowingAcreage [ ha ]	Rice Area(m2)		Mesh_ID	B_1RiceFlag	B_4RiceRate	Rice Area(m2)	
1										
2	386	2.12	0.31	24300		386		0	0	
3	1479	0.84	1.44	22800		1479	1	29.37	11748	
4	1861	2.26	0.2	24600		1861	1	100	40000	
5	1995	1.39	0.31	17000		1995	1	11.87	4748	
6	2192	0.7	1.22	19200		2192	1	55.62	22248	
7	2216	1.82	0.25	20700		2216	1	64.37	25748	
8	2404	1.79	0.69	24800		2404	1	100	40000	
9	2529	0.2	0	20700		2529	2	0	0	
10	3600	2.09	0.3	24600		3600	1	20	8000	
11	3622	1.33	1.06	22800		3622	1	100	40000	
12	3651	1.86	0.5	27000		3651	1	77.5	31000	
13	3821	0.95	0.69	12200		3821	1	80.62	32248	
14	4375	0.84	0.69	27400		4375	1	74.3	29720	
15	4552			21200		4552	1	95.6	38240	
16	5092			31500		5092	1	96.57	38628	
17	5133			1400		5133	2	0	0	
18	5647	0.81	0	8100		5647	1	10.62	4248	
19	6137	1.36	0.97	23300		6137	1	88.75	35500	
20	7037	1.53	0.45	19800		7037	1	91.25	36500	
21	7093	0.86	0.62	14800		7093	1	56.3	22520	
22	7386	1.22	0.36	15800		7386	1	2.5	1000	
23	7440	0.64	1.17	18100		7440	1	81.3	32520	
24	7465	1.48	0.48	19600		7465	1	62.5	25000	
25	7577	2.62	0.11	27300		7577	1	100	40000	
26	8445	1	1.51	25100		8445	1	48.75	19500	
27	8511	2.32	0.23	25500		8511	1	68.8	27520	
28	8862	1.79	0.55	23400		8862	2	0	0	
29	8982	1.37	0.08	14500		8982	1	20	8000	

Source: Screen shot generated by Remote Sensing Technology Center of Japan staff. 2015. Tokyo.



below 100% mean that INAHOR-AD underestimated the paddy area. If this is the case, consider revising the threshold values so that Threshold 1 is a bit higher while Threshold 2 is a bit lower. On the other hand, if calculated accuracy rates are above 100%, INAHOR-AD overestimated the paddy area. In this case, revise Threshold 1 to be a bit lower and Threshold 2 to be a bit higher.

Figure 6.23 presents paddy area estimates for the sample meshes in Nueva Ecija, Philippines. The total (unweighted) paddy area estimate from INAHOR-AD was 1,980,000 m<sup>2</sup>, while the total (unweighted) paddy

area estimate from the ground-truthing field survey was 2,247,320 m<sup>2</sup>. The calculated accuracy rate for INAHOR-AD was  $\frac{1,980,000\text{sqm}}{2,247,320\text{sqm}} \times 100\% = 88.10\%$ , which indicates that the INAHOR-AD paddy area estimate for Nueva Ecija was underestimated by about 12%.

### 6.6 Using INAHOR-AD for Estimating Paddy Production

Yield information should be inputted into the INAHOR-AD software to derive estimates of paddy production. The yield information may come from several sources—results of crop cutting surveys,

Figure 6.23: Accuracy Rate for INAHOR-AD Estimate of Paddy Area for Nueva Ecija, Philippines

Mesh ID	HarvestAcreage [ ha ]	GrowingAcreage [ ha ]	Rice Area (m <sup>2</sup> )	Mesh ID	B_1RiceFlag	B_4RiceRate	Rice Area (m <sup>2</sup> )
163406	0.71	0.43	11400	163406	1	93.8	37520
163820	0.7	0.54	12400	163820	1	75	30000
168515	0.68	0.92	16000	168515	1	75	30000
168825	0.67	3.24	39100	168825	1	81.3	32520
169331	0.36	0.7	10600	169331	1	100	40000
171354	0.67	2.47	31400	171354	1	50	20000
171393	0.34	2.93	32700	171393	1	100	40000
171394	0.34	0.48	8200	171394	1	100	40000
172745	0.67	2.05	27200	172745	1	62.5	25000
174417	0.67	1.66	23300	174417	1	93.8	37520
179926	0.65	0.4	10500	179926	1	81.3	32520
186363	0.65	0.22	8700	186363	1	93.8	37520
186825	0.64	3.29	39300	186825	1	98	39200
199908	0.62	2.28	29000	199908	1	56.3	22520
199909	0.33	1.57	19000	199909	1	100	40000
210066	0.62	0.74	13600	210066	1	12.5	5000
213899	0.62	0.59	12100	213899	1	6.3	2520
221992	0.59	0.79	13800	221992	1	56.3	22520
927910	0.33	0.43	7600	927910	1	100	40000
			Sum based on INAHOR-AD				Sum based on field survey
			1,980,000				2,247,320
							Rate of precision of INAHOR-AD estimate =(INAHOR-AD/Field survey)*100
							88.10

Source: Screen shot generated by Remote Sensing Technology Center of Japan staff. 2015. Tokyo.

farmers' estimate of yield based on farmer recall surveys, or official yield estimates from government statistical agencies. The steps in estimating paddy production using the INAHOR-AD software are presented in Section 3.13 of Chapter 3.

## **6.7 Accuracy Assessment Using the Results of Paddy Area Field Validation Ground-Truthing**

Ground-truthing is a key part of the evaluation of paddy area estimates derived using remote sensing data. It is necessary that area estimates are validated from the actual field situation at the time the rice crops are planted. In the ground-truthing field survey that is conducted, information on the growth stage of the rice crops is noted because this is vital in the validation of estimates derived using the INAHOR-AD software.

### **6.7.1 Comparison of Paddy Area Estimates**

Results derived from remote sensing data need to be supported by observations made on the ground. In the case of paddy area estimates derived from INAHOR-AD, comparing these with the paddy area estimates obtained from field validation surveys provides a measure of accuracy. Likewise, to further analyze the accuracy of paddy area estimates derived from INAHOR-AD, a comparison with farmers' estimates from the crop cutting or farmer-recall surveys may be done. Considering the knowledge of farmers on the actual area of their plots used for rice farming, this information will be essential in improving the paddy area estimates derived from INAHOR-AD. More importantly, comparing the

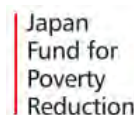
INAHOR-AD estimates with official government statistics on paddy areas will provide vital information in terms of making adjustments to the INAHOR-AD threshold values.

Based on these comparisons, adjustments to the INAHOR-AD threshold values (i.e., Threshold 1 and Threshold 2) can be made. It is important to note that the INAHOR-AD threshold values are adjusted to enable the software to derive paddy area estimates that capture the true conditions on the ground. As such, deriving paddy area estimates from INAHOR-AD over several cropping seasons may be needed to accurately determine the optimal threshold values. Cropping situations may also differ between the dry and wet rice-cropping seasons, hence, studies on deriving paddy areas using the INAHOR-AD software may also be done separately for the wet and dry rice-cropping seasons.

For further information on paddy area estimates derived from remote sensing data compared with other sources, please refer Durante et al. The working paper provides a comparison of paddy area estimates derived from the pilot projects on remote sensing conducted in the Lao People's Democratic Republic, Thailand, and Viet Nam. Paddy area estimates were compared using three methods: (i) measurement of plot size using a global positioning system instrument, (ii) utilizing a digitized map of farmer-identified plot boundaries on a high-resolution Google Earth image, and (iii) calculation of ratio estimates using independent mesh-level measures. Comparisons were also made with the estimates generated from administrative data from the pilot economies.

# APPENDIX 1: Ground-Truthing Field Survey Questionnaire and Enumerator’s Manual: Nueva Ecija, Philippines

## A1.1: Ground-Truthing Field Survey Questionnaire



### R-CDTA 8369: Innovative Data Collection Methods for Agricultural and Rural Statistics GROUND-TRUTHING FIELD SURVEY

#### SECTION A – GENERAL INFORMATION

A1. Team Number:

A2. Start Date (DD/MM/YYYY):

A3. Start time (HH:MM):

A4. Team Members: 1. \_\_\_\_\_  
2. \_\_\_\_\_

A5. Name of Team Leader: \_\_\_\_\_

#### Geographical Information

A6. Country Name:

A7. Country Code:

A8. Province Name:

A9. Province Code:

A10. Municipality Name:

A11. Municipality Code:

A12. Barangay Name:

A13. Barangay Code:

A14. Purok/Sitio Name:

#### Sampled Pixel Information

A16. Mesh/Pixel ID:

A17. Pixel Area (M<sup>2</sup>):

A18. Pixel Center Latitude (Y):

A19. Pixel Center Longitude (X):

#### Contact Information for Local Leaders

A20. Name of Barangay Captain: \_\_\_\_\_ A21. Phone Number: \_\_\_\_\_

A22. Name of Barangay Official 1: \_\_\_\_\_ A23. Phone Number: \_\_\_\_\_

A24. Name of Barangay Official 2: \_\_\_\_\_ A25. Phone Number: \_\_\_\_\_

#### SECTION B – MIXCEL INFORMATION

B1. Is there any rice in this mesh? 1 Yes 2 No

**IF ANSWER FOR B1 IS 1, GO TO NEXT QUESTION. IF ANSWER IS 2, SKIP TO C13.**

B2. Is this mesh a mixcel or not? (Encircle appropriate code.) 1 Yes 2 No

B3. Rice area rate/Mixel ratio from first impression (BETWEEN 0 AND 100)

B4. Rice area rate/Mixel ratio from 16 submeshes (BETWEEN 0 AND 100)

#### USE TABLE BELOW TO ANSWER B4

Number of sub-meshes with rice	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Percentage (%): 1/16x100%	0.0	6.3	12.5	18.8	25	31.3	37.5	43.8	50	56.3	62.5	68.8	75	81.3	87.5	93.8	100

B5. For rice areas, classify land status/stage of development. (Indicate appropriate code on the printed map.)

- 1 Land preparation
- 2 Planting/Transplanting | Planted/Transplanted
- 3 Growing – Vegetative stage
- 4 Growing – Reproductive stage
- 5 Growing – Maturing stage
- 6 Harvesting/Harvested
- 7 Rice field but left fallow





C13. Weather condition at time of interview (**Encircle appropriate code.**)

- 1 Clear/ Sunny (No clouds in the sky)
- 2 Mostly Clear / Mostly Sunny (between 1% and 25% of the sky is covered with clouds)
- 3 Partly Cloudy / Partly Sunny (26% to 50% of the sky is covered with clouds)
- 4 Mostly Cloudy / Considerable Cloudiness (51% to 90% of the sky is covered with clouds)
- 5 Completely Cloudy (The sky is 90% to 100% covered by clouds)
- 6 Rainy (The sky is completely covered by clouds and there is precipitation)

C14. End Date (DD/MM/YYYY):

C15. Time of Completion (HH:MM):

C16. Other Observations:

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**D. TO BE FILLED BY THE TEAM LEADER**

D1. Photo Numbers for Associated Pixel:

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## A1.2: Enumerator's Manual

### Introduction

This manual was prepared for guide enumerators conducting the ground-truthing field survey in the pilot province of Nueva Ecija, Philippines during the wet-cropping season in July 2015. Rice area estimates derived from the ground-truthing activity were compared with the rice area estimates resulting from the INAHOR-AD (International Asian Harvest Monitoring System for Rice - Advanced) software using SAR data from ALOS-2, and were used as a basis in adjusting the thresholds used in INAHOR-AD to compute rice area estimates. The manual can be used as a guide for future similar work.

### Sample Selection

Pixels or meshes of size 200 meters (m) x 200 m are randomly selected from rice area maps obtained by the International Rice Research Institute (IRRI) using 2015 Moderate Resolution Imaging Spectroradiometer data, and from land-use maps produced by the European Space Agency in 2009 under its GlobCover initiative. A total of 120 sample meshes and 30 replacement meshes are randomly selected as shown in Table A1.1.

### Team Composition

*Team composition.* Six (6) teams are formed to conduct the ground-truthing field survey. Each team was composed of one (1) team leader and two (2)

members. Responsibilities of each member are the following:

1. One member (usually the team leader) shall assume the role as the navigator of the team. He or she will handle the geolocation of the sample points, i.e., guide the team to the coordinates of the sample point based on the global positioning system (GPS) reading. This member will also take pictures (with GPS coordinates) to document the planting stage at each sample point.
2. Another member of the team shall serve as the recorder, i.e., will handle printed copies of the survey map and questionnaires. He or she will record the ground-truthing and fill up the survey questionnaires.
3. The third member who represents the field office shall serve as the enumerator and field coordinator of the team. He or she will handle the interview part of the survey. As field coordinator, he or she will coordinate with the local officials and provide information about the location of the sample points in the municipality or barangay.

One supervisor is assigned to manage the administration of the field survey.

*Sample mesh assignment.* Each team is assigned to survey 20 sample meshes within 6 days of the survey period. Approximately 3 to 4 sample meshes are expected to be surveyed by each team in 1 day.

**Table A1.1: Number of Sample Meshes and Replacements by Stratum**

Group	Sample Meshes	Replacements	Total
IRRI + GlobCover (overlap)	80	5	85
IRRI rice map (excluding GlobCover)	20	10	30
GlobCover land use map (excluding IRRI)	15	10	25
Others	5	5	10
<b>TOTAL</b>	<b>120</b>	<b>30</b>	<b>150</b>

IRRI = International Rice Research Institute

Source: Asian Development Bank estimates.

Team compositions and mesh assignments are presented in Table A1.2. The survey schedule is presented in Table A1.3.

### Tools and Materials

Each team is provided with the following items:

1. iPad mini 3 with waterproof protective cover - one unit per team
2. Power bank as back-up power source - one unit per team
3. File clip boards and pens
4. Measuring tape
5. Boots, cap or hat, raincoat
6. Printed copies of the survey map (for each 200 m x 200 m mesh assigned to the team)
7. Printed copies of the survey questionnaire

### Locating the Sample Mesh

The iPad mini 3s provided for each field survey team are installed with Google Earth, Google Maps (to be installed as an alternative for other map tools), Google Drive or iCloud (to be used in downloading the Keyhole Markup Language [KML] files to the iPads), and a map tool for GPS tracking, i.e., Map Plus (Offline Map + KML Editor + GPS Recorder). In addition, the KML files corresponding to the sample points assigned to each team are loaded on the iPad mini 3.

The GPS tracking apps on the iPads are used as guide to locate the sample points.

### Filling Out the Questionnaire

#### Section A

Upon arrival at the site, team members should fill out "SECTION A - GENERAL INFORMATION" on the survey questionnaire. Section A includes:

- i) information about the field survey team such as the team number, names of team members, and name of the team leader;
- ii) the date of the field visit and the time when the field survey was started;

- iii) geographical information on the target area;
- iv) information about the sample mesh including the pixel identification (ID), and the pixel center latitude and longitude; and
- v) information about the local leaders (in the Philippines, this included Barangay Captain and Kagawad).

#### Section B

This section of the survey questionnaire refers to mixcel information.

For Question B1, observe the area to determine whether there is rice planted in the area or not. If there is rice planted in the area, proceed to answer the succeeding questions. If there is no rice planted in the area, skip to C13 (weather condition).

For Question B2, classify the sample pixel as mixcel or not. A mixcel refers to a sample pixel/mesh wherein certain areas are planted with rice, while some areas are covered with other vegetation (such as grass or planted with other crops) or are covered by buildings, roads, rivers, forests and other structures.

Questions B3-B4: Rice Area Estimation on the Field

Three (3) methods are employed to derive rice area estimates within each of the 200 m x 200 m sample mesh.

Method 1: Estimate rice area visually and record the estimated rice area rate (0%–100%) on the survey questionnaire (*Item B3*).

Method 2: Using the printed map, subdivide the 200 m x 200 m sample mesh into 16 submeshes and estimate the rice area rate (0%–100%) in each of the 16 submeshes. Using the table below, which presents the percentage estimates of rice area (computed as  $1/16 \times 100\%$ ) based on the number of submeshes with rice, record on the

survey questionnaire the estimated rice area rate (0%–100%) for the 200 m x 200 m sample mesh (*Item B4*).

To illustrate how to use the percentage table: Suppose that out of the 16 submeshes, only 3 submeshes have rice. If the accumulated rice areas in the 3 submeshes can be “fitted” into only 1/16<sup>th</sup> submesh, then the rice area estimate for the whole 200 m x 200 m sample mesh is 6.3%; or if the accumulated rice areas in the 3 submeshes can be “fitted” into 2/16<sup>th</sup> submesh, then the rice area estimate is 12.5%, and so on.

#### USE TABLE BELOW TO ANSWER B3

Method 3: Use the GPS mapping software app installed on the iPad (Map Plus) and walk around the perimeter of rice areas within the sample mesh. Rice areas may be on separate polygons within a sample mesh. Walk around the perimeter of all the polygons to get rice area estimates for each and record on the questionnaire the shapefile name for the rice area covered (*Item C11*).

#### Identification of rice growth stage or land use

The objective of asking questions B5 and B6 is to identify the rice growth stage (for rice fields), or identify areas that may possibly be misclassified as rice area by the software (for non-rice areas).

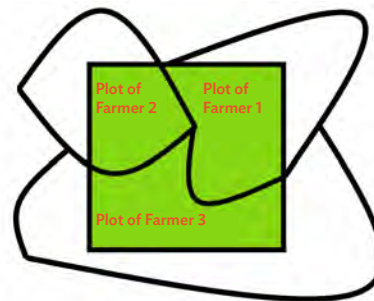
Question B5. For the identified rice areas, specify land classification (e.g., if land is in preparation stage); the rice growth stage (vegetative, reproductive, maturing, harvesting); or if the field is left fallow by circling the appropriate code. Draw a line around the rice areas corresponding to a specific growth stage or land status and indicate the corresponding code (1 to 7) on the printed map.

Question B6. For the identified non-rice areas, specify land use (e.g. if land area is grassland used for grazing animals, if other crops are present in the area, if land is unused, or if land is used for aquaculture) by encircling the appropriate code. If possible, identify the other crops present on the field.

#### Section C

Section C on the survey questionnaire refers to plot details.

1. Identify the number of farm owners and/or operators that operate within the 200 m x 200 m sample pixel. Coordinate with local officials, if needed.
2. Ask each farm operator the following:
  - a. Name and contact number(s) of the farm owner and/or operator or other family members of the farm operator.
  - b. Total area of plot (farmer’s estimate) - Ask for the total area of the whole plot or parcel of land owned by the farmer for which some part is covered within the 200 m x 200 m sample mesh (see diagram below). Indicate unit of measure used.



- c. Area of rice planted on the plot (farmer’s estimate) - Ask for the total rice area planted within the whole plot or parcel of land owned by the farmer. Indicate unit of measure used.

Number of submeshes with rice	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Percentage (%):1/16x100%	0	6.3	12.5	18.8	25	31.3	37.5	43.8	50	56.3	62.5	68.8	75	81.3	87.5	93.8	100



- d. Rice variety or varieties planted - Indicate the local name of the rice variety or varieties grown or refer to the list to enter the code.
- e. Rice planting or transplanting method - Indicate a code of 1 for direct-seeding, 2 for transplanting, or 3 if another method is used and then specify the method used.
- f. Estimated date of harvest - Ask farmers or operators when they expect to harvest the rice crop.
3. To estimate the total area of the plots owned by each farm owner or operator, walk around the boundaries of the plots and use the GPS mapping software app installed on the iPad (Map Plus) to estimate the area covered. Indicate unit of measurement used. Record on the questionnaire the shapefile name for the plots owned by each farm owner or operator (*Item C10*).

For question C13, indicate the weather condition at the time of the interview or survey. Use the table below as a guide.

Descriptive Picture	Weather Condition	Survey Response Code	Definition
	Clear / Sunny	1	No clouds in the sky.
	Mostly Clear / Mostly Sunny	2	Between 1% and 25% of the sky is covered with clouds.
	Partly Cloudy / Partly Sunny	3	26% to 50% of the sky is covered with clouds.
	Mostly Cloudy / Considerable Cloudiness	4	51% to 90% of the sky is covered with clouds.
	Completely Cloudy	5	The sky is 90% to 100% covered by clouds.
	Rainy	6	The sky is completely covered by clouds and there is precipitation.

Before leaving the survey area, indicate the date and time of completion of the field survey.

### For the Team Leader

As reference for enumerators, the team leader should indicate the photo numbers for the associated pixel.

## DEFINITION OF TERMS

**Mixel** - refers to a sample pixel or mesh wherein certain areas are planted with rice, while some areas are covered with other vegetation (such as grass or planted with other crops) or are covered by buildings, roads, rivers, forests, and other structures.

**Mixel ratio** - refers to the percentage of rice area within a sample pixel or mesh with a value from 0% to 100%. Zero if the pixel or mesh is entirely a non-rice area and 100% if the pixel or mesh is entirely a rice area.

**Non-rice area** - refers to agricultural areas identified as non-rice on the generated rice area maps. Does not include areas covered by buildings, roads, rivers, forests, and other structures.

**Land status and/or planting stage** - refers to the status of land (land preparation, harvesting or harvested, or left fallow) or the stage of rice crop growth (planting or growing) within the sample pixel.

- **Land preparation** - when rice fields are being prepared for planting. This involves (i) plowing to “till” or dig up, mix, and overturn the soil; (ii) harrowing to break the soil clods into smaller mass and incorporate plant residue, and (iii) leveling the field.

- **Planting or transplanting | Planted or transplanted stage** - when rice seeds or seedlings have been recently planted or transplanted on the field (not yet in the tilling stage).
- **Growing - Vegetative stage** - rice growth stage from germination to panicle initiation.
- **Growing - Reproductive stage** - rice growth stage from panicle initiation to flowering.
- **Growing - Maturing stage** - rice growth stage from flowering to production of mature grain.
- **Harvesting or harvested stage** - when mature rice crop is collected from the field. Paddy harvesting activities include cutting, stacking, handling, threshing, cleaning, and hauling.
- **Fallow** - when rice fields are left unsown or uncultivated for a time to restore fertility.

**Farm owner and/or operator** - refers to the person who owns, manages, or operates the activities on the field. He or she is the most knowledgeable about the crops planted on the farm that includes the 200 m x 200 m area of interest. It can also refer to the person who is available for an interview at the time of the field survey, because the owner might be living far away from the actual farm.

**Rice variety** - refers to the variety or varieties of rice cultivated on the field.

**Planting or transplanting method** - refers to the rice planting method used by the farm operator, which can be either direct-seeded or transplanted. Farmers from certain countries in the region may apply variations of these two methods.

**Direct-seeding** - seeds are sown directly in the field.

**Transplanting** - seedlings are first raised in seedbeds before they are planted in the field.







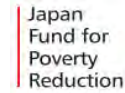
# APPENDIX 3: Crop Cutting Survey Questionnaire and Enumerator’s Manual: Nueva Ecija, Philippines

## A3.1 Crop Cutting Survey Questionnaire

**CONFIDENTIAL**



**R-CDTA 8369: Innovative Data Collection Methods  
for Agricultural and Rural Statistics  
CROP CUTTING SURVEY QUESTIONNAIRE**



**A. GENERAL INFORMATION**

	CODE	NAME												
1. PROVINCE	<input style="width: 20px; height: 20px;" type="text"/> <input style="width: 20px; height: 20px;" type="text"/>	.....												
2. MUNICIPALITY	<input style="width: 20px; height: 20px;" type="text"/> <input style="width: 20px; height: 20px;" type="text"/>	.....												
3. BARANGAY	<input style="width: 20px; height: 20px;" type="text"/> <input style="width: 20px; height: 20px;" type="text"/> <input style="width: 20px; height: 20px;" type="text"/>	.....												
4. MESH/PIXEL ID	<input style="width: 20px; height: 20px;" type="text"/> <input style="width: 20px; height: 20px;" type="text"/> <input style="width: 20px; height: 20px;" type="text"/> <input style="width: 20px; height: 20px;" type="text"/> <input style="width: 20px; height: 20px;" type="text"/>	.....												
5. CENTER PIXEL LATITUDE	<input style="width: 20px; height: 20px;" type="text"/> <input style="width: 20px; height: 20px;" type="text"/> <input style="width: 20px; height: 20px;" type="text"/> <input style="width: 20px; height: 20px;" type="text"/> <input style="width: 20px; height: 20px;" type="text"/> <input style="width: 20px; height: 20px;" type="text"/>	.....												
6. CENTER PIXEL LONGITUDE	<input style="width: 20px; height: 20px;" type="text"/> <input style="width: 20px; height: 20px;" type="text"/> <input style="width: 20px; height: 20px;" type="text"/> <input style="width: 20px; height: 20px;" type="text"/> <input style="width: 20px; height: 20px;" type="text"/> <input style="width: 20px; height: 20px;" type="text"/>	.....												
7. PLOT ID	<input style="width: 20px; height: 20px;" type="text"/> <input style="width: 20px; height: 20px;" type="text"/> <input style="width: 20px; height: 20px;" type="text"/>	.....												
8. FULL IDENTIFICATION: MESH + PLOT ID	<input style="width: 20px; height: 20px;" type="text"/> <input style="width: 20px; height: 20px;" type="text"/> <input style="width: 20px; height: 20px;" type="text"/> <input style="width: 20px; height: 20px;" type="text"/> <input style="width: 20px; height: 20px;" type="text"/> <input style="width: 20px; height: 20px;" type="text"/> <input style="width: 20px; height: 20px;" type="text"/> <input style="width: 20px; height: 20px;" type="text"/>	.....												
9. NAME OF FARM OPERATOR	.....													
10. ADDRESS OF FARM OPERATOR	.....													
11. CONTACT NUMBER OF FARM OPERATOR	.....													
12. RESPONDENT'S NAME	.....													
13. RELATIONSHIP TO THE FARM OPERATOR	.....													
14. ADDRESS OF RESPONDENT	.....													
15. CONTACT NUMBER OF RESPONDENT	.....													
16. TEAM MEMBERS/ ENUMERATORS' NAMES	.....													
	17. TEAM MEMBERS/ ENUMERATORS' CODES	<table border="1" style="border-collapse: collapse; width: 100%; text-align: center;"> <tr><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px;"></td></tr> <tr><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px;"></td></tr> <tr><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px;"></td></tr> <tr><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px;"></td></tr> </table>												
18. TIME INTERVIEW START:	<input style="width: 40px; height: 20px;" type="text"/> : <input style="width: 20px; height: 20px;" type="text"/> AM <input style="width: 20px; height: 20px;" type="text"/> PM	19. TIME INTERVIEW END: <input style="width: 40px; height: 20px;" type="text"/> : <input style="width: 20px; height: 20px;" type="text"/> AM <input style="width: 20px; height: 20px;" type="text"/> PM												
20. DATE OF INTERVIEW START (DD/MM/YYYY):	<input style="width: 40px; height: 20px;" type="text"/> / <input style="width: 20px; height: 20px;" type="text"/> / <input style="width: 20px; height: 20px;" type="text"/>	21. DATE OF INTERVIEW END (DD/MM/YYYY): <input style="width: 40px; height: 20px;" type="text"/> / <input style="width: 20px; height: 20px;" type="text"/> / <input style="width: 20px; height: 20px;" type="text"/>												
	(ENUMERATOR: ► GO TO SECTION B)													
22. NAME OF TEAM LEADER:	.....	23. TEAM LEADER CODE: <input style="width: 20px; height: 20px;" type="text"/> <input style="width: 20px; height: 20px;" type="text"/> <input style="width: 20px; height: 20px;" type="text"/>												
24. DATE OF QUESTIONNAIRE INSPECTION BY THE TEAM LEADER (DD/MM/YYYY):	<input style="width: 40px; height: 20px;" type="text"/> / <input style="width: 20px; height: 20px;" type="text"/> / <input style="width: 20px; height: 20px;" type="text"/>													
25. OBSERVATIONS ON THE INTERVIEW. RECORD GENERAL NOTES ABOUT THE CROP CUTTING ACTIVITY AND RECORD ANY SPECIAL INFORMATION THAT WILL BE HELPFUL FOR SUPERVISORS AND THE ANALYSIS OF THIS QUESTIONNAIRE. FOR EXAMPLE, IF THE WHOLE PLOT HAS ALREADY BEEN HARVESTED, EXPLAIN THAT IN THIS SECTION, TAKE A PICTURE AND PUT THE PICTURE NUMBER.														
<div style="border: 1px solid black; padding: 5px;"> <p>.....</p> <p>.....</p> <p>.....</p> </div>														

**B. RICE CROP CUTTING FORM**

1. ENTER THE MESH/PIXEL ID OF THE RICE FARM ON WHICH CROP CUTTING IS OCCURRING. (THIS SHOULD MATCH SECTION A Q4)		3. FULL IDENTIFICATION (SHOULD MATCH SECTION A Q8)	
2. ENTER THE PLOT ID OF THE RICE PLOT ON WHICH CROP CUTTING IS OCCURRING. (THIS SHOULD MATCH SECTION A Q7)			
4. TOTAL AREA OF PLOT (FARMER'S ESTIMATE)	ha	5. PRODUCTION ESTIMATE (FARMER'S ESTIMATE) FROM THIS PLOT	Kg/Sack
6. TOTAL AREA OF PLOT (USING GPS)	m <sup>2</sup>	7. FROM THE NORTH/WEST CORNER, ENTER THE RANDOMLY CHOSEN CORNER NUMBER FROM RANDOM NUMBER TABLE 1 WHICH YOU WALK TO.	8a. LONG SIDE: m
		8b. SHORT SIDE: m	9a. LONG SIDE: m
		9. ENTER THE RANDOM DISTANCE WALKED ON BOTH SIDES ADJACENT TO THE RANDOMLY CHOSEN CORNER	9b. SHORT SIDE: m
		10. GPS ACCURACY	11a. LATITUDE
		11. GPS COORDINATES OF THE CROP CUTTING SUB-PLOT RANDOM CORNER	11b. LONGITUDE

12. WHICH RICE VARIETY HAS BEEN PLANTED ON THIS PLOT? IF MORE THAN ONE TYPE, INDICATE THE ONE THAT IS PREDOMINANTLY PLANTED. <small>LOOK AT OPTIONS FROM MANUAL AND FILL APPROPRIATE CODE. USE OTHER VARIETY CODE 99. USE 99 IF VARIETY IS UNKNOWN. NAME IF FARMER DOES NOT KNOW, CODE 99.</small>	13. WHAT IS THE METHOD OF PLANTING USED? <small>DIRECT SEEDING.....1 BROADCASTING.....2 BANDSOWING.....3 OTHER, SPECIFY.....4</small>	14. WAS ANY PORTION OF THE RICE FROM THE CROP CUTTING SUB-PLOT HARVESTED BEFORE CROP-CUTTING? <small>YES.....1 NO.....2 (▶17)</small>	15. WHEN DID THE FARMER HARVEST THE RICE FROM THE CROP CUTTING SUB-PLOT? <small>VALUES FOR WEEK CAN RANGE FROM 1-4</small>	16. WHAT IS THE ESTIMATED PERCENTAGE OF AREA IN THE CROP CUTTING SUB-PLOT THAT HAS ALREADY BEEN HARVESTED? <b>IF 100%, REDO THE CORNER SELECTION, USE DIFFERENT QUESTIONNAIRE</b>	17. DATE OF CROP-CUT. <small>DATE THE FIELD TEAM IMPLEMENTS CROP CUTTING IN THE PLOT</small>	18. HOW MANY HILLS ARE FOUND IN THE CROP CUTTING PLOT IN TOTAL? <b>IF DIRECT SEEDING, COUNT THE TOTAL NUMBER OF HILLS. IF TRANSPLANTING, MULTIPLY NUMBER OF HILLS ALONG THE LENGTH AND WIDTH OF THE 2.5M X 2.5M SUB PLOT.</b>
		WEEK W	MONTH MM	YEAR YYYY	DAY DD	MONTH MM
				%		YEAR YYYY

19. PADDY (FRESH)		20. PADDY (DRY)	
20. WHAT IS THE FRESH WEIGHT OF PADDY AFTER THRESHING? USE WEIGHING SCALE. <small>IF MULTIPLE WEIGHING IS DONE, RECORD ALL WEIGHT MEASUREMENTS TO GET THE TOTAL WEIGHT. Note: Maximum capacity of weighing scale is 3 kg.</small>	21. WHAT IS THE WEIGHT OF THE PADDY AFTER SORTING TO REMOVE IMPURITIES? USE WEIGHING SCALE. <small>IF MULTIPLE WEIGHING IS DONE, RECORD ALL WEIGHT MEASUREMENTS TO GET THE TOTAL WEIGHT. Note: Maximum capacity of weighing scale is 3 kg.</small>	22. WHAT IS THE METHOD OF DRYING USED? <small>SUN DRYING.....1 PARCHING.....2</small>	23. WHAT IS THE MOISTURE CONTENT OF THE DRIED PADDY FROM THE CROP CUTTING SUBPLOT? <b>Use the AVERAGE of the three moisture content readings you will take for the final, DRIED paddy MC measurement</b>
GRAMS	GRAMS		%
24. DATE OF WEIGHING THE DRIED PADDY RICE FROM THE CROP-CUTTING SUBPLOT.	25. WHAT IS THE WEIGHT OF THE PADDY AFTER DRYING? USE WEIGHING SCALE. <small>IF MULTIPLE WEIGHING IS DONE, RECORD ALL WEIGHT MEASUREMENTS TO GET THE TOTAL WEIGHT. Note: Maximum capacity of weighing scale is 3 kg.</small>	DAY DD	MONTH MM
		YEAR YYYY	GRAMS

To be filled by data entry personnel.

26. DATA ENTRY CLERK NAME:

29. VERIFIER NAME:

27. DATA ENTRY CLERK CODE:

30. VERIFIER CODE:

28. DATE OF DATA ENTRY (DDMM/YYYY):

31. DATE OF VERIFICATION (DDMM/YYYY):

/	/	

/	/	

## A3.2 Crop Cutting Survey Enumerator's Manual

R-CDTA 8369: Innovative Data Collection Methods for Agricultural and Rural Statistics

Enumerator's Manual

Crop Cutting Questionnaire



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#### PART I: CROP CUTTING QUESTIONNAIRE

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#### PART II: ANNEXES

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Annex 2: Crop Cutting and Weighing Procedure

Annex 3: Tracking of Plot Boundaries Using Map Plus

Annex 4: Moisture Content Measurement

## Part I: Crop Cutting Questionnaire

### General Instructions

#### Objective

This crop cutting survey is being conducted to estimate rice yield and production in the pilot province of Nueva Ecija, Philippines.

#### Definition of Terms and Concepts

The following are explanations and clarifications of terminology used in this questionnaire and the research as a whole:

- **RESPONDENT** - Should be the main farmer or farm operator who is best placed to answer survey questions. In the absence of the main farmer or farm operator, you may seek help of the next-best informed person of the plot.
- **PLOT** - A continuous piece of land on which a unique crop or a mixture of crops is grown, under a uniform, consistent crop management system. It must be continuous and should not be split by an obstruction (e.g., river or path, etc.) of more than 1 meter (m) in width. Farm boundaries are defined according to crops grown and the operator.
- **CROP CUTTING SUBPLOT** - Part of a plot selected for yield measurement or density studies.

#### Team Composition

The survey team consists of the Team Leader and Field Enumerators. The specific functions of the team are summarized below.

The enumerator's work will be monitored by the Team Leader. Each Team Leader is responsible for monitoring and handling the sampled meshes, farmers, rice plots, and subplots in his or her assigned area during the entire period of the survey.

- The Team Leader is responsible for the following activities:
- helping enumerators find solutions to problems encountered in the field;
- ensuring that accurate survey procedures are followed during the operation;
- making spot checks and verifying the work of each enumerator in the assigned area;
- keeping records regarding the progress of the survey activities in each assigned area;
- facilitating crop cutting (yields) experiment and ensuring the correct protocol is followed; and
- reporting all the completed work to the staff of agricultural statistics in the Central Office within the range of the time specified on the survey timetable.

Before any work commences in a target municipality or barangay, you will first contact the barangay officials, the administrative heads, or their representatives and show them your letter of introduction from the Authority to secure their approval and support. Explain to them in detail how and why the survey is being conducted and the responsibility of the selected farmers and/or farm operators.

Next, take out the roster of farmers that were listed in the sample mesh during the field validation survey, and visit the site with the barangay officials. Walk around the perimeter of the mesh with the barangay official and identify all the farmers operating on that 200 m x 200 m mesh and obtain their plot size. Identify which of these farmers are growing rice on their plot. Also record which farmers have plots within the 200 m x 200 m ready for harvest.

Subsequent to this, create a shortlist of only rice farmers from the complete list of farmers. A separate procedure for selecting rice farmers on whose plots you will conduct the crop cutting is outlined in the Annex. Remember that you have to do crop cutting on 4 rice plots:



- If the total number of rice plots covering the 200 m x 200 m mesh has 4 or more rice farmers operating on them, you will do crop cutting on 4 randomly selected plots.
- If the total number of rice plots covering the 200 m x 200 m mesh has fewer than 4 rice farmers operating on them, then you perform crop cutting on all their plots. That is, if there are three plots, you perform crop cutting on 3; if two plots, then 2; and so on.

The enumerators are responsible for the following activities:

- performing randomized selection of rice plots and/or farmers;
- locating the sample mesh and the plots of the randomly selected farmers or farm operators, using the maps on the iPad;
- the enumeration and interview of randomly selected farmer or farm operators about agricultural activities;
- measuring all rice plots selected using the iPad and recording all measurements and coordinates on the form provided;
- coordinating with the farmer or farm operator to implement crop cutting on the subplots for yield measurements using the methodology outlined in this manual, under the supervision of the Team Leader; and
- recording information on the questionnaire when interviewing the farmers or farm operators.

### **Summary of the Field Team's Responsibilities During the Crop Cutting Survey**

- You are responsible for providing complete and accurate information to the barangay officials about the major objectives of the activity, and securing their cooperation to facilitate the smooth completion of tasks.
- You are responsible for identifying and visiting the plots of the randomly selected farmers or farm operators, as well as measuring the

boundaries of these plots with the iPads.

- You are responsible for performing crop cutting on rice plots that a farmer or farm operator may be harvesting.
- You must talk to the farmer or farm operator of every sampled plot to explain the objectives of your work, in a clear, complete, and accurate manner.
- You must arrange a reasonable time with the farmer or farm operator for interviewing or crop cutting on the farms before going to the site.
- After completing the questionnaire, you must check the questionnaire thoroughly to ensure you have not made any mistakes or errors before leaving the interviewed farmer or farm operator. For global positioning system (GPS) subplot coordinates, fill in the GPS coordinate questions in Section B Question 10.
- You must maintain frequent communication with your supervisor and Asian Development Bank Crop Cutting Consultant for assistance, as well as for inspection of your work.
- Where necessary, you will be required to answer some queries raised by your team leader. This is meant to ensure the efficiency and accuracy of your work.
- You must submit questionnaires to your team leader immediately after completion.

### **Research Tools**

- Each interviewer should have the following:
  - Identity card
  - Letter of introduction from the Philippines Statistics Authority
  - Enumerator's Manual
  - List of all farmers or farm operators in a given sample mesh to do the random farmer or plot selection
  - Questionnaire
  - Pen or Pencil
  - Writing clipboard
  - Notebook
  - Rain boots and raincoat

### Tools and Materials Needed for Crop Cutting

The enumerator needs to make sure that he or she has the following materials before going to the selected field for crop cutting:

- iPad mini 3
- Measuring tape
- Crop cutting frame
- Sticks for demarcation
- Sickle
- Bags to store the grain
- Mortar and pestle (for pounding or shelling the rice grains)
- Moisture meter
- Weighing scale
- Random number table for random selection of crop cutting plot
- Notebook, forms, and questionnaire to list and select the crop fields and record the results

### Skip Codes

#### CONDITIONAL SKIP

Throughout the questionnaire, you will find “skip codes”. Skip codes tell you to proceed to a different question than the one that immediately follows, to improve the flow of the interview. They are indicated by this symbol: (►Q#). The “Q#” tells you which question to skip to. This is the only kind of skip you will find in the questionnaire, and is called a “conditional skip”, which means that you skip based on the respondent’s answer to a given question.

#### Completion of Sections A and B

- Fill out Section A - General Information. For each mesh, you should have **four** Section A forms.
- Fill out Section B - Rice Crop Cutting Form. For each mesh, you should have **four** Section B forms.

- Both Sections A and B are for **one** rice subplot only. One form needs to be filled out for **each** of the rice plots sampled. In other words, there should most likely be **four** Section A forms and **four** Section B forms for the four rice subplots sampled from each mesh<sup>5</sup>.
- Section C should be used for randomly selecting the crop cutting subplot. Use the tables accordingly.

**Other responses.** If the respondent says “other” as his or her response, record the **specific response**. Write the code for “OTHER, SPECIFY”, then write the specific response next to the number.

**Entering dates.** When entering the month or year of an event, follow these rules:

**Calendar day:** Always enter 2 digits, e.g., the date of “1<sup>st</sup>” should be entered as “01” (NOT “1”)

**Calendar month:** Always enter 2 digits. Do not write the name of the month, e.g., “02” for February (NOT “2”)

**Calendar year:** Always enter 4 digits, e.g., “2015” (NOT “15”)

	DD	MM	YYYY
e.g.	19	06	2015

**Decimals.** Use decimals in all cases. When reporting portions of a quantity less than 1, please record the unit’s digit as “0” followed by a decimal point, followed by the three digits for the decimals. Record the weight of paddy up to three decimal places.

KILOGRAMS	
0.201	

**Comments.** Write any relevant or important comments at the space provided at the bottom of the first page of the questionnaire.

<sup>5</sup> Unless there are fewer than four farmers operating on the mesh

## Section A: General Information

**Questions 1-3.** We start with name of the province and its corresponding code. This is followed by the codes and names of the municipality and barangay.

**Questions 4-6.** Write the mesh or pixel number of the sample mesh selected, followed by the center pixel latitude and center pixel longitude. You may get the information by tapping any side of the square mesh using the iPad.

**Question 7.** Write the plot code of the specific plot owned by the farm operator. Write the plot code as “p01” for plot number 1, “p02” for plot number 2, and so on.

**Question 8.** Write down the full identification of the mesh and plot. Write the full identification as “12345-p01” for mesh with number “12345” and plot code “p01”.

**Question 9.** Write down the full name of the farm operator.

**Question 10.** Write down the address of the farm operator. This will be helpful while conducting the follow-up farmer recall survey to track down the responder.

**Question 11.** Write down the phone number of the farm operator. If the farmer has more than one phone number, record all of them.

**Question 12.** This may be a different person if the operator is different from the respondent. For example, if the operator is unavailable but his wife is available, then the respondent is the wife, since she is responding to the questionnaire. If it is the same person as the farm operator, write down the same name as Question 9.

**Question 13.** Write down the relationship of the respondent to the farm operator; e.g., “relative”, “spouse”, “someone else working on the farm”.

**Question 14.** Write down the address of the respondent. This will be helpful while conducting the follow-up farmer recall survey to track down the respondent.

**Question 15.** Write down the phone number of the respondent. If the respondent has more than one phone number, record all of them.

**Question 16.** Names of team members or enumerators. Here the interviewer writes the full names of all members of the team.

**Question 17.** Enumerator code. Every team member or enumerator will have a unique code; this is always filled in for each and every questionnaire he or she attends. This number will not change over the course of the survey.

**Question 18.** Time of interview start. The interviewer should record the starting time of the interview. The start time is divided into two boxes: one for the hour and the other for minutes. The hours entry box is before the “:”. This can range from “1” to “12”. The minutes entry box can range from “00” to “59”. Please be sure to circle “AM” or “PM” to indicate what time the interview has started.

**Question 19.** Time of interview end. The interviewer should record the finishing time of the interview. The start time is divided into two boxes: one for the hour and the other for minutes. The hours entry box is before the “:”. This can range from “1” to “12”. The minutes entry box can range from “00” to “59”. Please be sure to circle “AM” or “PM” to indicate what time the interview has ended.

**Question 20.** Date of interview start. Write the date the interview was commenced. Enter the date in day, month, and year format. Remember that day is two digits (DD), month (MM) is two digits, and year is four digits (YYYY). If the date is “1”, enter it as “01”. If the Month is “8” (August), enter it as “08”.

**Question 21.** Date of interview end. Write the date the interview was completed, regardless if it is the same day as the start date or not. Enter the date in day, month, and year format. Remember that day is two digits (DD), month (MM) is two digits, and year is four digits (YYYY). If the date is “1”, enter it as “01”. If the Month is “8” (August), enter it as “08”.

**Leave Questions 22, 23, 24, 25 blank for now and skip to Section B. Record any observations you may have from the interview in the space provided at the bottom of the cover page as you progress through the interview.**

**Questions 22-24.** These questions are for the team leader to fill out with his or her name, number, and the date of questionnaire inspection.

**Question 25.** Include any relevant views on how the interview was conducted, problems encountered, etc., which may help the team leader and the data analysts of the results of the survey. Observations should be written at the end of the interview.

## **Section B: Rice Crop Cutting Form**

This section is used to implement crop cutting on rice plots **that are ready for crop cutting**. If a randomly chosen plot as described in the procedures before Section A is not ready for crop cutting, select another plot randomly.

**Questions 1-3. THESE ARE FOR THE ENUMERATOR.** Enter the mesh or pixel number, plot code, and full identification (mesh number and plot code) of the farm on which rice crop cutting is

occurring. This should match the information on Section A (Questions 4, 7, and 8, respectively).

**Question 4.** Ask the farmer to estimate the total area of the plot. Please note the unit of measurement used by the farmer to estimate the area.

**Question 5.** Ask the farmer to estimate the amount of rice that will be harvested from the plot of land. Please take note of the unit of measurement used by the farmer to estimate the production.

**Question 6. THIS IS FOR THE ENUMERATOR.** Using Map Plus, get an estimate of the total area of the randomly selected plot. Tap the location button to start locating your current position. Tap the record button on the operation bar. Walk around the boundaries of the plot and record your track. Using the editing function of Map Plus, draw a polygon to get an estimate of area of the plot. **Record the area estimate on the questionnaire.**

**Question 7. THIS IS FOR THE ENUMERATOR.** FROM THE NORTH-WEST CORNER WHERE YOU STARTED, ENTER THE RANDOMLY CHOSEN CORNER NUMBER FROM RANDOM NUMBER TABLE 1 (AT BACK OF QUESTIONNAIRE) WHICH YOU WALK TO.

**Question 8.** FROM RANDOM NUMBER TABLE 2 (AT BACK OF QUESTIONNAIRE), ENTER THE LENGTH OF BOTH SIDES ADJACENT TO RANDOMLY CHOSEN CORNER. “8a” refers to the longer side and “8b” refers to the shorter side from the chosen corner.

**Question 9. THIS IS FOR THE ENUMERATOR.** ENTER THE DISTANCE WALKED ON BOTH SIDES ADJACENT TO THE RANDOMLY CHOSEN CORNER. “9a” refers to the longer side and “9b” refers to the shorter side from the chosen corner.



**Question 10.** Using the iPad, enter the GPS accuracy measurement in meters.

**Question 11.** Using the iPad, identify the GPS coordinates of the crop cutting subplot corner and record on the questionnaire. "11a" is the latitude and "11b" is the longitude.

**Question 12.** Ask the farmer the rice variety planted on the plot. If more than one rice variety is planted, ask for the predominant variety planted. Look at the variety codes available in the appendix of the manual and apply those codes. For other rice varieties, use code 98 and write down the specific rice variety planted. Otherwise, if the farmer does not know the rice variety planted, use code 99.

**Question 13.** Ask the farmer the method of planting. For direct-seeding, use code 1; for transplanting, use code 2; for ratooning, use code 3; or if another method is used, use code 4 and specify the planting method. Ratooning is a method of harvesting a crop that leaves the roots and the lower parts of the plant uncut to give the ratoon or the stubble crop.

**Question 14.** Was any portion of the rice from the crop cutting subplot harvested BEFORE crop cutting? This means any portion where we won't find rice because it was harvested before the team made it to the plot. If yes, go to the next question. If no, mark "2" and skip to Question 17.

**Question 15.** When did the rice farmer harvest the rice from the crop cutting subplot? Follow the prescribed format in reporting (DD/MM/YYYY). Remember that week only ranges from "1" to "4". Month codes go from "01" to "12". Year is a 4-digit code.

**Question 16.** Ask the farmer what percentage of the area in the crop cutting subplot has already been harvested? This would be the farmer's estimate. Emphasize that you are only asking

**about the crop cutting plot.** If all of the rice from the crop cutting subplot has already been harvested, i.e., the answer is 100%, **redo the corner selection and repeat the process.**

**Question 17. Record the date of crop cut. This is also in the format of DD/MM/YYYY.**

**These questions apply for rice in paddy form.**

**Question 18.** In the crop cutting subplot, count the total number of "hills" of rice found. A hill of rice is a single shoot growing out of the ground. For example, in the picture on the right, you see one hill of rice with three stems. You can tell that it is one hill because it has just one cluster of roots and grows from one place on the ground.

For transplanting, you can simply calculate the total number of hills on the length and width of the crop cutting subplot and then multiply the number.

For direct-seeding or ratooning, you will have to physically count the total number of hills. This task is easier after harvesting the rice.

**Question 19. Thresh the rice and, using a weighing scale, get the weight in kilograms (kg) in its PADDY form.** This is the fresh weight of rice on the day of the crop cutting. Remember that the rice grain is being weighed and it still has the husk and other impurities. Before weighing, ensure that the scale is set to zero (including any container used to hold the goods to be weighed). The maximum capacity of the digital weighing scales is 3 kg. If multiple weighing is done, record all weight measurements to get the total weight.

**Question 20.** Using a moisture meter, get the moisture content of paddy after threshing.

**Question 21. Sort the sample after threshing to remove the leaves, straws, rocks, and other impurities. Using a weighing scale, get the weight**

**of the paddy after sorting.** If multiple weighing is done, record all weight measurements to get the total weight.

**These questions apply for dried rice in paddy form.**

The method for drying rice on the field is parching, which involves putting the threshed rice in a stove or drying equipment and heating it to remove the moisture content. In our case, the rice probably will be heated in a pot and turned around regularly after threshing, so that moisture content can be evenly reduced. Dry till the point the moisture content hits 14% by taking random samples.

**Question 22.** Write down the method of drying used by your team: sun-drying or parching (as described above).

**Question 23.** Use the moisture meter provided to your team to measure the moisture content of the dried paddy from the crop-cut subplot. Record the measurement on the questionnaire.

**Question 24.** Record the date of dry weighing of rice in paddy form. The format is DD/MM/YYYY.

**Question 25.** After drying, weigh all the rice that is still in paddy form. Report the dry weight of the crop-cut rice in paddy form in kilograms.

Before weighing, ensure that the scale is set to zero (including any container used to hold the paddy to be weighed). If multiple weighing is done, record all weight measurements to get the total weight.

During data entry and verification, data entry personnel should fill-out the following:

**Question 26.** The data entry clerk writes down his/her full name.

**Question 27.** Data entry clerk code. Every data entry clerk will have a unique code; this is always filled in for each and every questionnaire he or she encodes.

**Question 28.** Record the date of data entry. This is also in the format of DD/MM/YYYY.

**Question 29.** The verifier writes down his or her full name. The verifier will also encode data from the questionnaire (second data entry).

**Question 30.** Verifier code. Every verifier will have a unique code; this is always filled in for each and every questionnaire he or she encodes.

**Question 31.** Record the date of verification (second data entry). This is also in the format of DD/MM/YYYY.



- i. Record “Y” if the rice is ready for harvest, and move on to entering information for the next plot. Record “N” if not, and continue to Question #5.
- j. If the rice is not ready for harvest, enter the date the rice will be ready for harvest, in the 1-digit week, 2-digit month, and 4-digit year format: **W/MM/YYYY**
- k. Make a shortlist of all the farmers who own plots in the 200 m x 200 m mesh, and are growing rice, and will be harvesting this season. Include their serial number in order of appearance.
- l. From the list in “k”, randomly select four plots using Table A3.1. Note that this is only a partial picture of the table. If the total number of plots is five, then plot numbers 1, 2, 4, and 5 will be selected, since these appear under main sample of plots. If the total number of plots is 19, then plot 6, 10, 16, and 19 will be selected. There is a possible need to replace plots if any of the main sample plots are unavailable for crop cutting.

Table A3.1: Systematic Selection of Plots from Listing in Sample Segment						
Number of plots listed in sample segment	Main sample of plots				Replacement plots	
	1	2	3	4	1	2
5	1	2	4	5	3	
6	1	2	4	5	3	6
7	1	2	4	5	3	6
8	1	4	5	8	2	6
9	2	5	6	9	3	8
10	1	3	6	8	4	9
11	3	5	8	10	1	7
12	2	4	8	10	6	12
13	3	6	10	12	1	8
14	4	6	11	13	2	9
15	5	7	12	15	2	10
16	5	8	13	16	2	10
17	2	4	10	13	7	16
18	3	6	12	15	9	18
19	6	10	16	19	3	13

Source: Screen shot generated by Asian Development Bank, 2015. Manila.

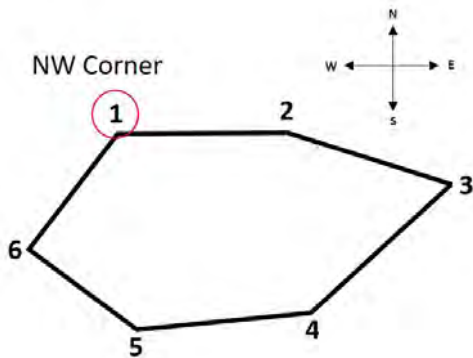
- m. Crop cutting will be done in one subplot within the plot of each of the randomly selected farmer or farm operator.
- n. If four or fewer than four farmers or farm operators own plots within the 200 m x 200 m sample mesh, crop cutting will be done in all of the plots. If more than four farmers or farm operators meet the criteria in “c”, four will be randomly selected.
- o. **REMEMBER THAT YOU CAN STILL SELECT THE SUBPLOT FROM WHICH YOU WILL CUT RICE, EVEN IF THE RICE IS NOT READY FOR HARVEST ON YOUR FIRST TRIP TO THE PLOT! THIS WILL SAVE YOU TIME WHEN YOU RETURN.**



**Crop Cutting Area Selection**

- a. Using the app installed on the iPad, measure the plot and take waypoints of all the corners of the plot. When the measurement is done, count the total number of corners, and identify the northwest corner.

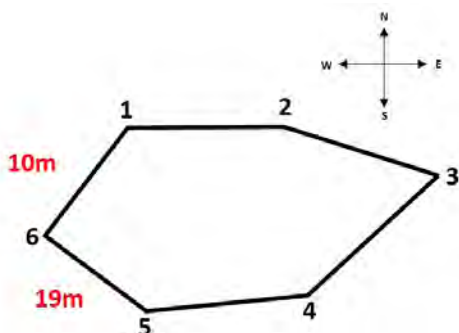
An Example is presented below.



- b. Use Random Number Table #1 to identify the corner of the farm you will start the crop cutting activity. Use the first number in the random number table that matches one of the corners of the field. The corner in which you started the area measurement, the northwest corner, is corner #1. Corner #2 is the next corner of the field, moving around the field clockwise. The procedure goes on the same way.

28	15	10	6	14	22	24
----	----	----	---	----	----	----

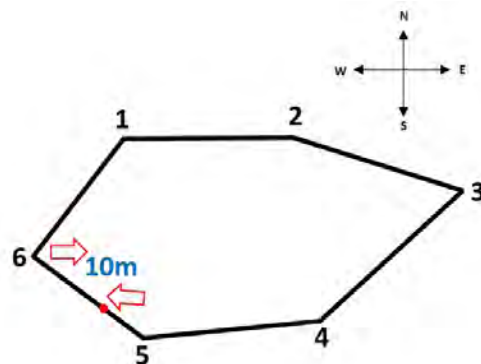
- c. Measure the distance of the two sides along the selected corner with the measuring tape. Identify which is the longer side and which is the shorter side.



- d. Take the bearing from the start corner down the longer side. Note this in your notebook.
- e. Use the Random Number Table #2 provided for this plot. The first number should be the number of meters that you will walk along the length of the longer side of the field. If the first number is larger than the length of the side, choose the next random number (and so on, until you find a number that is less than the length of the side). For example, if the length of the longer side is 19 m and the first random number in the list is 30, move on to the next number. In the example below, the new number is 34, which is still greater than 19 m, so move on. The third number is 10, which is the number to work with.

30	34	10	28	33
----	----	----	----	----

- f. Beginning at your starting point and continuing along the longer side of the field, walk the number of meters indicated by your random number.

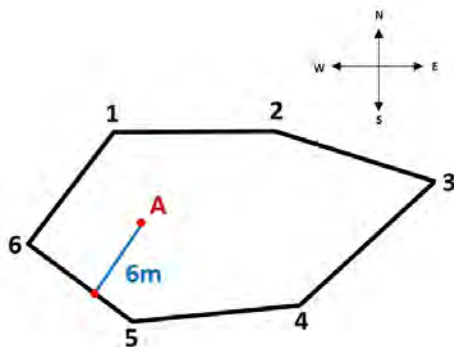


- g. Turn into the field so that your bearing is the same as the bearing you measured down the shorter side of the field. This means you will be entering the field parallel to the shorter side. Choose the next random number from Random Number Table #2 that is shorter than the length of the shorter side, then walk the number of meters indicated by this second random

number. You should be walking in a direction that is parallel to the shorter edge of the field. Walk in a straight line. Try not to veer to the right or left to avoid shrubs or wet spots.

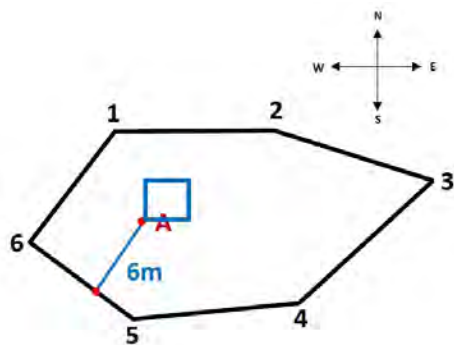
30	34	10	28	33	17	19	6	3
----	----	----	----	----	----	----	---	---

- h. The center of the crop cutting area is located where your foot lands on the last step: this is point A.



### Crop Cutting Section Demarcation

- a. At point A, place the 2.5 m x 2.5 m crop cutting frame at the upper right corner. Insert sticks at the four corners of the square to embed the frame firmly into the ground. This is the subplot on which crop cutting will take place.



- b. Proceed with the crop cutting of the rice on the subplot. Also make sure that the GPS measurements are taken for the crop cutting subplot.

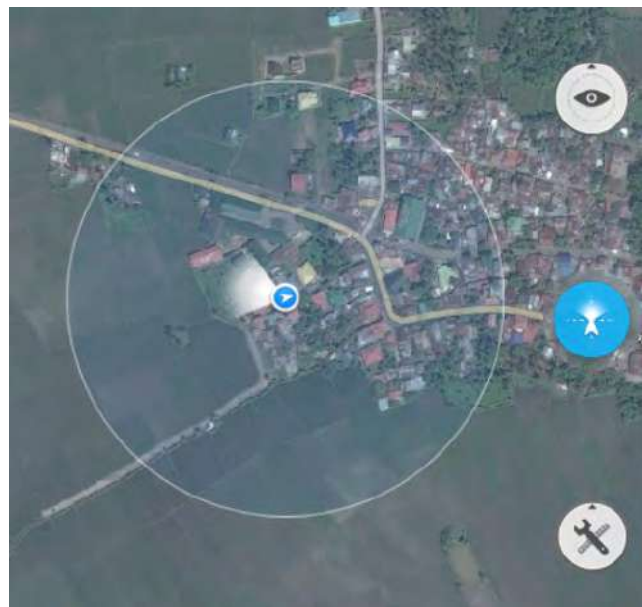
### Annex 2: Crop Cutting and Weighing Procedure

- With the consent of the farmer, harvest all of the rice contained within the demarcated subplot area.
- Thresh the paddy from the crop cutting subplot and get the weight using the weighing scale. Fill out the information in your questionnaire in the appropriate box and measure the moisture content.
- Dry the threshed paddy using the method the farmer uses for drying, then take the dry weight using the weighing scale. Measure the moisture content using the moisture meters provided. Fill out the information in your questionnaire in the appropriate box.
- Return the grain to the farmer, thanking him or her for their assistance.

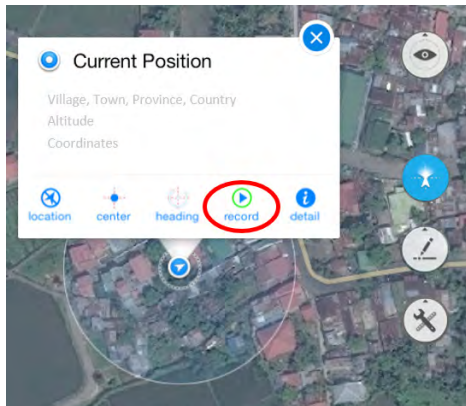
### Annex 3: Tracking of Plot Boundaries Using Map Plus

#### Tracking of Plot Boundaries

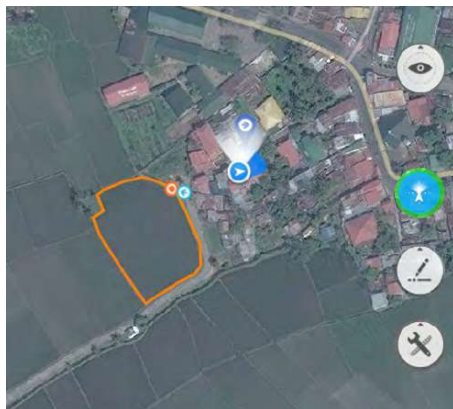
- a. Tap the “location” button to start locating your current position. Wait for few seconds until the current position icon is shown on the map and your location seems stable.



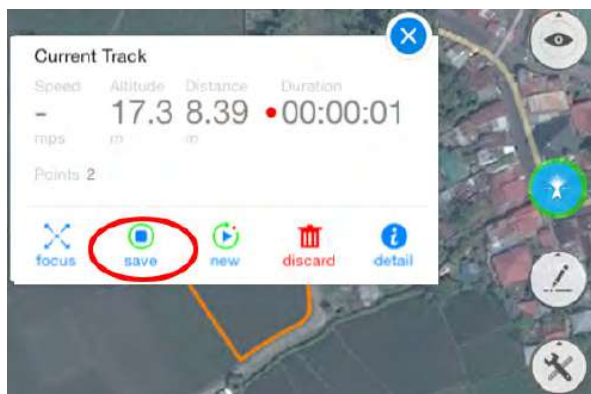
- b. Tap the “record” button on the operation bar.



- c. Walk around the boundaries of the plot. During the recording, the current track is displayed and there is an annotation for the start point.



- d. Tap “save” button to stop and save the track to your root folder.



- e. Change the filename of the track by tapping the “detail” icon button on the operation bar. Select

“Edit” and change the filename using the plot-naming convention accordingly. Press “Done” after editing the filename.



### Area Estimation

- a. Tap the “Tools” icon to open the menu and select “Edit”.



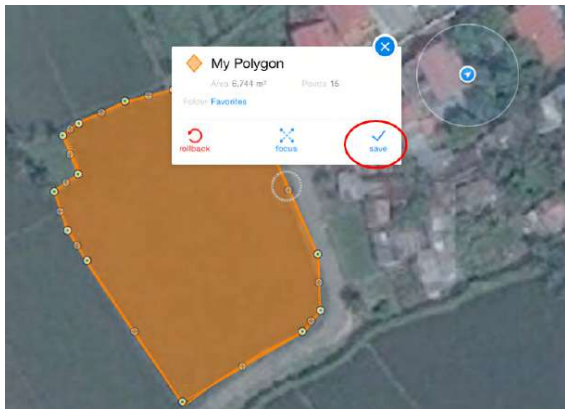
- b. Tap the “Edit” icon to open the edit menu and select “Create Shape”.



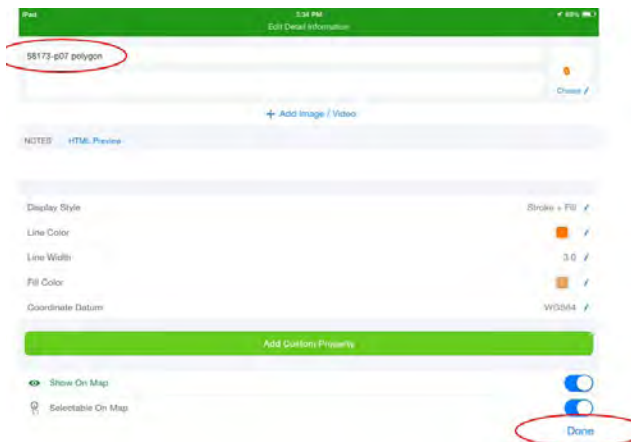
- c. Long press and drag to move the point of the polygon to the corners of the plot.



- d. Tap the “save” button in the menu.



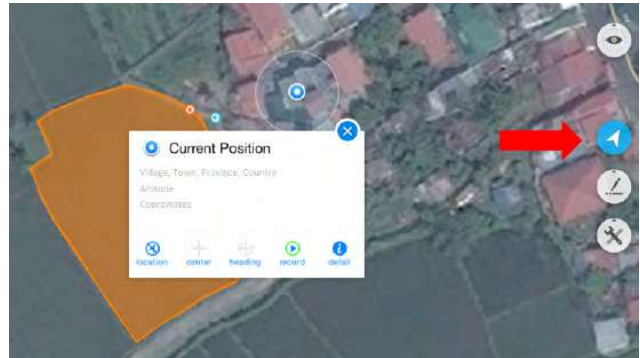
- e. Edit the filename using the plot-naming convention accordingly



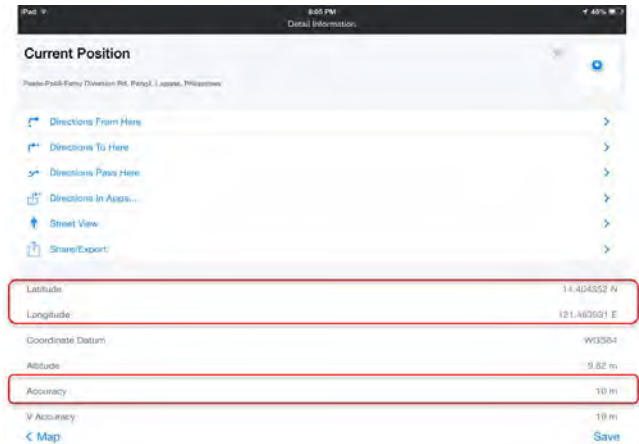
- f. Record the area estimate in square meters.

### GPS Location Fix

- a. Tap the “location” icon on the map and get the coordinates of your location.



- b. Record the coordinates of your current location in the questionnaire and the mapping accuracy.





#### Annex 4: Moisture Content Measurement

The Scientific and Handy Equipment for Gintong Ani III (SHEGA III) moisture meter, manufactured in the Philippines, will be used to measure moisture content of paddy from the crop cutting plot.



LCD = liquid crystal display

The *release button* is used to release grains on the *grain loader* onto the *test chamber*, which contains the tool that measures the moisture of the grains. It has a *control panel* used to select the modes, e.g., choosing to measure rice or corn, and a *liquid crystal display panel* where the moisture content measurement is shown.

- Make sure that the moisture meter's test chamber is clean and empty.
- Fill the grain loader with grain samples.
- Gently place the sample-filled loader on top of the moisture meter.



- Turn on the moisture meter by pressing the "ON/OFF" key.

- Press the "RESET" key to reset any previous commands made to the device.
- Press the "MEASURE" key.
- Press the "MODE Selector" and select "PALAY" (the Filipino term for paddy rice).
- Press the grain loader's release button to allow the grains to drop into the test chamber.



- Press the "MEASURE" key to register the moisture content.



- The measuring process may be repeated to get the average the moisture content. You may use the automatic averaging calculation function of the moisture meter. The number of measurements done is shown on the display panel as "N=#". For example, if two measurements were made, the display will show "N=2", as well as the average moisture content of the two measurements made.









**SECTION B. HOUSEHOLD ROSTER AND DETAILS**

**PROMPTS AND DEFINITIONS:**

**Paid employee:** One who does work for a wage, salary, commission, or any payment in kind; including doing paid apprenticeship, domestic work, or paid farm work.  
**Agricultural activities:** Includes farming, raising livestock or fishing, whether for sale or for household food. Includes 2015 rice harvest.

HOUSEHOLD ID	7. What is (NAME)'s civil status? 1 SINGLE.....1 2 MARRIED.....2 3 WIDOWED/ER.....3 4 DIVORCED/SEPARATED.....4 5 COMMON LAW/LIVE IN.....5 6 OTHER, SPECIFY.....6 IF "DON'T KNOW," ENTER "DK"	8. From January-December 2015, how would (NAME) define his/her main NON-AGRICULTURAL work activity, if any? REFER TO PROMPTS and DEFINITIONS in MANUAL, AND ABOVE PAID EMPLOYEE: GOVERNMENT.....1 PAID EMPLOYEE: PRIVATE SECTOR.....2 PAID EMPLOYEE: NON-GOVERNMENT ORGANIZATION.....3 PAID EMPLOYEE: INTERNATIONAL ORGANIZATION.....4 PAID WORKER FOR OTHER HOUSEHOLD(S).....5 SELF-EMPLOYED (NON-AGRICULTURAL): WITH EMPLOYEES.....6 SELF-EMPLOYED (NON-AGRICULTURAL): WITHOUT EMPLOYEES.....7 UNPAID FAMILY HELPER (NON-AGRICULTURAL).....8 UNPAID APPRENTICESHIP (NON-AGRICULTURAL).....9 RETIRED WITH PENSION.....10 OTHER, SPECIFY.....11 DID AGRICULTURAL WORK ONLY .....12 >> SKIP 9a and 9b, PROCEED TO NEXT HH STUDENT.....13 >> SKIP 9a and 9b, PROCEED TO NEXT HH DID NOT WORK.....14 >> SKIP 9a and 9b, PROCEED TO NEXT HH	9a. From January-December 2015, for how much time did (NAME) spend on this (non-agricultural) work activity?  RECORD THIS INFORMATION AS: - TOTAL number of months - AVERAGE weeks per month - AVERAGE days per week - AVERAGE hours per day  IF "DON'T KNOW," ENTER "DK"	9b. How much did (NAME) earn in total from this work activity in January-December 2015?  IF "DON'T KNOW," ENTER "DK"  IN THE CASE OF A BUSINESS, REPORT THE PROFIT, CALCULATED AS : PROFIT = REVENUE - COST	PLEASE SEE MANUAL FOR INSTRUCTIONS AND EXAMPLES ON HOW TO FILL IN INFORMATION FOR THIS SECTION											
					WORK ACTIVITY #1			WORK ACTIVITY #2			WORK ACTIVITY #1			WORK ACTIVITY #2		
		TOTAL number of MONTHS	Average WEEKS per MONTH	Average DAYS per WEEK	Average HOURS per DAY	TOTAL number of MONTHS	Average WEEKS per MONTH	Average DAYS per WEEK	Average HOURS per DAY	TOTAL number of MONTHS	Average WEEKS per MONTH	Average DAYS per WEEK	Average HOURS per DAY	WORK ACTIVITY #1 AMOUNT (in PHP)	WORK ACTIVITY #2 AMOUNT (in PHP)	
HH1																
HH2																
HH3																
HH4																
HH5																
HH6																
HH7																
HH8																
HH9																
HH10																
HH11																
HH12																
HH13																
HH14																
HH15																
HH16																
HH17																
HH18																
HH19																
HH20																

**SECTION B1. OTHER INCOME FROM AGRICULTURE:**  
**HOUSEHOLD TOTAL**  
 PLEASE REPORT TOTALS FOR ALL HOUSEHOLD MEMBERS FOR ALL THREE ACTIVITIES BELOW.

<b>HOUSEHOLD TOTALS</b>	
10a. <b>SALES: NON-RICE CROPS</b> What was the total value of sales of any crops, other than rice, cultivated by the household in January-December 2015?	
	AMOUNT (in PHP)
10b. <b>SALES: LIVESTOCK</b> What was the total value of sales of any livestock raised by the household in January-December 2015?	
	AMOUNT (in PHP)
10c. <b>SALES: FISH AND AQUATIC ANIMALS</b> What was the total value of sales of any fish and aquatic animals raised by the household in January-December 2015?	
	AMOUNT (in PHP)

**SECTION B2. INCOME FROM REMITTANCES:**  
**HOUSEHOLD TOTAL**  
 PLEASE REPORT THE TOTAL AMOUNT OF REMITTANCES RECEIVED BY THE ENTIRE HOUSEHOLD.

<b>HOUSEHOLD TOTALS</b>	
11. <b>TOTAL INCOME: REMITTANCES</b> What was the total value of REMITTANCES received by the household in January-December 2015? INCLUDE BOTH OVERSEAS AND DOMESTIC REMITTANCES	
	AMOUNT (in PHP)
<b>DOUBLE CHECK THAT INFORMATION FOR ALL HOUSEHOLD MEMBERS IS COMPLETE IN SECTION B1.</b>	

**DOUBLE CHECK THAT INFORMATION FOR ALL HOUSEHOLD MEMBERS IS COMPLETE IN SECTION B1.**

**SECTION C. PLOT ROSTER**

ENUMERATOR: RECORD THE ID OF THE RESPONDENT FROM HOUSEHOLD ROSTER:

HH ROSTER ID CODE:

A PLOT IS A CONTINUOUS PIECE OF LAND ON WHICH A UNIQUE CROP OR A MIXTURE OF CROPS IS GROWN, UNDER A UNIFORM, CONSISTENT CROP MANAGEMENT SYSTEM. IT MUST BE CONTINUOUS AND SHOULD NOT BE SPLIT BY A PATH OF MORE THAN ONE METER IN WIDTH. PLOT BOUNDARIES ARE DEFINED ACCORDING TO THE CROPS GROWN AND THE OPERATOR.

List ALL PLOTS you or anyone in your household owned or cultivated during the 2015 rainy season. **List RICE PLOTS FIRST!!**

RECALL PLOT ID:	FULL IDENTIFICATION NUMBER: If the plot fell within the mesh during the Crop Cutting phase of the study, it was assigned a Full Identification Number. Enter this number here, if one exists for the plot.	1. PLOT NAME How does the operator/owner refer to this plot, to distinguish it from his/her other plots?	2. LOCATION & DESCRIPTION	3. FARMER'S ESTIMATE OF AREA  (hectares)	4. WAS RICE HARVESTED ON THIS PLOT IN THE 2015 RAINY SEASON (harvest period from SEPTEMBER to DECEMBER 2015)?  YES.....1 NO.....2
RR01					
RR02					
RR03					
RR04					
RR05					
RR06					
RR07					
RR08					
RR09					
RR10					

**SECTION D: PLOT DETAILS**

ENUMERATOR: RECORD THE ID OF THE RESPONDENT FROM HOUSEHOLD ROSTER:  HH ROSTER ID CODE:

ENUMERATOR: RECORD THE ID OF THE RESPONDENT FROM HOUSEHOLD ROSTER:   
 - ASK THE FOLLOWING FOR EACH PLOT RECORDED IN THE PLOT ROSTER (SECTION C).  
 - REPEAT EVERY QUESTION IN SECTION D ONE PLOT AT A TIME, FOR EACH PLOT

**PLOT OWNERSHIP**

RECALL PLOT ID	FULL IDENTIFICATION NUMBER	PLOT NAME	1. What is the distance from [PLOT] to:			2. What is the tenurial status of this [PLOT]?	3. Which household member(s) have ownership of or right to use/co-use to this plot?			4. Does a legal record/document exist that proves your ownership rights of use/co-use to the plot?	5. Does your household share legal ownership rights for this plot, or right to use/co-use, with someone outside the household?	6. What share of the plot do members of the household own or have right to use/co-use?	7. In which year was the plot acquired by members of this household?
			HOME (m)	NEAREST ROAD (m)	NEAREST MARKET (m)		HH ID	HH ID	HH ID				
RR01						OWNED/BEING AMORTIZED.....1 RENTED/CO-RENTED OUT.....2 RENTED/CO-RENTED IN.....3 "BUWISAN".....4 RENT-FREE WITH CONSENT OF OWNER.....5 >> 18 RENT-FREE WITHOUT CONSENT OF OWNER.....6 >> 18 REFUSED TO ANSWER.....7 >> 18 OTHER, SPECIFY.....8 >> 18	YES.....1 NO.....2	YES...1 NO...2 >> 7					
RR02													
RR03													
RR04													
RR05													
RR06													
RR07													
RR08													
RR09													
RR10													



SECTION D: PLOT DETAILS

RECALL PLOT ID	FULL IDENTIFICATION NUMBER	PLOT NAME	PLOT OWNERSHIP				PERCENTAGE	HH ID	HH ID	HH ID	HH ID	13. What percentage of the whole plot do you rent/co-rent in?	14. Which household member(s) rent/co-rent in this plot?	15. Do you co-rent in this plot with someone outside this household?  YES.....1 NO.....2	16. What was the TOTAL rent paid to the landlord by all co-renters of this plot?  INCLUDE: - IN-KIND PAYMENTS - PAYMENT BY CROP OUTPUT - FUTURE/PLANNED PAYMENTS - PAST PAYMENTS FOR THE 2015 RAINY SEASON	17. How much of this total rent was contributed by the household members?
			8. Who in the household can decide whether to rent this plot, use it as collateral, sell or otherwise monetize usage rights to the plot?  LIST UP TO 2 JOINT OWNERS FROM HOUSEHOLD ROSTER	9. Was this plot rented out during the 2015 rainy season?  YES...1 NO....2 >> 18	10. What was the total income from renting out this plot during the 2015 rainy season?  INCLUDE IN-KIND INCOME	11. If plot ownership was shared with someone outside the respondent's household, how much of the total rental income was received by household members?										
RR01																
RR02																
RR03																
RR04																
RR05																
RR06																
RR07																
RR08																
RR09																
RR 10																

SECTION D: PLOT DETAILS

RECALL PLOT ID	FULL IDENTIFICATION NUMBER	PLOT NAME	PLOT USAGE					21. How steep is the slope of this plot?	22. What was the most recent year in which the plot was left in fallow?	23. For how many consecutive years was this plot left in fallow the last time?	24. How was this plot used during the 2015 rainy season?
			18. What was the soil type on this plot? LIST AS MANY OPTIONS AS APPLY	19. What is the soil quality of this plot? DONT KNOW: ENTER "DK"	20. How do you know the quality of the soil?	22. What was the most recent year in which the plot was left in fallow?	NUMBER				
RR01											
RR02											
RR03											
RR04											
RR05											
RR06											
RR07											
RR08											
RR09											
RR10											



SECTION D: PLOT DETAILS

THE FOLLOWING QUESTIONS ARE ONLY FOR PLOTS ON WHICH RICE WAS GROWN IN THE 2015 RAINY SEASON ("yes" answers to QUESTION D-28: "Was rice cultivated on this plot in the 2015 rainy season?")

PLOT CONDITIONS AND MANAGEMENT: RICE

RECALL PLOT ID	FULL IDENTIFICATION NUMBER	PLOT NAME	29. Were there any erosion problems with this plot during the 2015 rainy season?  YES...1 NO...2 >> 33	30. What was the cause of these erosion problems?  TERRAIN.....1 FLOODING.....2 WIND.....3 ANIMALS.....4 CULTIVATION WHICH DOES NOT COMPLY WITH SOIL CONSERVATION.....5 OTHER, SPECIFY.....6	31. Was there any erosion control/water harvesting facility on this plot in the 2015 rainy season?  YES...1 NO...2 >> 33	32. What type of erosion control/water harvesting facility was on this plot?  TERRACES.....1 EROSION CONTROL BUNDS.....2 GABIONS / SANDBAGS.....3 VETIVER GRASS.....4 TREE BELTS.....5 WATER HARVEST BUNDS.....6 DRAINAGE DITCHES.....7 DAMS.....8 OTHER, SPECIFY.....9  IF OPTION 1 IS SELECTED, MAKE SURE THIS RESPONSE MATCHES THAT FOR QUESTION 21	33. Was this plot in the upland or lowland (rain-fed or irrigated) area?  UPLAND.....1 >> 36 LOWLAND - RAINFED.....2 >> 36 LOWLAND - IRRIGATED.....3	34. What was the type of irrigation facility?  NATIONAL IRRIGATION SYSTEM (NIS).....1 COMMUNAL IRRIGATION SYSTEM (CIS).....2 TUBE WELL.....3 DUG WELL (shallow or deep).....4 SURFACE/RAM PUMP.....5 SMALL FARM RESERVOIR (SFR).....6 SHALLOW WELL IMPOUNDING PROJECT (SWIP).....7 SMALL DIVERSION DAM (SDD).....8 OTHER, SPECIFY.....9	35. What was the source of water for irrigation?  DAMMED RIVER/STREAM.....1 WELL.....2 BOREHOLE.....3 LAKE/POND.....4 TANK.....5 RIVER/STREAM.....6 OTHER, SPECIFY.....7	
					1st		2nd			
RR01										
RR02										
RR03										
RR04										
RR05										
RR06										
RR07										
RR08										
RR09										
RR10										

**SECTION D: PLOT DETAILS**

**THE FOLLOWING QUESTIONS ARE ONLY FOR PLOTS ON WHICH RICE WAS GROWN IN THE 2015 RAINY SEASON**  
 ("yes" answers to QUESTION D-28: "Was rice cultivated on this plot in the 2015 rainy season?")

**ORGANIC FERTILIZERS: RICE**

RECALL PLOT ID	FULL IDENTIFICATION NUMBER	PLOT NAME	36. Did you use any ORGANIC fertilizer on this plot during the 2015 rainy season? YES..1 NO...2 >> 42		37. What is(are) the type(s) of ORGANIC fertilizer you used on this plot? LIST UP TO 3 TYPES ANIMAL MANURE.....1 COMPOST.....2 GREEN MANURE.....3 MICROBIAL FERTILIZER.....4 OTHER, SPECIFY.....5		38. What was the quantity of ORGANIC fertilizer applied?			39. Was any of this ORGANIC fertilizer purchased? YES..1 NO...2 >> 42			40. What quantity of the total ORGANIC fertilizer applied was purchased?			41. Of the total ORGANIC fertilizer applied, what was the total value purchased?
			TYPE I	TYPE II	TYPE III	QUANTITY IN LOCAL UNIT USED	WEIGHT IN KG PER LOCAL UNIT USED	QUANTITY IN LOCAL UNIT USED	VOLUME IN LITER PER LOCAL UNIT USED	QUANTITY IN LOCAL UNIT USED	WEIGHT IN KG PER LOCAL UNIT USED	QUANTITY IN LOCAL UNIT USED	VOLUME IN LITER PER LOCAL UNIT USED	AMOUNT (in PHP)		
RR01																
RR02																
RR03																
RR04																
RR05																
RR06																
RR07																
RR08																
RR09																
RR10																



SECTION D: PLOT DETAILS

THE FOLLOWING QUESTIONS ARE ONLY FOR PLOTS ON WHICH RICE WAS GROWN IN THE 2015 RAINY SEASON ("yes" answers to QUESTION D-28: "Was rice cultivated on this plot in the 2015 rainy season?")

INORGANIC FERTILIZERS: RICE

RECALL PLOT ID	FULL IDENTIFICATION NUMBER	PLOT NAME	42. Did you use any INORGANIC FERTILIZER on this plot during the 2015 rainy season? YES..1 NO...2 >> 46	43. Which INORGANIC FERTILIZER(S) did you use in the LARGEST QUANTITIES on this plot? LIST UP TO 3 TYPES, AND THEIR QUANTITIES																	
				TYPE I	FORM (Liquid/Solid)	QUANTITY IN LOCAL UNIT	LOCAL UNIT USED	WEIGHT/VOLUME PER LOCAL UNIT	TYPE II	FORM (Liquid/Solid)	QUANTITY IN LOCAL UNIT	LOCAL UNIT USED	WEIGHT/VOLUME PER LOCAL UNIT	TYPE III	FORM (Liquid/Solid)	QUANTITY IN LOCAL UNIT	LOCAL UNIT USED	WEIGHT/VOLUME PER LOCAL UNIT			
RR01																					
RR02																					
RR03																					
RR04																					
RR05																					
RR06																					
RR07																					
RR08																					
RR09																					
RR10																					

UREA (46-0-0) .....1  
COMPLETE .....2  
AMMONIUM SULFATE (21-0-0-26) .....3  
AMMONIUM PHOSPHATE (16-20-0) .....4  
OTHER, SPECIFY .....5

LIQUID.....1  
SOLID.....2

**SECTION D: PLOT DETAILS**

**THE FOLLOWING QUESTIONS ARE ONLY FOR PLOTS ON WHICH RICE WAS GROWN IN THE 2015 RAINY SEASON**  
 ("yes" answers to QUESTION D-28: "Was rice cultivated on this plot in the 2015 rainy season?")

RECALL PLOT ID	FULL IDENTIFICATION NUMBER	PLOT NAME	INORGANIC FERTILIZERS: RICE		PESTICIDES: RICE		46. Did you use any PESTICIDES on this plot during the 2015 rainy season?  YES...1 NO...2 >> 50a	47. What quantity did you use?  Give the TOTAL for the MAIN TYPE of product applied: The main type is the product used in the GREATEST QUANTITY (not the most expensive)	48. Of the total MAIN TYPE of pesticide used, what was the total value purchased?	49. Why did you choose to use this specific type of pesticide?  LIST AS MANY OPTIONS AS APPLY  ADVICE BY AGRICULTURAL OFFICER.....1 RECEIVED VOUCHER.....2 OWN EXPERIENCE.....3 NEIGHBOR ADVICE.....4 OTHER, SPECIFY.....5
			44. Of the total INORGANIC fertilizer applied, what was the total value purchased?  AMOUNT (in PHP)	45. Why did you choose to use these specific types of INORGANIC FERTILIZER?  LIST AS MANY OPTIONS AS APPLY  ADVICE BY AGRICULTURAL OFFICER.....1 RECEIVED VOUCHER.....2 OWN EXPERIENCE.....3 NEIGHBOR ADVICE.....4 OTHER, SPECIFY.....5	QUANTITY IN LOCAL UNIT	WEIGHT IN KG PER LOCAL UNIT				
RR01										
RR02										
RR03										
RR04										
RR05										
RR06										
RR07										
RR08										
RR09										
RR10										

SECTION D: PLOT DETAILS

THE FOLLOWING QUESTIONS ARE ONLY FOR PLOTS ON WHICH RICE WAS GROWN IN THE 2015 RAINY SEASON  
 ("Yes" answers to QUESTION D-28: "Was rice cultivated on this plot in the 2015 rainy season?")

HOUSEHOLD LABOR: RICE

RECALL PLOT ID	FULL IDENTIFICATION NUMBER	PLOT NAME	50a. During the 2015 rainy season, how many days did members of your household spend on the following activity on this plot?  LIST UP TO SIX HOUSEHOLD MEMBERS INCLUDE TIME SPENT SUPERVISING THESE ACTIVITIES												50b. During the 2015 rainy season, how many days did members of your household spend on the following activity on this plot?  LIST UP TO SIX HOUSEHOLD MEMBERS INCLUDE TIME SPENT SUPERVISING THESE ACTIVITIES													
			LAND PREPARATION						PLANTING (INCLUDES DIRECT-SEEDING AND TRANSPLANTING)						LAND PREPARATION						PLANTING (INCLUDES DIRECT-SEEDING AND TRANSPLANTING)							
ENUMERATOR: COPY FROM PLOT ROSTER (SECTION C)	ENUMERATOR: COPY FROM PLOT ROSTER (SECTION C)	ENUMERATOR: COPY FROM PLOT ROSTER (SECTION C)	HH ID:	DAYS	HH ID:	DAYS	HH ID:	DAYS	HH ID:	DAYS	HH ID:	DAYS	HH ID:	DAYS	HH ID:	DAYS	HH ID:	DAYS	HH ID:	DAYS	HH ID:	DAYS	HH ID:	DAYS	HH ID:	DAYS		
RR01																												
RR02																												
RR03																												
RR04																												
RR05																												
RR06																												
RR07																												
RR08																												
RR09																												
RR10																												



SECTION D: PLOT DETAILS

**THE FOLLOWING QUESTIONS ARE ONLY FOR PLOTS ON WHICH RICE WAS GROWN IN THE 2015 RAINY SEASON**  
 ("yes" answers to QUESTION D-28: "Was rice cultivated on this plot in the 2015 rainy season?")

HOUSEHOLD LABOR: RICE		HIRED LABOR: RICE																						
RECALL PLOT ID	FULL IDENTIFICATION NUMBER	PLOT NAME	50e. During the 2015 rainy season, how many days did members of your household spend on the following activity on this plot?  LIST UP TO SIX HOUSEHOLD MEMBERS INCLUDE TIME SPENT SUPERVISING THESE ACTIVITIES										51. Did you hire any labor to work on this plot in the 2015 rainy season?  INCLUDE IN-KIND PAYMENTS											
			HARVEST AND POST HARVEST ACTIVITIES										LAND PREPARATION											
ENUMERATOR: COPY FROM PLOT ROSTER (SECTION C)	ENUMERATOR: COPY FROM PLOT ROSTER (SECTION C)	ENUMERATOR: COPY FROM PLOT ROSTER (SECTION C)	HH ID:	DAYS	HH ID:	DAYS	HH ID:	DAYS	HH ID:	DAYS	HH ID:	DAYS	HH ID:	DAYS	TOTAL NUMBER OF WOMEN	TOTAL AMOUNT OF DAYS (in PHP)	TOTAL NUMBER OF MEN	TOTAL NUMBER OF DAYS	TOTAL AMOUNT (in PHP)	TOTAL NUMBER OF CHILDREN (15 years old and below)	TOTAL NUMBER OF DAYS	TOTAL AMOUNT (in PHP)		
RR01																								
RR02																								
RR03																								
RR04																								
RR05																								
RR06																								
RR07																								
RR08																								
RR09																								
RR10																								



**SECTION D: PLOT DETAILS**

**THE FOLLOWING QUESTIONS ARE ONLY FOR PLOTS ON WHICH RICE WAS GROWN IN THE 2015 RAINY SEASON**  
 ("yes" answers to QUESTION D-28: "Was rice cultivated on this plot in the 2015 rainy season?")

**HIRED LABOR: RICE**

RECALL PLOT ID	FULL IDENTIFICATION NUMBER	PLOT NAME	52b. During the rainy season 2015, how many days did your household hire LABOR ONLY for the following activity on this plot, and at what wage?													
			PLANTING (INCLUDES DIRECT-SEEDING AND TRANSPLANTING)							WEEDING						
			INCLUDE IN-KIND PAYMENTS							INCLUDE IN-KIND PAYMENTS						
			TOTAL NUMBER OF WOMEN	TOTAL NUMBER OF MEN	TOTAL NUMBER OF DAYS	TOTAL AMOUNT (in PHP)	TOTAL NUMBER OF CHILDREN (15 years old and below)	TOTAL NUMBER OF DAYS	TOTAL AMOUNT (in PHP)	TOTAL NUMBER OF WOMEN	TOTAL NUMBER OF MEN	TOTAL NUMBER OF DAYS	TOTAL AMOUNT (in PHP)	TOTAL NUMBER OF CHILDREN (15 years old and below)	TOTAL NUMBER OF DAYS	TOTAL AMOUNT (in PHP)
RR01																
RR02																
RR03																
RR04																
RR05																
RR06																
RR07																
RR08																
RR09																
RR10																

SECTION D: PLOT DETAILS

THE FOLLOWING QUESTIONS ARE ONLY FOR PLOTS ON WHICH RICE WAS GROWN IN THE 2015 RAINY SEASON ("yes" answers to QUESTION D-28: "Was rice cultivated on this plot in the 2015 rainy season?")

HIRED LABOR: RICE

RECALL PLOT ID	FULL IDENTIFICATION NUMBER	PLOT NAME	52d. During the rainy season 2015, how many days did your household hire LABOR ONLY for the following activity on this plot, and at what wage?		52e. During the rainy season 2015, how many days did your household hire LABOR ONLY for the following activity on this plot, and at what wage?		INCLUDE IN-KIND PAYMENTS														
			ALL OTHER NON-HARVEST ACTIVITIES: RIDGING, FERTILIZING, PESTICIDE APPLICATION,						HARVEST AND POST HARVEST ACTIVITIES												
ENUMERATOR: COPY FROM PLOT ROSTER (SECTION C)	ENUMERATOR: COPY FROM PLOT ROSTER (SECTION C)	ENUMERATOR: COPY FROM PLOT ROSTER (SECTION C)	TOTAL NUMBER OF WOMEN	TOTAL NUMBER OF MEN	TOTAL NUMBER OF DAYS	TOTAL AMOUNT (in PHP)	TOTAL NUMBER OF WOMEN	TOTAL NUMBER OF MEN	TOTAL NUMBER OF DAYS	TOTAL AMOUNT (in PHP)	TOTAL NUMBER OF WOMEN	TOTAL NUMBER OF MEN	TOTAL NUMBER OF DAYS	TOTAL AMOUNT (in PHP)	TOTAL NUMBER OF CHILDREN (15 years old and below)	TOTAL NUMBER OF DAYS	TOTAL AMOUNT (in PHP)	TOTAL NUMBER OF CHILDREN (15 years old and below)	TOTAL NUMBER OF DAYS	TOTAL AMOUNT (in PHP)	
RR01																					
RR02																					
RR03																					
RR04																					
RR05																					
RR06																					
RR07																					
RR08																					
RR09																					
RR10																					

**SECTION D: PLOT DETAILS**

**THE FOLLOWING QUESTIONS ARE ONLY FOR PLOTS ON WHICH RICE WAS GROWN IN THE 2015 RAINY SEASON**  
 ("yes" answers to QUESTION D-28: "Was rice cultivated on this plot in the 2015 rainy season?")

CONTRACTED LABOR: RICE		53	54	55	56	57	
RECALL PLOT ID	FULL IDENTIFICATION NUMBER	PLOT NAME	Did you hire someone to contract out any labor on this plot in the 2015 rainy season?  YES..1 NO...2 >> <b>NEXT PLOT</b>	What did you hire this contractor to do?  <b>LIST ALL THAT APPLY</b>  Note that Option 6 is "All of the Above"  LAND PREPARATION.....1 PLANTING (DIRECT-SEEDING OR TRANSPLANTING).....2 WEEDING.....3 ALL OTHER PRE-HARVEST ACTIVITIES.....4 HARVEST AND ALL POST-HARVEST ACTIVITIES.....5 ALL OF THE ABOVE.....6 OTHER, SPECIFY.....7	Over what length of time was the work to be completed, if the contract stipulated a specific timeframe?  <b>INDICATE THE NUMBER OF DAYS</b>  If no period of time was specified, enter "N/A"	What was the area of land, in hectares, on which the work was to be completed, according to the contract?	What was the total amount paid to the contractor to achieve this work?
				LENGTH (DAYS)	AREA (ha)	TOTAL AMOUNT (in PHP)	
RR01							
RR02							
RR03							
RR04							
RR05							
RR06							
RR07							
RR08							
RR09							
RR10							

ENUMERATOR: COPY FROM PLOT ROSTER (SECTION C)

ENUMERATOR: COPY FROM PLOT ROSTER (SECTION C)

ENUMERATOR: COPY FROM PLOT ROSTER (SECTION C)















SECTION F: RICE - HOUSEHOLD TOTALS

CROP NAME	CROP CODE	SALES		STORAGE						18.			19.	
		10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	OPTION 1	OPTION 2	
		Was any portion of the quantity harvested sold under a contract growing/outgrower scheme?	What was the quantity sold under a contract growing/outgrower scheme?	Who in your household is responsible for negotiating the sale of [RICE CROP]?	Who in your household decided what to do with the earnings from sales of [RICE CROP]?	Do you have any of the harvest of [RICE CROP] from the 2015 rainy season in storage now?	How much of the harvest of [RICE CROP] do you still have in storage?	What is your main method of storage of the [RICE CROP] harvest?	Did you do anything to protect the stored [RICE CROP]?	What did you do to protect the stored [RICE CROP]?	When you store [RICE CROP], what is usually the main purpose of storing it?			
		YES.....1 NO.....2 >> 12	KILOGRAMS	LIST UP TO 2 FROM HOUSEHOLD ROSTER	LIST UP TO 2 FROM HOUSEHOLD ROSTER	YES..1 NO..2 >> NEXT ROW	KILOGRAMS	OWN HOUSE/ FARM HOUSE.....1 RICE MILL.....2 RICE TRADER'S WAREHOUSE.....3 OTHER, SPECIFY.....4	YES..1 NO..2 >> 19	LIST UP TO THREE PREDOMINANTLY USED METHODS	LIST TWO PREDOMINANT OPTIONS			
				HH ID	HH ID					1	2	3		



**SECTION G: RICE - EXTENSION SERVICES**

ENUMERATOR: RECORD THE ID OF THE RESPONDENT FROM HOUSEHOLD ROSTER:

HH ROSTER ID CODE:

SOURCE	1. Did you receive information/advice about agricultural activities related to rice cultivation from [SOURCE] during the 2015 rainy season?		2. Did you receive any information/advice from [SOURCE] about...?					3. Who in your household received information/advice from [SOURCE]?				4. How would you rate the information/advice received?	5. Did you pay anything in order to receive the information/advice?	6. How much did you pay in total?	7. How many times did someone from [SOURCE] visit your farm during the 2015 rainy season? <b>ENTER "0" IF NEVER</b>	
	YES...1 NO...2 >> NEXT SOURCE	1 <sup>st</sup>	A. RICE PRICES 2 <sup>nd</sup>	B. RICE PRODUCTION TECHNIQUES	C. RICE PROCESSING	D. RICE MARKETING	E. RICE SUBSIDIES GIVEN BY THE GOVERNMENT	HH ID	HH ID	HH ID	HH ID					GOOD...1 AVERAGE...2 BAD...3
1 Government extension																
2 NGO																
3 Cooperative/Farmer's Association																
4 Large-Scale Farmer																
5 Radio/Television																
6 Internet																
7 Publication																
8 Neighbor																
9 Other, Specify																

THE INTERVIEW IS NOW OVER. PLEASE THANK THE RESPONDENT AND REMEMBER TO INDICATE THE END TIME OF THE INTERVIEW ON THE FRONT PAGE OF THE QUESTIONNAIRE.

## RICE VARIETIES/CODES

CODE	Commercial Name	NSIC Registered Number
1	Abra	NSIC 1997 Rc54 (PSB Rc54)
2	Agno	NSIC 1995 Rc28 (PSB Rc28)
3	Agus	NSIC 1995 Rc30 (PSB Rc30)
4	Agusan	NSIC 1997 Rc66 (PSB Rc66)
5	Akian	NSIC 1999 Rc74 (PSB Rc74)
6	Ala	NSIC 1994 Rc18 (PSB Rc18)
7	Anahawan	NSIC 2001 Rc108
8	Angelica	NSIC 2003 Rc122
9	Apo	NSIC 2001 Rc9
10	Arayat	NSIC 1997 Rc5 (PSB Rc5)
11	Balili	NSIC 2001 Rc104
12	Baliwag	NSIC 1995 Rc42 (PSB Rc42)
13	Bamban	NSIC 1997 Rc70 (PSB Rc70)
14	Banahaw	NSIC 2000 Rc7
15	Bigante (Mestiso 4)	NSIC 2004 Rc124H
16	Buguey	NSIC 2000 Rc90
17	Burdagol	NSIC 1995 Rc34 (PSB Rc34)
18	Cağayan	NSIC 1994 Rc24 (PSB Rc24)
19	Canlaon	NSIC 2001 Rc11
20	Chayong	NSIC 1995 Rc40 (PSB Rc40)
21	Chico	NSIC 1994 Rc20 (PSB Rc20)
22	Dapitan	NSIC 1997 Rc56 (PSB Rc56)
23	Gandara	NSIC 1997 Rc52 (PSB Rc52)
24	Ginilingan Puti	NSIC 1997 Rc3 (PSB Rc3)
25	Gohang	NSIC 1995 Rc44 (PSB Rc44)
26	Hagonoy	NSIC 1995 Rc48 (PSB Rc 48)
27	Hungduan	NSIC 2000 Rc94
28	Ibulao	NSIC 2000 Rc96
29	Japonica 1	NSIC 2009 Rc220SR
30	Jaro	NSIC 1995 Rc32 (PSB Rc32)
31	Kabataan	NSIC 1997 Rc64 (PSB Rc64)
32	Lian	NSIC 2000 Rc98
33	Liliw	NSIC 1994 Rc22 (PSB Rc22)
34	Ma-ayon / Ennano II	NSIC 1995 Rc36 (PSB Rc36)
35	Mabango 1	NSIC 2004 Rc128
36	Mabango 2	NSIC 2006 Rc148
37	Mabango 3	NSIC 2009 Rc218SR
38	Magat Hybrid	NSIC 1994 Rc26(PSB Rc26H)
39	Malagkit 1	NSIC 2004 Rc13
40	Malagkit 3	NSIC 2004 Rc17
41	Malagkit 4	NSIC 2005 Rc19
42	Malakit 2	NSIC 2004 Rc15
43	Mamburao	NSIC 2000 Rc102
44	Matatag 2	Stop gap variety
45	Matatag 3	NSIC 2003 Rc18
46	Matatag 6	NSIC 2003 Rc120
47	Matatag 9	Stop gap Variety
48	Matnog	NSIC 2000 Rc86 (PSB Rc86)

## OTHER CROPS/CODES

Commodity Code	Name of Commodity
<b>I. CEREALS</b>	
1021	Corn, matured, white
1022	Corn, matured, yellow
1023	Green corn, white
1024	Green corn, yellow
1025	Other cereals: SPECIFY
<b>II. FRUIT VEGETABLES</b>	
1401	Ampalaya
1402	Banana Blossoms
1403	Chayote
1404	Cucumber
1405	Eggplant, long, purple
1406	Eggplant, native, round
1407	Jackfruit, green
1408	Kamansi
1409	Okra
1410	Papaya, green
1411	Patola, Baguio
1412	Patola, native
1413	Squash
1414	Tomato
1415	Upo (Gourd)
1516	Other fruit vegetables: SPECIFY
<b>III. LEAFY VEGETABLES</b>	
1501	Ampalaya leaves
1502	Asparagus
1516	Broccoli
1503	Cabbage
1504	Carnote tops
1505	Cauliflower
1518	Celery
1506	Chayote tops
1507	Gabi leaves
1508	Kangkong
1517	Lettuce
1509	Malunggay leaves
1519	Mustard
1510	Pechay, Chinese (wongbok , Baguio)
1511	Pechay, native
1512	Saliyot
1513	Sili leaves
1514	Sitao tops
1515	Squash tops
1516	Other leafy vegetable: SPECIFY

## OTHER CROPS/CODES

Commodity Code	Name of Commodity
<b>VII. FRUITS</b>	
2043	Atis
2001	Avocado
2002	Banana, Bungulan, green
2041	Banana, Cavendish
2003	Banana, Lakatan, green
2004	Banana, Latundan, green
2005	Banana, Saba, green
2006	Calamansi
2044	Chico
2007	Durian
2008	Grapes, green
2009	Grapes, red
2010	Guapple
2011	Guava
2012	Guayabano
2042	Honey Dew
2013	Jackfruit
2014	Lanzones
2015	Mandarin, King
2016	Mandarin, Ladu
2017	Mandarin, Szinhom
2018	Mango, carabao, green
2020	Mango, Indian
2021	Mango, other variety, green
2019	Mango, pico, green
2022	Mangosteen
2023	Marang
2024	Muskmelon
2025	Orange
2026	Papaya, Hawaiian
2027	Papaya, native
2028	Papaya, sinta
2029	Papaya, solo
2030	Pineapple, Formosa
2031	Pineapple, Hawaiian
2032	Pineapple, native
2033	Pomelo
2040	Rambutan
2034	Santol, Bangkok/Improved
2035	Santol, native
2036	Siniguelas
2037	Starapple
2038	Tamarind
2039	Watermelon
2040	Other fruits: SPECIFY

## RICE VARIETIES/CODES (continued)

CODE	Commercial Name	NSIC Registered Number
49	Mayapa	NSIC 1997 Rc58 (PSB Rc58)
50	Mestizo 10 (PSD 3)	NSIC2007 Rc166H
	Mestizo 11	
51	(BCS 064)	NSIC 2007 Rc168H
	'Arize H64'	
52	Mestizo 12 (LP 0331)	NSIC 2008 Rc174H
53	Mestizo 13 (LP 0353)	NSIC 2008 Rc176H
54	Mestizo 14 (LP 0330)	NSIC 2008 Rc178H
55	Mestizo 15	NSIC 2008 Rc180H
56	Mestizo 16	NSIC 2009 Rc196H
57	Mestizo 17	NSIC 2009 Rc198H
	Mestizo 18	
58	(BCS 065)	NSIC 2009 Rc200H
	'Arize Tej'	
59	Mestizo 19 (PRUP 7)	NSIC 2009 Rc202H
60	Mestizo 20 (PRUP 9)	NSIC 2009 Rc204H
61	Mestizo 21	NSIC 2009 Rc206H
62	Mestizo 22 (NK 6401)	NSIC 2009 Rc208H
63	Mestizo 23 (PHB 71)	NSIC 2009 Rc210H
64	Mestizo 24	NSIC 2010 Rc228H
65	Mestizo 25	NSIC 2010 Rc230H
66	Mestizo 26	NSIC 2010 Rc232H
67	Mestizo 27	NSIC 2010 Rc234H
68	Mestizo 28	NSIC 2010 Rc236H
69	Mestizo 5 (Maglias)	NSIC 2004 Rc126H
70	Mestizo 6 (SL 8H)	NSIC 2004 Rc132
71	Mestizo 7	NSIC 2005 Rc136H
72	Mestizo 1	NSIC 1997 Rc72H (PSB Rc72H)
73	Mestizo 2	NSIC 2002 Rc114H
74	Mestizo 3	NSIC 2002 Rc116H
75	MS 11	NSIC 2008 Rc170 SR
76	MS 13	NSIC 2008 Rc172 SR
77	Naga	NSIC 2000 Rc88 (PSB Rc88)
78	Naguilian	NSIC 1997 Rc62 (PSB Rc62)
79	Pampanga	NSIC 2000 Rc78 (PSB Rc78)
80	Panay	NSIC 1999 Rc76H (PSB Rc76H)
81	Pasig	NSIC 2000 Rc80 (PSB Rc80)
82	Penaranda	NSIC 2000 Rc82 (PSB Rc82)
83	Rinara	NSIC 1995 Rc38 (PSB Rc38)
84	Sacobia	NSIC 1997 Rc68 (PSB Rc68)
85	Sagada	NSIC 2000 Rc92
86	Sahod Ulian 1	NSIC 2009 Rc192
87	Salinas 1	NSIC 2009 Rc182
88	Salinas 2	NSIC 2009 Rc184
89	Salinas 3	NSIC 2009 Rc186
90	Salinas 4	NSIC 2009 Rc188
91	Salinas 5	NSIC 2009 Rc190
92	Santiago	NSIC 2000 Rc100

## OTHER CROPS/CODES (continued)

Commodity Code	Name of Commodity
<b>IV. BEANS &amp; LEGUMES</b>	
1601	Kadios, green
1602	Kadios, dry
1603	Habichuelas (Bagoio beans)
1604	Mongo, green (labo)
1606	Mongo, green (shiny)
1605	Mongo, yellow (labo)
1607	Mongo, yellow (shiny)
1608	Patani
1610	Peanut, with shell, dry
1609	Peanut, with shell, fresh
1612	Peanut, without shell, dry
1611	Peanut, without shell, fresh
1613	String beans (sitao)
1614	Bush sitao (paayap)
1615	Sweet peas, Bagoio (Chinese)
1616	Sweet peas, native (lapad)
1617	Winged beans (sigarillas)
1618	Yam bean (pods)
1619	Other beans and legumes: SPECIFY
<b>V. ROOTS &amp; TUBERS</b>	
1701	Arrowroot
1702	Carrots
1703	Cassava, dried chips
1704	Cassava, fresh tuber
1705	Gabi, Cebu
1706	Gabi, Pao-galiang
1707	Gabi, Tagalog
1708	Gabi, with stalk
1709	Radish
1710	Sweet potato (camote)
1711	Turnip (singkamas)
1712	Ubi
1713	White potato
1714	Other roots and tubers: SPECIFY
<b>VI. CONDIMENTS</b>	
1901	Garlic
1902	Ginger, Hawaiian
1903	Ginger, native
1904	Onion leaves (spring onion)
1905	Onion Leeks
1906	Onion, red (Bermuda red)
1907	Onion, red shallot (Sibuyas Tagalog)
1908	Onion, yellow granex (Bermuda white)
1909	Pepper, bell
1910	Pepper, black (paminta)

## OTHER CROPS/CODES (continued)

Commodity Code	Name of Commodity
<b>VIII. COMMERCIAL CROPS</b>	
2401	Abaca
2402	African palm oil
2403	Cacao, dry beans
2404	Castor beans
2407	Coffee, Arabica, dry beans
2406	Coffee, Arabica, dry berries
2405	Coffee, Arabica, fresh berries
2410	Coffee, Excelsa, dry beans
2409	Coffee, Excelsa, dry berries
2408	Coffee, Excelsa, fresh berries
2413	Coffee, Liberica, dry beans
2412	Coffee, Liberica, dry berries
2411	Coffee, Liberica, fresh berries
2416	Coffee, Robusta, dry beans
2415	Coffee, Robusta, dry berries
2414	Coffee, Robusta, fresh berries
2417	Copra, corfiente
2436	Copra, fresh
2418	Copra, resecada
2419	Cotton
2420	Maguy
2421	Piña fiber
2422	Ramie
2423	Rubber, cup lump
2424	Rubber, latex
2425	Soybeans
2426	Sugarcane, centrifugal sugar
2427	Sugarcane, for chewing
2435	Sugarcane, for milling
2428	Sugarcane, muscovado sugar
2430	Tobacco, burley, dry
2429	Tobacco, burley, fresh
2432	Tobacco, native, dry
2431	Tobacco, native, fresh
2434	Tobacco, Virginia, dry
2433	Tobacco, Virginia, fresh
2434	Other commercial crops: SPECIFY
<b>IX. NUTS</b>	
2602	Cashew nut, shelled (without shell)
2601	Cashew nut, without apple (with shell)
2603	Coconut, green, young (buiko)
2604	Coconut, matured
2605	Pili nut, with hull
2606	Pili nut, with shell
2607	Pili nut, without shell
2608	Other nut variety: SPECIFY

## RICE VARIETIES/CODES (continued)

CODE	Commercial Name	NSIC Registered Number
93	Sipocot	NSIC 2000 Rc84 (PSB Rc84)
94	Submarino 1	NSIC 2009 Rc194
95	Sumadel	NSIC 1995 Rc46 (PSB Rc46)
96	Sumilao	NSIC 2001 Rc106
97	Tubigan 1	NSIC 2002 Rc110
98	Tubigan 11	NSIC 2006 Rc154
99	Tubigan 12	NSIC 2006 Rc156
100	Tubigan 13	NSIC 2006 Rc158
101	Tubigan 14	NSIC 2006 Rc160
102	Tubigan 15	NSIC 2009 Rc212
103	Tubigan 17	NSIC 2009 Rc216
104	Tubigan 18	NSIC 2009 Rc222
105	Tubigan 19	NSIC 2010 Rc224
106	Tubigan 2	NSIC 2002 Rc112
107	Tubigan 20	NSIC 2010 Rc226
108	Tubigan 3	NSIC 2004 Rc130
109	Tubigan 4	NSIC 2005 Rc134
110	Tubigan 5	NSIC 2005 Rc138
111	Tubigan 6	NSIC 2005 Rc140
112	Tubigan 7	NSIC 2005 Rc142
113	Tubigan 8	NSIC 2005 Rc144
114	Tubigan 9	NSIC 2006 Rc150
115	Tugatog	NSIC 1997 Rc60 (PSB Rc60)
116	Other rice variety: SPECIFY	

Source: National Seed Industry Council

Bureau of Plant Industry

## OTHER CROPS/CODES (continued)

Commodity Code	Name of Commodity
<b>VI. CONDIMENTS (continued)</b>	
1911	Pepper, finger (panigang)
1912	Pepper, hot (red, labuyo)
1913	Other condiments variety: SPECIFY

## OTHER CROPS/CODES (continued)

Commodity Code	Name of Commodity
<b>X. CUTFLOWERS</b>	
2701	Anthurium
2711	Aster
2702	Chrysanthemum
2703	Dahlia
2704	Daisy
2713	Dancing lady (Oncidium)
2705	Dendrobium
2712	Euphorbia
2706	Gladiola
2707	Heliconia
2708	Roses
2709	Sampaguita
2710	Vanda
2711	Other cut flowers variety: SPECIFY

## A4.2 Enumerator's Manual

R-CDTA 8369: Innovative Data Collection Methods for Agricultural and Rural Statistics

Enumerator's Manual

Farmer Recall Questionnaire



Japan  
Fund for  
Poverty  
Reduction



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## Part I: Farmer Recall Questionnaire

### General Instructions

#### Objective

This farmer recall survey is being conducted to estimate rice yield and production in the pilot province of Nueva Ecija, Philippines. This data will be compared with rice yield and production data collected during the crop cutting segment of the study. In addition, the survey will collect information on other crops, agricultural methods, and household economics and demographics, for the purpose of understanding the context of the data collected, and to inform policy planning.

#### Confidentiality

Information collected from respondents is confidential. Unauthorized persons not related to this study should not have access to this information. This information will only be used for identification purposes and planning. It is important to assure respondents that the information they provide will be kept confidential, and be used for research purposes only.

#### Repeated Identifiers

- The Farmer Recall Questionnaire has three sections
- Section D: Plot Details
- Section E: Crop Details
- Section F: Rice - Household Totals

for which the relevant identifiers (e.g., Recall ID, Crop Code, etc.) are repeated on each page of the questionnaire. These sections have a large number of questions, and the identifiers are repeated in order to prevent distortion of the data due to enumerator errors (i.e., entering the wrong information for a given plot, crop, etc.).

For Section D: Plot Details, plots are listed by:

- RECALL PLOT ID (printed on the questionnaire)
- FULL IDENTIFICATION (ID) NUMBER (these are the same “Full Identification Numbers” that were used in the crop cutting segment of the study; only plots that fell within the mesh will have them)
- PLOT NAME

This information originates from Section C. Enumerators should carefully match the information from Section C to the first three columns in Section D. Then, the **REPEATED IDENTIFIER** is:

- RECALL PLOT ID

For Section E: Crop Details, plots are listed by:

- RECALL PLOT ID
- PLOT NAME
- CROP NAME
- CROP CODE

and the **REPEATED IDENTIFIERS** are:

- RECALL PLOT ID
- CROP NAME
- CROP CODE

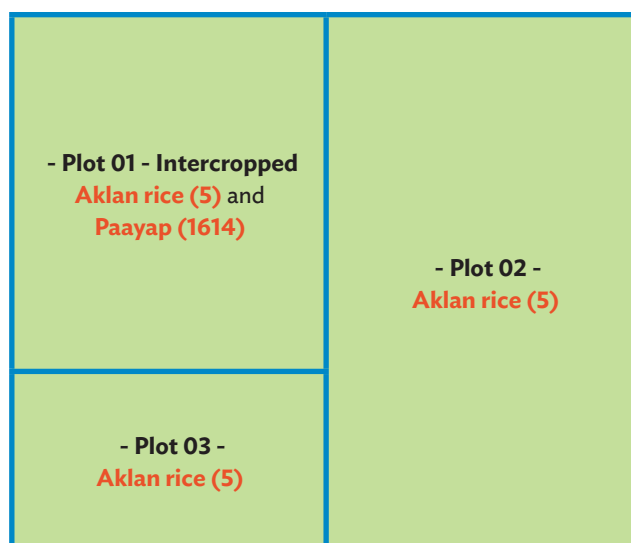
Section E records information for each crop on each plot. As explained in greater detail at the beginning of the Section E portion of this manual, this allows for accurate information for plots on which more than one crop is grown.

For Section F: Crops-Household Totals, the **REPEATED IDENTIFIERS** are:

- CROP NAME
- CROP CODE

Section F is distinct from Sections D and E in that each **rice crop** is recorded only once (regardless of how many plots exist on which this crop is being cultivated).

Consider the following example, for Mesh 12345, which all happen to belong to a farmer named Mrs. Durante:



For Section D (and Section C), these plots would be referenced using the following information:

Sections C and D		
Recall Plot ID	Full ID Number	Plot Name
RR01	12345-p01	Durante's Intercropped Plot
RR02	12345-p02	Durante's Aklan Plot - North
RR03	12345-p03	Durante's Aklan Plot - South

For Section E, these plots would be referenced using the following information:

Section E			
Recall Plot ID	Plot Name	Crop Name	Crop Code
RR01	Durante's Intercropped Plot	Aklan	5
RR01	Durante's Intercropped Plot	Paayap	1614
RR02	Durante's Aklan Plot - North	Aklan	5
RR03	Durante's Aklan Plot - South	Aklan	5

For Section F, these plots would be referenced using the following information:

Section F	
Crop Name	Crop Code
Aklan	5

### Skip Codes

There will be “skip codes” throughout the questionnaire. The skip codes guide you to continue to a different question than the one that immediately follows. This improves the flow of the interview.

A “conditional skip” will be the first type of skip you will find in the questionnaire, where the skip depends on the respondent’s answer to a particular question.

For example, in Section E, if the respondent tells you in Question 17 that they have harvested some of the given rice crop from a plot in the 2015 rainy season, you do not want to ask Question 18: “Why didn’t you harvest any [CROP] on this plot?” Therefore, you will find a skip code for Question 17, instructing you to continue to Question 20 if the answer to Question 17 is “yes”.

If, on the first plot listed in Table A4.1, some of the crop was harvested in the 2015 rainy season, then the skip code applies and the interview continues with Question 20. However, if instead, none of the crop was harvested, continue with the next question, Question 18, asking why none of the crop was harvested (in this case, because of drought).

In this case, Question 18 also has a skip code, instructing you to skip to Question 34a if the respondent gives any answer other than “3 – Typhoon Lando”. This is because Question 19 is a Typhoon Lando-specific question (and therefore, you would not ask it if the reason for harvesting none of the plot was any reason other than Typhoon Lando).

Another type of skip code in the questionnaire is an “unconditional skip”. These codes have a box around them for easier identification. With unconditional skips, you should skip to the question indicated in the box **regardless of the respondent’s answers**. All unanswered questions because of the skip pattern should be left blank—no information should be recorded.

In the given example, you should always skip to Question 34a after answering Question 19, no matter what the respondent indicates. This is because Questions 20-33 all relate to the harvest, but Question 17 indicates that the household did not harvest anything from the plot at all. Therefore, **it is not necessary or logical to ask questions about the harvest**.



### Questions for the Enumerator

There are several questions throughout the survey that are intended for the ENUMERATOR, not the respondent. Usually these are questions that have already been asked of the respondent, and are filter questions for the enumerator. These are in ALL CAPITALS, and are prefaced with the word “ENUMERATOR”.

For example, Question 4 in Section B asks “ENUMERATOR: IS THIS PERSON THE QUESTIONNAIRE RESPONDENT?” In this case, it will be obvious who is answering the questions and who is not present, so the enumerator should enter the correct information accordingly.

### Calculating Time for “Non-Agricultural Work Activity” in Section B

Question 9a in Section B asks the enumerator to enter information on how much time in the last 12 months (January to December 2015) each household member spent on non-agricultural work activities (in other words, it asks for the household’s sources of income apart from the income generated from their own farming activities).

Time should be described as:

- The **TOTAL** number of months, disaggregated into:
  - **AVERAGE** weeks per month
  - **AVERAGE** days per week
  - **AVERAGE** hours per day

The minimum number of months per year should be “one”, the minimum number of weeks per month should be “one”, and the minimum number of days per week should be “one”, regardless of how many hours per day were spent on the activity. These numbers should be given as **integers** (whole numbers).

For example, what if a household member works eight hours a day, five days a week, and six weeks per year on a given work activity?

Then the fields for Question 9a should be filled out as follows:

Work Activity #1			
TOTAL number of MONTHS	Average WEEKS per MONTH	Average DAYS per WEEK	Average HOURS per DAY
2	3	5	8

Note that six weeks per year is the same as an AVERAGE of three weeks per month, over a TOTAL of two months. Since the question does not ask for the specific time period, or whether the six weeks were consecutive or not, you need only to enter integers which indicate six weeks per year: an average of three weeks per month for two months is equivalent to six weeks per year:

$$6 \text{ weeks per year} = 3 \text{ weeks per month} \times 2 \text{ months per year}$$



Note that multiplying all the numbers here gives us the average number of hours worked per year on this activity, which is a good way to check your work:

$$240 \text{ hours per year} = 8 \text{ hrs a day} \times 5 \text{ days a week} \times 3 \text{ weeks per month} \times 2 \text{ months per year}$$

In another example, what if a household member works one hour per day, one day per week, for only three weeks out of the year? This would be the equivalent of working three hours per year on this activity. Then the fields for Question 9a should be filled out as per the below:

Work Activity #1			
TOTAL number of MONTHS	Average WEEKS per MONTH	Average DAYS per WEEK	Average HOURS per DAY
1	3	1	1

Again, multiplying all of these figures together gives us the number of hours per year worked on this activity:

$$3 \text{ hours per year} = 1 \text{ hr a day} \times 1 \text{ day a week} \times 3 \text{ weeks per month} \times 1 \text{ month per year}$$

### Calculating Days Worked for Hired Labor in Section D

In Section D, Questions 52a-52e, the questionnaire asks about hired labor for three categories of workers: women, men, and children aged 15 years old and below. The questionnaire requires you to obtain this information for each category IN AGGREGATE. **You should therefore enter the total number of people in each category who worked, the total number of days for which they were paid for work, and the total amount paid to those people.**

For example, if three women were hired for 10 days each to do harvesting, and were paid PHP 500 per day, you would enter the following information:

- Total Number of Women: 3
- Total Number of Days: 30 (because  $3 \times 10 = 30$ )
- Total Amount Paid: PHP 15,000 (because  $3 \times 10 \times 500 = \text{PHP } 15,000$ )

Remember that it does not matter if the three women worked the same 10 calendar days, 10 different calendar days, or some combination thereof: they each need to be paid for the number of days they worked, so you should enter "30 days" as the total number of days.

In another example, what if three women were hired to do harvesting, and were paid PHP 500 per day, but 2 women worked 10 days each, and 1 woman worked 5 days each? Then you would enter the following information:

- Total Number of Women: 3
- Total Number of Days: 25 (because  $(2 \times 10 = 20) + (1 \times 5 = 5) = 25$ )
- Total Amount Paid: PHP 12,500 (because  $25 \times 500 = \text{PHP } 12,500$ )

The wage is the daily wage in PHP that the woman or women were paid for the activity. Include the PHP equivalent of in-kind payments.

### **The Listing Form: Use and Instructions**

For the Farmer Recall Survey in the Philippines, enumerators are required first to fill out a Listing Form for each mesh. This ordinarily would have been done during the Crop Cutting portion of the study, for the purpose of taking crop cutting samples; in this case, it will enable us to determine which farmers we will interview.

First speak to the barangay official or another authority who can give you accurate and current information about who owns and operates the plots which fall within the mesh. Using the MapPlus program in the iPads, printed maps of the meshes, and the information from the barangay official, first draw the boundaries of all the plots which fall within the mesh. For simplicity and consistency, include fallow plots, forested areas, fish ponds, houses, and any other areas not used for agriculture.

Remember our definition of a plot:

A CONTINUOUS PIECE OF LAND ON WHICH A UNIQUE CROP OR A MIXTURE OF CROPS IS GROWN, UNDER A UNIFORM, CONSISTENT CROP MANAGEMENT SYSTEM. IT SHOULD NOT BE SPLIT BY A PATH OR OTHER DIVISION (DYKE, IRRIGATION CHANNEL, ETC.) OF MORE THAN ONE METER IN WIDTH. PLOT BOUNDARIES ARE DEFINED ACCORDING TO THE CROPS GROWN AND THE OPERATOR.

Once all plots have been identified, list them on the Listing Form, using identification numbers “p01”, “p02”, and so on. List all plots in a geographically serial and serpentine manner.

Next, fill in the name of the plot owner on the Listing Form. Ask the barangay official for an estimate of the area of the plot in hectares, and enter this information.

Then find out if rice was planted on the plot during any of the 2015 season. If so, enter “Y” into this column on the Listing Form. If not, enter “no”, and do not ask for any additional information about the plot.

Then ask if the owner or operator expected to harvest rice on this plot during the 2015 season (the harvest period for this season was September to December 2015). It does not matter if no rice was harvested, due to losses or some other problem – what we want to know is if the farmer planted rice that he or she expected or hoped to harvest during that season.

If answers to both of these questions are “yes”, assign the plot a serial number in the first column on the listing form, on the left. Remember that serial numbers may not necessarily be the same as plot numbers.

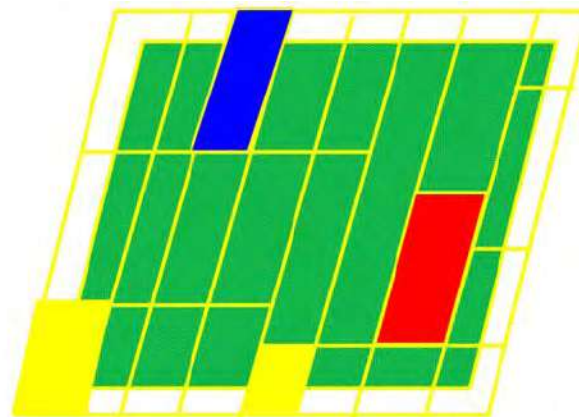
However, you may come across plots which are operated by someone other than the owner. For each plot for which the answers to both questions are “yes”, ask the barangay official if the owner is also the operator of the plot, or if someone else is operating it. If someone other than the owner is operating the plot, ask the barangay official how far away the owner lives from the plot. If s/he lives farther than one hour away by a commonly-used mode of transportation, find out if s/he is willing to do the interview over the phone and ask if s/he knows the details about the farm operation. . Inform the owner that the interview might take two hours. If he is not willing to be interviewed, ask who is the most “knowledgeable person” who can be the respondent for the survey (e.g. farm operator).

**Remember that if the respondent is the plot manager/operator but NOT the plot owner, he or she may not have full information about rice sales or other economic information related to production. Enumerators should do their best to obtain this information, and indicate “DK” (“don’t know”) if the respondent is unable to answer.**

Once serial numbers are assigned, use the Random Number table to determine the serial numbers of the four plots belonging to farmers you will interview.

If more than one of the plots selected is owned and operated by the same farmer, then these are the farmers you should interview. To illustrate, if two of the four plots selected are owned by the same person, and the two others are both owned by different people, you will interview only three farmers. Remember, for the farmer who owns two of the selected plots, to enter BOTH Full Identification Numbers on the cover page of the questionnaire:

**Interview only three farmers in this case:**



Farmer 1: ■ Farmer 2: ■ Farmer 3: ■

**When interviewing Farmer 1, enter BOTH Full ID numbers on the questionnaire’s cover page:**

11. FULL IDENTIFICATION NUMBER: MESH + PLOT ID	1	2	3	4	5	-	p	0	1
IF CROP-CUTTING WAS DONE ON MORE THAN ONE PLOT OWNED BY THE SAME PERSON, ENTER ADDITIONAL FULL IDENTIFICATION NUMBERS :	1	2	3	4	5	-	p	1	3
						-			
						-			

### Summary of the Interviewer's Responsibilities

- You are responsible for seeking out the barangay leaders to provide them with information regarding the major objectives of the activity. This will secure their cooperation in the survey, and facilitate the smooth completion of tasks.
- You must talk to the farmer or farm operator of every plot to explain the objectives of your work.
- Arrange a reasonable time with the farmer or farm operator for interviewing, before going to the site.
- Upon completion of the questionnaire, carefully check the questionnaire ensuring there are no mistakes or errors before you leave the interviewed farmer or farm operator.
- Communicate regularly with your supervisor and Asian Development Bank Farmer Recall Consultant for assistance. Your work will likewise be inspected by the supervisor.
- To ensure the efficiency and accuracy of your work, you may be required to answer some questions raised by your team leader.
- Submit completed questionnaires to your team leader immediately after completion.

### Definition of Terms and Concepts

The following are explanations and clarifications of terminology used in this questionnaire and the research as a whole:

- **HOUSEHOLD:** The word “household” refers to a social unit consisting of a person living alone or a group of persons who sleep in the same housing unit and have a common arrangement in the preparation and consumption of food.<sup>6</sup>
- **HEAD OF HOUSEHOLD:** The head of household is the person who generally provides the chief source of income for the household unit. He is the adult person, male or female, who is responsible for the organization and care of the household or who is regarded as such by the members of the household.<sup>7</sup>
- **RESPONDENT:** This is the person who will answer the survey questions. It should be the main farmer or farm operator. In the absence of the main farmer or farm operator, you may seek help of the person who is next-best informed about the farm plots.
- **PLOT:** A continuous piece of land on which a unique crop or a mixture of crops is grown, under a uniform, consistent crop management system. It must be continuous and should not be split by an obstruction (e.g., river, dyke, path, etc.) of more than 1 meter in width. Farm boundaries are defined according to crops grown, and the operator.
- **AGRICULTURAL ACTIVITY:** Includes farming, raising livestock or fishing, whether for sale or for household food. It includes the 2015 rice harvest.
- **PAID EMPLOYEE:** One who does work for a wage, salary, commission, or any payment in kind; including doing a paid apprenticeship, domestic work, or paid farm work.
- **TEMPORARY CROP:** Temporary crops are those that are both sown and harvested during the same agricultural year, sometimes more than once.<sup>8</sup>
- **PERMANENT CROP:** Permanent crops are those that are sown or planted once, then occupy the land for some years and need not be replanted after each annual harvest. Some examples are cocoa, coffee, and rubber. This category includes flowering shrubs, fruit trees, nut trees, and vines, but excludes trees grown for wood or timber.<sup>9</sup>

6 <https://psa.gov.ph/content/household>

7 <https://psa.gov.ph/content/household-head>

8 [http://www.fao.org/fileadmin/templates/ess/ess\\_test\\_folder/documents/Production\\_trade/definitions/Crops\\_statistics\\_concepts\\_definitions\\_classifications.doc](http://www.fao.org/fileadmin/templates/ess/ess_test_folder/documents/Production_trade/definitions/Crops_statistics_concepts_definitions_classifications.doc)

9 *ibid.*

- **2015 RAINY SEASON:** Refers to July to December 2015.
- **HARVEST PERIOD 2015:** Refers to September to December 2015.
- **“LAST 12 MONTHS”:** Refers to January to December 2015.

### Research Tools

Each interviewer should have the following:

- Identity card
- Letter of introduction from the Philippine Statistics Authority (PSA)
- Farmer Recall Questionnaire
- Farmer Recall Enumerator's Manual (**this document**)
- iPad to reference and identify plots
- Mesh maps to reference and identify plots
- List of plots on which crop cutting was done during the crop cutting portion of the study
- List of all farmers or farm operators in a given sample mesh on whose plots crop cutting was done during the crop cutting portion of the study, with their addresses and phone numbers
- Pen or pencil
- Writing clipboard
- Plastic cover for writing clipboard (and Questionnaire and Manual)
- Notebook
- Plastic cover for notebook
- Plastic cover for iPad
- Rain boots and raincoat



## Section A: Cover or Plot Identification

**Question 1.** Time of interview start. The starting time of the interview should be recorded by the interviewer. The start time is divided into two boxes: one for the hour and the other for minutes. The hours entry box is before the “:”. This can range from “1” to “12”. The minutes entry box can range from “00” to “59”. Please be sure to circle “AM” or “PM” to indicate what time the interview has started.

**Question 2.** Date of interview start. Write the date the interview started. Start with day, month, and then year. Remember that day is two digits (DD), month (MM) is two digits, and year is four digits (YYYY). If the date is “1”, enter it as “01”. If the Month is “8” (August), enter it as “08”.

**Question 3.** Time of interview end. The time the interview ends should be recorded by the interviewer. The end time is divided into two boxes: one for the hour and the other for minutes. The hours entry box is before the “:”. This can range from “1” to “12”. The minutes entry box can range from “00” to “59”. Please be sure to circle “AM” or “PM” to indicate what time the interview has ended.

**Question 4.** Date of interview end. Write the date the interview ended. If it is the same day as in **Question 2**, enter the same date, in DD/MM/YYYY format.

**Questions 5-7.** Write the province name and its corresponding code, and the codes and names of the municipality and barangay.

**Questions 8-10.** Write the mesh or pixel number of the sample mesh to which you are returning, followed by the center pixel latitude and center pixel longitude. You may get this information by tapping any side of the square mesh using the iPad.

**Question 11.** Write down the Full Identification Number of the specific mesh and plot to which you are returning. Write the Full ID as “12345-p01” for mesh with number 12345 and plot code “p01”. If crop cutting was done on more than one plot owned by the same person, enter additional full identification numbers.

**Questions 12-14.** Write down the full name, address, and phone number(s) of the farm operator.

**Question 15.** Write down the full name of the respondent. This is a different person than the information entered in **Question 12** if the operator is different from the respondent. For example, if the operator is unavailable but her husband is available, then the respondent is the husband, since he is responding to the questionnaire. If it is the same person as the farm operator, then write down the same name as **Question 12**.

**Question 16.** Write down the respondent’s relationship to the farm operator. Use the options and codes given in the box. If “Other,” specify the relationship in writing.

## Definitions:

- **HEAD OF HOUSEHOLD:** The person who generally provides the chief source of income for the household unit. He is the adult person, male or female, who is responsible for the organization and care of the household or who is regarded as such by the members of the household.<sup>10</sup>
- **SPOUSE:** The husband or wife of the head of household.
- **SON OR DAUGHTER:** A son or daughter (adopted or biological) of the head of household.
- **PARENT:** The mother or father of the head of household.
- **BROTHER OR SISTER:** The brother or sister (sibling) of the head of household.
- **SON-IN-LAW OR DAUGHTER-IN-LAW:** A person married to the head of household's brother or sister, or the brother or sister of the spouse (husband or wife) of the head of household.
- **MATERNAL OR PATERNAL GRANDPARENT:** The parents of the head of household's parents (mother's mother, mother's father, father's mother, or father's father).
- **MATERNAL OR PATERNAL GRANDCHILD:** Any grandchildren of the head of household.
- **DOMESTIC HELP:** A person working and living in the household but not a family member (if this person is a family member, indicate the relationship with one of the options above, or select "other relative").
- **OTHER RELATIVE:** Any other blood relative who does not fall into the categories given above.
- **OTHER NONRELATIVES:** Any other person who is not a blood relative and not a domestic worker, but who is living in the household.

**Questions 17-18.** Write down the respondent's address and phone number(s).

**Question 19.** Names of team members or enumerators. Here the interviewer writes the full names of all members of the team, EXCEPT FOR THE TEAM LEADER. Do not include the Team Leader here.

**Question 20.** Enumerator code. Every team member or enumerator will have a unique code; this is always filled in for each and every questionnaire he or she attends. This number will not change over the course of the survey. DO NOT INCLUDE THE TEAM LEADER HERE.

**Leave Questions 21, 22, 23, and 24 blank for now and skip to the next section. Record any observations you may have from the interview in the space provided at the bottom of the cover page as you progress through the interview.**

**Questions 21-23.** The team leader should fill out these questions with his or her name, code number, and date the questionnaire was inspected.

**Question 24.** Include any relevant views on how the interview was conducted, problems encountered, etc., which may help the team leader and the data analysts of the results of the survey. The Team Leader's observations and comments should be written after the interview has ended.

**Reminder: In writing observations, make sure to follow this format:**

**Section – Question no. — Identifier (e.g. HH ID, Recall Plot, etc.): \_\_\_\_\_**

<sup>10</sup> <https://psa.gov.ph/content/household-head>

## Section B: Household Roster and Details

YOU SHOULD COMPLETE **QUESTIONS 1-4** FOR ALL HOUSEHOLD MEMBERS **BEFORE** MOVING ON TO THE REMAINING QUESTIONS.

**THE INTERVIEWER SHOULD TAKE CARE IN RECORDING HOUSEHOLD MEMBERS' INFORMATION. WRONG CODING WILL AFFECT THE WHOLE DATASET.**

LIST ONLY UP TO 20 HOUSEHOLD MEMBERS. FOR HOUSEHOLDS WITH MORE THAN 20 HOUSEHOLD MEMBERS, USE SECTION A24 AND LIST OTHER MEMBERS.

AFTER QUESTIONS 1-9b HAVE BEEN COMPLETED, ENTER THE INFORMATION FOR QUESTIONS 10a-10c, and 11.

### Question 1. NAME

List the names of all household members in this order: head, spouse of the head (if there is any), never-married children of head/spouse from the oldest to the youngest, ever-married children of head/spouse and their families from the oldest to the youngest, other relatives of head, and nonrelatives of head. Name should be written as [Surname], [First Name] [Middle Initial]. If the HH member has the same LAST NAME as the previous HH member on the list, write the name as —, FIRST NAME, MIDDLE INITIAL. **To ensure that all members of the household are listed, read out the names to the household head.**

### Question 2. SEX

Gender codes are “1” for females and “2” for males. This is an important question for all household members. Refrain from determining gender by names. Some names are used by both genders. Even for children, make sure to record the correct gender. , Boys can sometimes look like girls, and girls can look like boys.

### Question 3. How old is [NAME]?

List the age of all household members in years, rounded down (refers to age as of last birthday). If the Household Member is a baby less than one year old, enter “0” as the age in years.

### Question 4. ENUMERATOR: IS THIS PERSON THE QUESTIONNAIRE RESPONDENT?

Note that this is the first question in the survey that is intended for the enumerator only: **do not ask the respondent this question.** Indicate whether the person (people) you are speaking with is (are) the respondent(s). Indicate ANY and ALL household members who responded to the questionnaire. Enter “1” for respondent(s) and “2” for everyone else.

**ONCE YOU HAVE ENTERED INFORMATION FOR ALL HOUSEHOLD MEMBERS IN QUESTIONS 1-4, COMPLETE THE REMAINING QUESTIONS FOR EACH PERSON IN THE HOUSEHOLD:**

### Question 5. What is [NAME]'s relationship to the head of household?

Indicate each household member's relationship to the head of household. If the respondent is the head of household, enter “Head – 1”.

**Question 6.** What was the highest level of school completed by [NAME]?

Indicate each household member's level of education, if any, using the options given. These options are adapted from the Philippines 2015 Census of Population.

**Question 7.** What is [NAME]'s civil status?

For all household members aged 15 or older, indicate his or her marital status.

**Question 8.** In the past 12 months, how would [NAME] define his or her main NON-AGRICULTURAL work activity, if any?

This question asks about the main NON-AGRICULTURAL work activity (or activities), if any, of each household member over the past 12 months. **What you are trying to determine is income OTHER THAN those generated by the household's own farming activity.** Use the following definitions (as per the Terms and Concepts section above):

- **PAID EMPLOYEE:** One who does work for a wage, salary, commission, or any payment in kind; including doing a paid apprenticeship, domestic work, or paid farm work for another household.
- **AGRICULTURAL ACTIVITY:** Includes farming, raising livestock or fish, whether for sale or for household food. Includes 2015 rice harvest.
  - INCOME FROM AGRICULTURAL ACTIVITY DONE FOR THE HOUSEHOLD'S OWN FARM SHOULD NOT BE INCLUDED. However, if a household member does work on someone else's farm, this SHOULD be included, and coded as 5: "Paid Worker for Other Household(s)".

List up to two non-agricultural work activities, in descending order of PROPORTION OF TOTAL INCOME. In other words, list first the activity or activities from which the household member earned the most amount of money over the last 12 months, regardless of the time spent on the activity. If the household member has more than two non-agricultural work activities, list the two from which the household member earned the most money over the last 12 months.

Unpaid nursing practicums, or internships, which are a requirement to complete a nursing degree, should be coded as 9: "Unpaid apprenticeships: Non-Agricultural".

Remittances should NOT be included here: the questionnaire has a separate section to record any remittances received by the household.

Remember that if you have selected a plot for interviewing for which the owner is not available, and are interviewing the manager or operator of this plot, you would enter the time and earnings from this management as "Paid worker for other household(s)". This is because these earnings do not come from the respondent's own farm holdings.

Definition:

1. **PAID EMPLOYEE - GOVERNMENT:** A paid employee of the national or regional governments of the Philippines.
2. **PAID EMPLOYEE - PRIVATE SECTOR:** A paid employee in a nongovernment entity, usually a company, which requires profit to sustain its existence, and seeks profit and growth as its ultimate goal.
3. **PAID EMPLOYEE - NONGOVERNMENT ORGANIZATION (NGO):** A paid employee of a nongovernment entity that does not seek to make profit, but rather relies on donations or an endowment to sustain its existence. NGOs tend to have a social focus.

4. **PAID EMPLOYEE - INTERNATIONAL ORGANIZATION:** A paid employee of an international NGO, or a multilateral institution (e.g., Asian Development Bank, World Bank, etc.).
5. **PAID WORKER FOR OTHER HOUSEHOLD:** A person who does any kind of work for another household. **THIS INCLUDES AGRICULTURAL WORK:** If the respondent says that someone in the household does agricultural work on someone else’s farm, you should enter that that person is a “paid worker for other household”.
6. **SELF-EMPLOYED (NONAGRICULTURAL) - WITH EMPLOYEES:** A person who makes money from doing any kind of work other than agricultural work on their household’s own farm, and has other people working for them in running that business or providing that service.
7. **SELF-EMPLOYED (NONAGRICULTURAL) - WITHOUT EMPLOYEES:** A person who makes money from doing any kind of work other than agricultural work on their household’s own farm, but runs that business or service on their own, without any other workers.
8. **UNPAID FAMILY HELPER (NONAGRICULTURAL):** A person who helps with a nonagricultural business that someone else in the household is running, but who does not earn any money from this business. For example, if someone in the household is running a small shop, and has their daughter helping in the shop without receiving wages, the daughter is an “unpaid family helper”. (Remember that, if a household member does unpaid agricultural work on the family’s plots, you would enter “Did agricultural work only” for this household member.)
9. **UNPAID APPRENTICESHIP (NONAGRICULTURAL):** A person who is learning some kind of trade, craft, or skill, and is required to work without pay to become a professional in this trade. This can be a trade like carpentry, or a nursing internship. If someone in the household is doing a paid apprenticeship, you would enter that they were some form of “Paid employee,” using the options given above.
10. **RETIRED WITH PENSION:** A person who is entitled to leave the work force because of his or her advanced age, and receive a government pension for support.
11. **DID AGRICULTURAL WORK ONLY:** A person who only is involved in agricultural work on the household’s own farm.
12. **STUDENT:** A full-time student, who has his or her studies as his or her main occupation. This may be a young person who is required by law to be a full-time student.
13. **DID NOT WORK:** A person who is eligible to be in the work force, but who does not work.

**Question 9a.** During the past 12 months, for how much time did [NAME] spend on this work activity?

For this question, indicate how much time each household member spent on his or her main NONAGRICULTURAL work activity (or activities) in the past 12 months.

For detailed description, refer to “Calculating Time for “Non-Agricultural Work Activity” in Section B” on the General Instructions.

If the respondent does not know, code as “DK”.

**Question 9b.** How much did [NAME] earn in total from this work activity in the past 12 months?

Indicate how much each household member earned from each of his or her main NONAGRICULTURAL work activity (or activities) in the past 12 months, in aggregate. In the case of a business, report the profit, not the earnings from sales (also known as revenue). Profit is calculated as revenue less the costs associated with running the business:

$$\text{PROFIT} = \text{REVENUE} - \text{COSTS}$$

If the respondent does not know, code as “DK”.



**Section B1: Other Income from Agriculture: Household Totals**

**THE NEXT THREE QUESTIONS ARE TOTALS FOR THE ENTIRE HOUSEHOLD, NOT QUESTIONS FOR INDIVIDUAL HOUSEHOLD MEMBERS. DO NOT ANSWER PER PERSON.**

**GIVE THE AGGREGATE FOR THE ENTIRE HOUSEHOLD'S AGRICULTURAL ACTIVITIES.**

**HOWEVER, DO NOT INCLUDE INCOME FROM SALES OF CROPS OR LIVESTOCK OR FISH CULTIVATED BY OTHER HOUSEHOLDS. THIS INFORMATION SHOULD BE RECORDED IN SECTION B, Question 9.**

The purpose of these questions is to obtain information on the household's agricultural (farm) income from sources other than rice. Together with information on nonagricultural work activities and information on rice sales (in later sections), this data allows for a complete profile of the household's income.

**Question 10a.** What was the total value of sales of all crops, other than rice, cultivated by the household in the past 12 months?

This question seeks information on the earnings from the sale of any and all crops (with the exception of rice) that were cultivated by the household. Later sections of the questionnaire will gather data about rice sales. Be certain to indicate the amount in PHP.

**Question 10b.** What was the total value of sales of all livestock raised by the household in the past 12 months?

This question seeks information on the earnings from the sale of any and all livestock raised by the household during the same period. Be certain to indicate the amount in PHP. If there is any income from hunting, or from the sale of livestock or animals not raised by the household, this should be included in nonagricultural work activity under **Question 9**.

**Question 10c.** What was the total value of sales of all fish and aquatic animals raised by the household in the past 12 months?

This question seeks information on the earnings from the sale of any and all fish and aquatic animals (such as crabs, shellfish, prawns, etc.) raised by the household during the same period. Be certain to indicate the amount in PHP. If there is any income from fish and aquatic animals not raised by the household, this should be included in nonagricultural work activity under **Question 9**.

**Section B2: Income From Remittances: Household Totals**

**THE NEXT QUESTION ASKS FOR TOTALS FOR THE ENTIRE HOUSEHOLD, NOT QUESTIONS FOR INDIVIDUAL HOUSEHOLD MEMBERS. DO NOT ANSWER PER PERSON.**

**GIVE THE AGGREGATE FOR REMITTANCES RECEIVED BY THE ENTIRE HOUSEHOLD. INCLUDE BOTH OVERSEAS AND DOMESTIC REMITTANCES.**

The purpose of this question is to obtain information on the household's additional income from remittances. Remittances are monetary transfers to the household which are not earned, but are given. They are usually in the form of money sent to the household by family members who are living and working in another area of the country, or abroad. Remittances can provide a substantial proportion of support in the form of income to the household.

Together with information on other agricultural income, non-agricultural work activities, information on rice sales (in later sections), this data allows for a complete profile of the household's income.

**Question 11.** What was the total value of REMITTANCES received by the household in the past 12 months?

This question asks the respondent to estimate the TOTAL VALUE of all remittances received by the entire household (each household member, in aggregate) over the last 12 months. Include both overseas and domestic remittances in the response. Be certain to indicate the amount in PHP.

## Section C: Plot Roster

THIS SECTION SHOULD INCLUDE DATA FOR ALL PLOTS THE RESPONDENT OR ANYONE ELSE IN HIS OR HER HOUSEHOLD **OWNED** OR **CULTIVATED** DURING THE 2015 RAINY SEASON.

THIS INCLUDES THE PLOT(S) ON WHICH CROP CUTTING WAS DONE, AND ALL OTHER PLOTS THAT MEET THIS DEFINITION, WHETHER RICE OR NOT.

HOWEVER, **LIST RICE PLOTS FIRST**. Because of the way in which the questionnaire is designed, doing this will make it easier to organize the information.

Remember that our definition of a plot from crop cutting is:

- A CONTINUOUS PIECE OF LAND ON WHICH A UNIQUE CROP OR A MIXTURE OF CROPS IS GROWN, UNDER A UNIFORM, CONSISTENT CROP MANAGEMENT SYSTEM. IT MUST BE CONTINUOUS AND SHOULD NOT BE SPLIT BY A PATH OF MORE THAN 1 METER IN WIDTH. PLOT BOUNDARIES ARE DEFINED ACCORDING TO THE CROPS GROWN, AND THE OPERATOR.

**THE RECALL PLOT ID IS GIVEN IN THE QUESTIONNAIRE. YOU SHOULD ENTER INFORMATION FOR THE FOLLOWING TWO FIELDS FOR ALL PLOTS *BEFORE* MOVING ON THE REMAINING QUESTIONS:**

1. FULL IDENTIFICATION NUMBER
2. PLOT NAME

**Full Identification Number.** Enter the Full Identification Number for the plot, if one exists. ALL plots which fall within the sample mesh will have a Full Identification Number. NO plots which fall outside the sample mesh will have this number. Use the Listing Forms, hardcopy maps, and iPad satellite images to determine which, if any, plots within the mesh are operated by the household.

### **Question 1.** Plot Name

Indicate the name the owner or operator uses to refer to each plot, in order to distinguish it from other plots. This name can be in any format as long as it is unique from all other plot names listed.

### **Question 2.** Location and Description

Give any other information that can augment the information given in **Question 1**, so that each plot is unique in description of its location and other distinguishing characteristics.

### **Question 3.** Farmer's Estimate of Area

Ask the farmer to provide an estimate of the plot size in hectares. If the plot area is given in any other unit, be sure to indicate the correct unit.

### **Question 4.** Was rice harvested on this plot in the 2015 rainy season (September-December 2015)?

Indicate if rice was harvested from this plot during the 2015 rainy season, which ran from September-December.

## Section D: Plot Details

YOU SHOULD COMPLETE THE FIRST THREE COLUMNS FOR ALL PLOTS **BEFORE** MOVING ON THE REMAINING QUESTIONS. CONTINUE TO FILL OUT THESE COLUMNS ON EACH NEW PAGE.

**RECALL PLOT ID.** This is the same number as in Section C: Plot Roster - copy from this Section C.

**FULL IDENTIFICATION NUMBER.** The Enumerator should copy this number from Section C: Plot Roster.

**PLOT NAME.** The Enumerator should copy this number from Section C: Plot Roster.

**Question 1:** What is the distance from [PLOT] to:

- a. the home of the respondent (in meters)
- b. the nearest road (in meters)
- c. the nearest market (in meters)

Ask the respondent to estimate the distance if they are uncertain. If they give distances in terms of minutes of walking, estimate the distance based on the following approximation: 10 minutes is equivalent to walking 1 kilometer. (Hence, 15 minutes would approximately be about 1500 m.)

A “road” is any paved or unpaved path on which a wheeled vehicle (motorized or unmotorized) can travel unhindered.

The nearest market should be the nearest market where agricultural products can be sold, and agricultural inputs can be bought.

## PLOT OWNERSHIP

**Question 2.** What is the tenurial status of this [PLOT]?

Tenure is the right under which the plot is held or operated. A plot may be owned, rented, leased or held under other forms like those that are held as mortgage, or a squatter basis or rent free. Ask the respondent how s/he is entitled to use of this plot in the 2015 rainy season, even if the plot was acquired prior to the 2015 rainy season. Use the options given, and follow the conditional skips.

Philippine Statistics Authority definitions are:

1. **OWNED/BEING AMORTIZED:** Refers to the land operated with a title of ownership and consequently the right to determine the nature and extent of the use of the land. It includes lands whose absolute ownership is vested in the holder thru sale, inheritance, etc. A plot is also considered fully owned if the holder has an absolute deed to the sale of the land. Likewise, lands of the tillers with Emancipation Patent.
2. **RENTED/CO-RENTED OUT:** A plot is “rented out” if the household has usage rights to the plot, and are collecting rent from someone else so that person can cultivate or otherwise use the plot.
3. **RENTED/CO-RENTED IN:** A plot is “rented in” if the household pays rent to usage rights holder in order to cultivate the plot (the household are tenants on the plot). To differentiate this category from

“Buwisan”, rented/co-rented in plots usually refer to temporary rental of plots. For example, the plot is rented only during the dry season when the owner will not use the plot for rice cultivation, and the renter will use the plot to cultivate vegetables.

4. **”BUWISAN”**: Refers to plots where the operator (and his/her family) pays tax or “buwis” to the plot owner. This includes what is called “Buwisang MALAYA” where the operator is expected to pay tax to the plot owner in his/her lifetime, and payment of tax is usually passed from generation to generation.
5. **RENT-FREE WITH CONSENT OF OWNER**: Refers to an area operated without title of ownership and without paying rent but with the consent or permission of the landowner.
6. **RENT-FREE WITHOUT CONSENT OF OWNER**: Refers to an area operated without title of ownership and without paying rent and without the consent or permission of the landowner.
7. **OTHERS, SPECIFY**: Includes land held as mortgage and all other forms not categorized above, including squatter of less than 30 years.

**Question 3.** Which household member(s) have ownership of, or right to use or co-use, this plot?

For respondents whose households own or co-own the plot, or have the right to use or co-use this plot, record up to three Household IDs from the Household Roster. If the household member co-owns or co-uses the plot with a nonhousehold member, enter the household member’s ID ONLY.

**Question 4.** Does a legal record or document exist that proves your ownership rights of use or co-use of the plot?

This can include a title of ownership, or deed to the sale of the land. If a legal record or document exists, even if it is not kept in the household but is kept by the barangay’s records office, which prove the household’s ownership of or usage rights to the plot, code “yes”.

**Question 5.** Does your household share tenurial or legal ownership rights for this plot, or right to use or co-use, with someone outside the household?

This question asks about people who co-own or co-use the plot with the household, but who are not members of the respondent’s household. If the answer is “no”, code “2”, then skip to **Question 7**.

**Question 6.** What share of the plot do members of the household own or have right to use or co-use?

This question asks the respondent what portion of the shared plot the household owns, or has rights to co-use. Enter the percentage if known; if the respondent is not certain, ask him or her to estimate.

**Question 7.** In which year was the plot acquired by members of this household?

Ask the respondent in which year the plot was acquired, and record the year in four digits. In cases where the respondent’s household had always owned the plot, or that the plot has belonged to the respondent’s household since before he or she was born, record 1900. If the respondent does not know, code as “DK”.

**Question 8.** Who in the household can decide whether to rent this plot, use it as collateral, sell it, or otherwise monetize usage rights to the plot?

Ask the respondent which household members have the power to decide about renting out the plot for use, using it as collateral, selling it, or otherwise earning money from ownership of the plot. Ask only for up to two household members and record the corresponding Household Roster IDs.



**Question 9.** Was this plot rented out during the 2015 rainy season?

This question asks if plot owners or co-owners rented their plots out to tenants during the 2015 rainy season, rather than cultivating the plots themselves. If “no”, code as “2”, then skip to **Question 18**.

**Question 10.** What was the total income from renting out this plot during the 2015 rainy season?

Ask for the total income earned from renting out the plot, including cash payments, estimated cash value of payments in-kind, and “planned or future payments” or the cash value of payments expected from tenants, including from tenants who have not yet paid.

**Question 11.** If plot ownership was shared with someone outside the respondent’s household, how much of the total rental income was received by household members?

If the household rented out the plot, and shared land use rights with someone outside the household (i.e., a network member), enter the amount of income that went to the HOUSEHOLD. Include in-kind income. For example, if the answer to **Question 10** is PHP400,000, and PHP150,000 of that income went to the network member and PHP250,000 was kept by the household, enter PHP250,000 for **Question 11**. If no income was shared, enter the same amount in **Question 11** as you did in **Question 10**.

**Question 12.** Do you rent in, or co-rent in, a portion of this plot?

This question asks, for those who own at least a portion of the plot, if they ALSO rent in or co-rent in another portion of this plot. If the answer is “no”, code “2”, then skip to **Question 18**.

**Question 13.** What percentage of the whole plot do you rent in or co-rent in?

Ask the respondent what percentage of the plot the household rents in, for those who answered “yes” to **Question 12**.

**Question 14.** Which household member(s) rent in or co-rent in this plot?

Ask this question when household members rent a plot together. For example, if the household head and his or her daughter live in the same household, cultivate a plot together, and both pay rent to the landowner, then the head and his daughter co-rent the plot. The Household IDs for both the head and his or her daughter should be entered for **Question 14**.

**Question 15.** Do you co-rent in this plot with someone outside this household?

This question asks, for households that co-rent, if there is another tenant(s) who is a nonhousehold member.

**Question 16.** What was the TOTAL rent paid to the landlord by all co-renters of this plot?

Include ALL payments by ALL tenants regarding how the plots were used during the 2015 rainy season. Include cash, payments for crop harvests, other payments in-kind, payments expected to be made in the future, and payments received in the past (no matter how long ago) but directly made for using the plot during the 2015 rainy season.

**Question 17.** How much of this total rent was contributed by the household member(s)?

If the household rented the plot with someone outside the household (i.e., a network member), enter the amount of income that was contributed by the HOUSEHOLD. For example, if the answer to **Question 16** is

PHP300,000, and PHP100,000 in rent was contributed by the respondent's household, and PHP200,000 was contributed by the nonhousehold co-tenants, enter PHP100,000 for **Question 17**. If the household paid 100% of the rent (i.e., no rent was contributed by the other tenants), enter the same amount for **Question 17** as you did for **Question 16**.

## PLOT USAGE

**Question 18.** What is the soil type of this plot?

Knowledge on soil texture is useful to understand the plot's potential for crop production. For example, sandy soil is characterized as "light", clay soil is considered "heavy" and is good for making bricks, while loam soil is in between sandy and clay soil. Silt is rock and mineral particles that are larger than clay but smaller than sand, and are carried by water, ice, and wind, and can lie beneath water. Alluvial soils are those developed from alluvial (river water) deposits.<sup>11</sup> Residual soil is formed by the erosion of rock. If the respondent cannot identify the soil type, enumerator could write down the local term.

**Question 19.** What is the soil quality of this plot?

Soil quality refers to how fertile the soil is. Fertile soils where large harvests can be sustained are considered good soil. However, for soils which are bad, it is difficult to make large harvests. Soils ranked between good and bad soils are average soils. Refer to the 2015 rainy season (the last completed rainy season).

**Question 20.** How did you know the quality of the soil?

Collect information on the means by which he or she was able to check the fertility or quality of the soil. Usually, assessment of the soil quality will be based on one's "own experience", unless soil from the farmer's land has been tested by an extension agent.

However, if the farmer mentions that he or she has done any kind of scientific test on the soil, even if it is a test of soil characteristics (such as acidity), respond 1: "Scientifically tested".

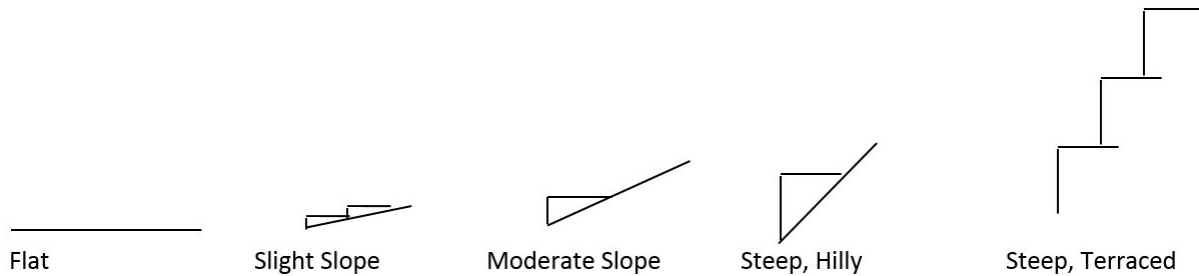
**Question 21.** How steep is the slope of this plot?

Plots are considered flat if water does not easily drain from it, whereas for steep and hilly plots, crop cultivation may be a bit difficult due to the slope. If the plot is a terraced plot, indicate this here. See **Annex 1** for an image of a terraced plot, and **Question 32** in this section for a description/definition.

Note that the options given here are somewhat subjective, "slight slope" and "moderate slope" in particular. It is not necessary to measure slopes to answer this question; record the answer that the respondent gives, to the best of his or her judgement.

<sup>11</sup> <http://www.fao.org/soils-portal/soil-survey/soil-classification/fao-legend/key-to-the-fao-soil-units/en/>

Illustration:



**Question 22.** What was the most recent year in which the plot was left fallow?

To improve the quality of the soil, farmers would leave the land empty or “fallow” after harvest. This question asks for the most recent year when the farmer left the plot to fallow. Write the year in 4 digits (e.g. “2015”). If the plot has never been left fallow, code “0”; if the respondent does not know, code “DK”; in both cases the skip codes indicated on the questionnaire should be followed.

Note: Plot is defined as fallow if land is empty for two or more consecutive cropping seasons.

**Question 23.** For how many consecutive years was this plot left fallow the last time?

Record the number of the consecutive years for which the plot was left fallow.

**Example:** Suppose a plot was planted in 2011 and was left fallow for 2 years, say from 2012 to 2014, and then planted again in 2015, the response to **Question 22** is “2014”, and “2” to **Question 23**.

**Question 24.** How was this plot used during the 2015 rainy season?

This question is asked to determine how the plot was used during the 2015 rainy season, say, the plot could have been used to cultivate crops, rented out, given out for free, etc. Use the codes listed in the questionnaire, carefully following the appropriate skip patterns. In other words, **continue with the next set of questions only if the plot has been cultivated** (note that this includes cases where the plot has been identified as a “demo farm”).

If “Option 2 - Rented Out” is selected, cross reference with **Question 9** to make sure these responses match.

Definition:

- **CULTIVATED BY HOUSEHOLD:** Land used by the household to grow crops.
- **RENTED OUT:** A plot is “rented out” if the household has usage rights to the plot, and is collecting rent from someone else so that person can cultivate or otherwise use the plot.
- **GIVEN OUT FOR FREE:** If the respondent’s household permits a person or persons outside the household to use the plot for free, and does not receive crops or any other payments (in cash or in kind) from the person who cultivated it.
- **PASTURE:** Land used for grazing animals.
- **FALLOW:** Arable land that can be used for cultivation, but is purposely left uncultivated to rest the soil and reintroduce nutrients; sometimes part of a crop rotation system.
- **FOREST OR WOODLOT:** Land that has significant tree cover.
- **WATER SURFACE:** Land that is under water (this includes fish ponds).

- **RESIDENTIAL LAND:** Land on which a housing structure is built or erected, which is used primarily as the living place.
- **SLASH AND BURN LAND:** Land that has been cleared of trees and/or other vegetation by cutting and burning this plant growth. Select this option if the plot has been slashed and burned, but is not cultivated.

**Question 25.** What crops were planted on this plot in the 2015 rainy season?

Enter up to three of the most prevalent crops planted on the plot in the 2015 rainy season, using the Crop Names and Crop Codes from the list at the end of the questionnaire.

**THESE QUESTIONS SHOULD BE ASKED OF ALL RESPONDENTS, REGARDLESS OF THE OWNERSHIP STATUS OF THE PLOT.**

**Question 26.** Who decided what to plant on this plot during the 2015 rainy season?

Ask the respondent who made the decision in terms of what crop(s) were planted during the 2015 rainy season. List up to three ID codes from the Household Roster. If any non-household members were involved in the decision, code as “yes”. If the respondent does not know, code “DK”.

**Example:** If the household head and spouse made the decision together on what to plant, write both their ID numbers from the Household Roster. If the household negotiated with a large agricultural buyer to grow a specific kind of rice to be purchased by the buyer after the harvest, then you should enter “yes” (1) in the “NON HH MEMBER” field.

**Question 27.** Who made decisions about input use on this plot during the 2015 rainy season?

Ask the respondent who decided on the use of inputs such as seeds, fertilizers, pesticides, etc. Examples of decisions are those made in relation to the kind and amount of inputs used, the method by which the inputs are to be applied to the plots, etc. List up to three ID codes from the Household Roster. If any non-household members were involved in the decision, code as “yes”. If the respondent does not know, code “DK”.

**Example:** If the household head decided on the kind of input to use and his spouse decided on the amount of input to be used on each plot, then both their Household Roster ID numbers should be recorded.

**Question 28.** ENUMERATOR: WAS RICE CULTIVATED ON THIS PLOT IN 2015 RAINY SEASON?

**Do not ask the respondent this question, this question is for the enumerator.** The questions following this one are to be asked only for plots on which rice was cultivated in the 2015 rainy season. Refer to **Section C, Question 4** to answer this question if you are not sure; make sure that these responses are compatible.

If the response is “no”, code “2”. If the response is “don’t know”, code “DK”. In both cases, do not ask the respondent any more questions about the plot, and begin asking questions about the next plot in the list (begin with **Question 1**).

**THE FOLLOWING QUESTIONS ARE ONLY FOR PLOTS ON WHICH RICE WAS GROWN IN THE 2015 RAINY SEASON** (“yes” answers to **Question 28**)

**PLOT CONDITIONS AND MANAGEMENT: RICE**

**Question 29.** Were there any problems with erosion on this plot during the 2015 rainy season?

Ask for information related to soil erosion. Erosion refers to the loss of topsoil due to rain, wind, animals, or people. If all or some of the plot suffered from soil erosion during the 2015 rainy season, record “yes”. Follow the appropriate skip codes if the response is “no”.

**Question 30.** What was the cause of these erosion problems?

Record the response using the codes listed in the questionnaire. Note that the response “cultivation that does not comply with soil conservation” is only applicable if the household grows crops on the plot using methods that cause erosion.

Definition:

- **TERRAIN:** Erosion resulting from the topography of the land: this determines the velocity at which surface runoff will flow, which in turn determines the erosive power of the runoff. Longer, steeper slopes (especially those without adequate vegetative cover) are more susceptible to very high rates of erosion during heavy rains than shorter, less steep slopes. Steeper terrain is also more prone to mudslides, landslides, and other forms of gravitational erosion processes.
- **FLOODING:** Erosion caused by topsoil being washed away by more water than the soil is capable of absorbing.
- **WIND:** Erosion caused by topsoil becoming dry enough to be blown away by the wind.
- **ANIMALS:** Erosion caused either by overgrazing by animals, or by animals digging burrows and holes.
- **CULTIVATION THAT DOES NOT COMPLY WITH SOIL CONSERVATION:** Use this option if the method of cultivation itself causes the soil to erode.

**Question 31.** Was there any erosion control or water harvesting facility on this plot in the 2015 rainy season?

Ask the respondent if any erosion control or water harvesting facility was used on the plot during the 2015 rainy season. **Question 32** provides a list of the possible methods used. To better explain to the respondent what you mean by “erosion control or water harvesting facility,” read the methods listed in the next question. Follow the skip codes if the respondent’s answer is “no”.

**Question 32.** What type of erosion control or water harvesting facility was used on this plot?

List up to two methods used in order of importance. Description for each method is listed below. Photos are also available in **Annex 1**.

- **TERRACES:** These are similar to carving the side of a sloped plot creating stair-like steps providing flat growing areas, preventing water runoff.
  - If “terraces” is selected, make sure this response matches what was entered for **Question 21**.
- **EROSION CONTROL BUNDS:** Bunds are built up by farmers, usually made out of stone or soil, to prevent runoff on steep slopes.
- **GABIONS/SANDBAGS:** Gabions are structures, usually made of metal mesh, that are filled with earth



and/or stone to build walls on slopes. Sandbags can similarly be used to prevent water or soil from running off the land.

- **VETIVER GRASS:** Vetiver grass may be established as a permanent vegetative barrier in the bed of the gully to slow down runoff. They also trap sediment and organic matter, which enhances regeneration of vegetation and terrace formation within the gully.
- **TREE BELTS:** Tree belts are lines of trees planted to either break the wind or to stabilize erosion prone areas.
- **WATER HARVEST BUNDS:** Water harvest bunds are built out of earth or stone to channel water into collection areas.
- **DRAINAGE DITCHES:** Drainage ditches are ditches built to collect runoff water. They are very commonly found on roadsides.
- **DAM:** A dam stops or slows the course of a river or stream to allow water to collect into a pond.

**Question 33.** Was this plot in the upland or lowland (rain-fed or irrigated) area?

The third option (LOWLAND – IRRIGATED) applies to areas irrigated by either mechanized or manual irrigation. For upland or rain-fed areas, code “1” or “2”, respectively, and skip to **Question 36**.

Additional definitions are:

**IRRIGATED:** Area with irrigation facilities supplying water through artificial means like gravity, force/power, pump, etc. Irrigated area become rainfed only, when the irrigation system is no longer operational for the past two (2) years and beyond repair and there is no plan of irrigating the farm.

**RAINFED:** The area holds standing water but solely dependent on rainfall for its water supply. It may have dikes that retain rainwater.

**UPLAND:** Farm land which has no amenities to hold for standing water. It is usually located along elevated lands, along rivers, between hills, hillsides, etc. Though crops planted in this type of ecosystem are drought-resistant and do not require standing water for their normal growth, irrigation by flushing is sometimes practiced to improve the crops' performance especially during the long dry spell.

**Question 34.** What was the type of irrigation facility?

Collect information on the type of irrigation used on the plot. Record the corresponding code in the questionnaire. List one method; if more than one, record the predominantly used method. Description of the methods are listed below. Photos are also available in **Annex 2**.

**NATIONAL IRRIGATION SYSTEM (NIS):** An irrigation system with service area of 1,000 hectares and above which is constructed and operated by the National Irrigation Administration (NIA).

**COMMUNAL IRRIGATION SYSTEM (CIS):** *An irrigation system with a service area of less than 1,000 hectares constructed by NIA but turned over to the Irrigators Associations for operation and maintenance. The chargeable cost is to be amortized by the Irrigators Associations for a period not to exceed 50 years.*

**TUBE WELL:** A circular well consisting of tubes or pipes bored into the ground to tap groundwater supplies of one or more aquifer.

**DUG WELL:** *An artificial pit or hole that derives groundwater from the interstices of the rocks or soil which it penetrates.* The opening is large enough to allow a man to enter it and to descend in it to the water level. For our purposes, “dug well” includes both shallow and deep dug wells.

**SURFACE/RAM PUMP:** *A device for forcing running water to a higher level by using kinetic energy of flow.*

**SMALL FARM RESERVOIR (SFR):** *A water impounding structure with a maximum height of embankment of 4 meters and average pond area of 1,500 square meters.* It serves limited areas no more than 2 hectares and is designed to become an integral part of individual rainfed farms with catchment area not exceeding 10 hectares.

**SHALLOW WELL IMPOUNDING PROJECT (SWIP):** An earth dam structure built across a narrow depression or valley to store rainfall and run-off for multiple uses. It has a maximum height of 30 meters. The average service area of SWIP is about 60 hectares (25-150 hectares).

**SMALL DIVERSION DAM (SDD):** *A concrete or rockfill structure constructed across a channel of streams, creeks and small rivers of continuous and dependable flow to raise the water level.* It allows diversion of water by gravity from the source to the adjoining farmlands.

**OTHERS:** *Include irrigation facilities not in the list mentioned.* If “Other” is selected, specify the irrigation facility falling under this category.

**Question 35.** What was the source of water for irrigation?

Ask for information regarding the source of water for irrigation. Record the response using the appropriate code as listed in the questionnaire.

Definition:

- **WELL:** A pit or hole sunk into the earth to reach a supply of water.
- **BOREHOLE:** A deep, narrow hole made in the ground, especially to locate water (or oil). Usually deeper and narrower than a well.
- **LAKE OR POND:** A body of standing water, usually fed from a spring beneath it. Ponds are generally smaller than lakes, but the terms are somewhat interchangeable.
- **RIVER OR STREAM:** Naturally occurring flowing water. Streams are small, while rivers are large enough to be navigable by boats.
- **DAMMED RIVER OR STREAM:** A river or stream that is part of a dam system. If this is the case, be sure to select this option and not “river or stream”.

If “Other”, specify the water source.

## ORGANIC FERTILIZER: RICE

**Questions 36-41** ask for information on the use of organic fertilizer on rice plots. Fertilizers made from animal or plant waste products are called organic fertilizers. Ask these questions only once for each plot. However, in some cases, more than one crop may be planted on a single plot. In such cases, ask for the TOTAL amount for all crops on the plot. (Apply the same rule for questions related to inorganic fertilizers, pesticides, herbicides, etc.)

**Question 36.** Did you use any ORGANIC FERTILIZER on [PLOT] during the 2015 rainy season?

Ask the respondent regarding the use of organic fertilizer on the plot during the 2015 rainy season. Record “yes” if fertilizer was applied to ANY crop on this plot. The “yes” response applies even if organic fertilizer was not applied to all crops on the plot. If “yes”, code “1”; if “no”, code “2”, then skip to **Question 42**.

**Question 37.** What is the type of ORGANIC fertilizer you used on this plot?

This question asks for information on the type of organic fertilizer used. Use the codes provided in the questionnaire, listing up to 3 types of organic fertilizer used.

Definition:

- **ANIMAL MANURE:** Animal waste products (feces).
- **COMPOST:** Decomposed organic matter, usually from plants.
- **GREEN MANURE:** Growing plants or plant parts (not decomposed) that are plowed back into the soil.
- **MICROBIAL FERTILIZER:** Microbial inoculants made up of living micro-organisms such as bacteria, algae, or fungi (or combinations thereof) which improve crop productivity.

**Question 38.** What was the quantity of ORGANIC fertilizer used?

Collect information regarding the amount of organic fertilizer applied, both for solid and/or liquid organic fertilizers. Write weight/volume in local or non-standard units, and convert to kilograms/liters as necessary.

**Question 39.** Was any of this ORGANIC fertilizer purchased?

There may be many cases where farmers will respond that they use organic fertilizer made from animal wastes on their farms. Or that the fertilizer they used were animal manure received from neighboring farms free of charge. This question asks if any organic fertilizer used by the farmer were purchased from a person or commercial provider. If the answer is “no”, code “2”, then skip to **Question 42**.

**Question 40.** What quantity of the total ORGANIC fertilizer applied was purchased?

Ask for information regarding the quantity of organic fertilizer purchased, both for solid and/or liquid organic fertilizers. Write weight/volume in local or non-standard units, and convert to kilograms/liters as necessary.

**Question 41.** Of the total ORGANIC fertilizer applied, what was the total value purchased?

The question asks for information related to the amount spent on the organic fertilizer purchased. Record the value in peso. In cases where a portion of the payment for the organic fertilizer was in-kind, ask the respondent to estimate the value of the payment made in-kind. Likewise, record the value in peso.

### **INORGANIC FERTILIZER: RICE**

**Questions 42-45** are related to the use of inorganic fertilizers such as urea, diammonium phosphate (DAP), etc. on rice plots. They ask for the **THREE** most predominantly used types of inorganic fertilizers; following questions (such as form, quantity) are for each type of inorganic fertilizers, while question on value purchased is for **ALL** types of inorganic fertilizer **IN AGGREGATE**. If inorganic fertilizer reported is in solid form, indicate quantity in kilograms; if in liquid form, indicate amount in liters.

**Question 42.** Did you use any **INORGANIC FERTILIZER** on [PLOT] during the 2015 rainy season?

Ask the respondent if **ANY** inorganic fertilizer was used on the [PLOT] during the 2015 rainy season. If “yes”, code “1”; if “no”, code “2”, then skip to **Question 46**.

**Question 43.** Which **INORGANIC FERTILIZER(S)** did you use in the **LARGEST QUANTITIES** on this plot? Collect information on the type of inorganic fertilizer(s) that the respondent used. Record the responses based on the codes listed in the questionnaire. Code “1” for liquid fertilizers and “2” for solid fertilizers. List up to three predominantly used types, and their quantities. Be sure to list the types used in the largest quantities (not the most expensive ones). Please note that “Complete” is equivalent to NPK 12-12-12, 14-14-14, 15-15-15.

**Question 44.** Of the total **INORGANIC** fertilizer applied, what was the total value purchased?

Ask the respondent for the total (aggregate) value of the inorganic fertilizers purchased. In cases where the respondent used a voucher, **ONLY** the actual amount spent by the respondent should be recorded, and not the total value of fertilizer received.

**Question 45.** Why did you choose to use these specific types of **INORGANIC FERTILIZER**?

On this question, ask the respondent to provide the reason why they chose to use these inorganic fertilizers.

**ADVICE BY AGRICULTURAL OFFICER:** The respondent chose to use this fertilizer after consulting a professional. Advice may have been provided by an NGO outreach program, an agricultural extension agent, or other similar program.

**RECEIVED VOUCHER:** The respondent decided to use this fertilizer so that he or she can use a voucher he or she received for purchases of that type.

**OWN EXPERIENCE:** The respondent chose to use this fertilizer based on his or her normal farm practices.

**NEIGHBOR ADVICE:** The respondent chose to use this fertilizer after receiving advice from neighbors, friends, or other farmers in the community.

**OTHER:** Specify by writing a short description for the reason of the farmer why s/he chose to use the fertilizer.

### **PESTICIDES: RICE**

**Questions 46-49** concern the use of pesticides on rice plots. Pesticides are any substance, product, or mixture intended to control, prevent, repel, or mitigate the destructive impact of a pest or insect. For the purposes of this questionnaire, pesticides will be defined to include the following:

- Insecticide: refers to chemicals used to control insects
- Herbicide: refers to chemicals used to control weeds
- Fungicide: refers to chemicals used to control fungi
- Rodenticide: refers to chemicals used to control rodents
- Molluscicide: refers to chemicals used to control snails
- Nematocide: refers to chemicals used to control worms
- Others, specify – include those not previously classified

**Question 46.** Did you use any PESTICIDES on [PLOT] during the 2015 rainy season?

This question asks the respondent if any of these products were used on (PLOT) during the 2015 rainy season. If “yes”, code “1”; if “no”, code “2”, then skip to **Question 50a**.

**Question 47.** What quantity did you use?

Collect information related to the total amount of the main type of pesticide applied. The main type is the product used in the GREATEST QUANTITY (not the most expensive). In cases where the product was applied more than once, the TOTAL amount for the MAIN TYPE of product applied should be recorded. Use the codes provided in the questionnaire to record the correct amount and unit. Record information for pesticides used in both solid and liquid forms.

**Question 48.** Of the total MAIN TYPE of PESTICIDE used, what was the total value purchased?

Request for information on the total value of the pesticide purchased. In cases where the purchase made of any of these products was MORE than was used, record ONLY the cost for the amount used. (For example, if a farmer purchased 50 kg of pesticide for PHP100,000, but only used 10 kg this season, record 10 kg used in **Question 47**, and record the cost of PHP20,000 in **Question 48**.)

**Question 49.** Why did you choose to use this specific type of PESTICIDE?

In this question, the respondent shall provide the reason why they chose to use this pesticide. Indicate as many responses as apply. Codes and definitions are the same as in **Question 45**.

### **HOUSEHOLD LABOR: RICE**

This section records each individual household member's labor on the household's rice plots during the 2015 rainy season, for up to **SIX** household members.

The section asks about five different types of activities; definitions<sup>12</sup> are below:

#### **1. LAND PREPARATION**

- a. A series of tasks that ensure that the rice field is ready for planting. A well-prepared field controls weeds, recycles plant nutrients, provides a soft soil mass for transplanting, and a suitable soil surface for direct seeding. These tasks usually include:
  - i) Plowing to “till” or dig up, mix, and overturn the soil.
  - ii) Harrowing to break the soil clods into smaller mass and incorporate plant residue.
  - iii) Leveling the field.

<sup>12</sup> www.knowledgebank.irri.org



**2. PLANTING**

Actual planting of the rice. This can be done either by direct-seeding (sowing seeds directly in the field), or transplanting (first raising seedlings in seedbeds, then planting them in the field).

**3. WEEDING**

Removal of weeds from the field. This can be done either by a nonselective herbicide (an herbicide that will kill all plants, not just weeds), by light cultivation, or by manual and/or mechanical weeding.

- a. Note that plowing, harrowing, and shallow tillage (tilling the soil at a depth of 1-3 centimeters) done in the land preparation stage, also removes weeds before planting has been done. This activity is included under “land preparation”; do not include this under “weeding”.

**4. RIDGING, FERTILIZING, and OTHER NONHARVEST ACTIVITIES**

These include all other activities before the harvest, such as application of fertilizer, application of pesticides (other than herbicides used for weeding), and water management tasks (such as field flooding).

**5. HARVESTING**

Harvesting is the process of collecting the mature rice crop from the field. Paddy harvesting activities include reaping, stacking, handling, threshing, cleaning, and hauling. These can be done individually, or simultaneously by use of a combine harvester.

For each member of the household who took part in any of the activities, write in the appropriate column their ID code from the Household Roster. Record the amount of time (in days) they spent working on the given activity for each household plot listed. Include time supervising other people doing these activities.

**The minimum number of days you can enter is one day; even if the person worked fewer than 8 hours on that activity, enter “one day” as the minimum.**

**Question 50a.** During the 2015 rainy season, how many days did members of your household spend on [LAND PREPARATION] on this plot?

**Question 50b.** During the 2015 rainy season, how many days did members of your household spend on [PLANTING] on this plot?

Include time spent moving seedlings (e.g. transplanting and direct seeding).

**Question 50c.** During the 2015 rainy season, how many days did members of your household spend on [WEEDING] on this plot?

**Question 50d.** During the 2015 rainy season, how many days did members of your household spend on [ALL OTHER NONHARVEST ACTIVITIES: RIDGING, FERTILIZING, PESTICIDE APPLICATION, ETC] on this plot?

Do **not** include time spent going to the field each day to check the crop.

**Question 50e.** During the 2015 rainy season, how many days did members of your household spend on [HARVEST and POST-HARVEST ACTIVITIES] on this plot?

**HIRED LABOR: RICE**

This section records information about individuals hired to work on the household's rice plots during the 2015 rainy season. This section asks about **LABOR ONLY AND LABOR OF MAN+ANIMAL, NOT WORKERS HIRED TO OPERATE RENTED OR LEASED MACHINERY. Questions on Machinery/Mechanization will be tackled in Section E.**

It asks about the labor of each category of workers (women, men, and children) IN AGGREGATE. **You should therefore enter the total number of people in each category who worked, the total number of days for which they were paid for work, and the total amount paid to those people.**

**If workers were instead paid by area, INDICATE THIS and enter the information given.**

Please note that CHILDREN refer to those aged 15 years old and below.

For detailed description, refer to "Calculating Days Worked for Hired Labor in Section D" on the General Instructions.

The section asks about five different types of activities related to rice farming:

- a. land preparation;
- b. planting;
- c. weeding;
- d. ridging, fertilizing, and other nonharvest activities; and
- e. harvesting and post-harvesting.

**Question 51.** Did you DIRECTLY hire any labor to work on this plot in the 2015 rainy season?

Code "1" for "yes" and code "2" for "no", then skip to **Question 53**. If the respondent INDIRECTLY hired labor (in other words, if someone was hired to subcontract out the labor), code as "2" and follow the skip.

**Question 52a.** During the rainy season 2015, how many days did your household hire labor for [LAND PREPARATION] on this plot, and at what wage?

Enter the wage and days for women, men, and children as per the instructions given above.

**Question 52b.** During the rainy season 2015, how many days did your household hire labor for [PLANTING, including DIRECT-SEEDING and TRANSPLANTING] on this plot, and at what wage?

Enter the wage and days for women, men, and children. Include any labor hired to move seedlings, and do transplanting.

**Question 52c.** During the rainy season 2015, how many days did your household hire labor for [WEEDING] on this plot, and at what wage?

Enter the wage and days for women, men, and children.

**Question 52d.** During the rainy season 2015, how many days did your household hire labor for [RIDGING, FERTILIZING, AND OTHER NONHARVEST ACTIVITIES] on this plot, and at what wage?

Enter the wage and days for women, men, and children.

**Question 52e.** During the rainy season 2015, how many days did your household hire labor for [HARVEST and POST-HARVEST ACTIVITIES] on this plot, and at what wage?

Enter the wage and days for women, men, and children.

**Question 53.** Did you hire someone to contract out any labor on this plot in the 2015 rainy season?

If the farmer paid one person a lump sum to hire labors to accomplish work on this plot (subcontracting), indicate this here. Code “1” for “yes” and code “2” for “no”, then skip to the next plot.

**Question 54.** What did you hire this contractor to do?

List ALL the tasks that the contractor was expected to accomplish in exchange for this lump-sum payment. Note that Option 6 is “All of the above”. If “Other” (Option 7) is selected, indicate what work was done that is not otherwise specified by the other options.

**Question 55.** Over what length of time was the work to be completed, if the contract stipulated a specific timeframe?

Record the period of time (e.g. actual number of days) in which the contractor was required to complete the work, according to the contracting agreement. If no period of time was specified, code as “N/A”.

**Question 56.** What was the area of land on which the work was to be completed, according to the contract?

Record area of farmland over which the contractor was required to complete the work, according to the contracting agreement. If no area was specified, code as “N/A”.

**Question 57.** What was the total amount paid to the contractor to achieve this work?

List the total amount of the entire contract (lump sum paid to the contractor) to do this work, in PHP.

## Section E: Crop Details

In Section D, each line on the questionnaire referred to a single plot. However, in Section E, each line will refer to a specific CROP on a particular plot. Section E also asks only about plots on which rice was grown during the 2015 rainy season.

Consider a household that grows several crops on the same plot. Each crop should be listed **SEPARATELY**. To illustrate, if Aklan Rice and paayap are grown on the same plot, information for each crop will be entered on separate lines in Section E.

Similarly, if the household cultivates the same crop on separate plots (say, Aklan Rice on two plots) information should also be recorded on different lines.

FOR ALL PLOTS ON WHICH RICE WAS CULTIVATED IN THE 2015 RAINY SEASON, YOU SHOULD ENTER INFORMATION FOR THE FIRST FOUR FIELDS:

1. RECALL PLOT ID
2. PLOT NAME
3. CROP NAME
4. CROP CODE (from CROP/SEED CODES list)

ENTER THE DATA FOR ALL PLOTS AND CROPS ON EACH PAGE, *BEFORE* MOVING ON TO THE QUESTIONS.

**Question 1.** Was [CROP] planted in the entire area of the plot?

Ask the respondent if the crop was planted on the whole plot, or if only a part of the plot was planted with the specific crop.

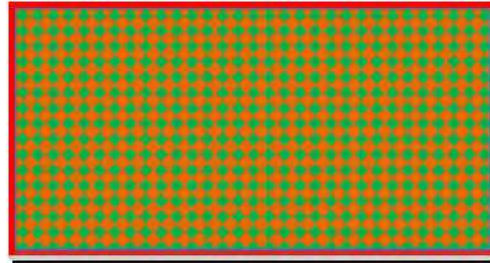
Consider the example below wherein in Plot 1, Aklan Rice and paayap are planted on separate halves of the plot and not on the entire plot. In this case, code “2” for “no” and move on to the next question. Remember that you will fill out one row for Aklan Rice, and one for paayap; both will have the same plot ID and plot name.

In Plot 2, both Aklan Rice and paayap are intercropped: Two (or more) crops are grown simultaneously in alternating rows, or sets of rows, over the entire area of one plot.<sup>13</sup> In this case, code “1” for “yes” and skip to **Question 5**. Remember that if a plot is intercropped, each crop does not have to be planted in equal proportion (for example, a farmer could plant 80% rice and 20% paayap; this is still intercropping if the rows alternate).

13 <http://www.knowledgebank.irri.org/images/docs/acronyms-and-glossary-of-rice-related-terminology.pdf>

**EXAMPLE:**

Plot 1: Half Aklan Rice and Half Paayap



Plot 2: Intercropped Aklan Rice and Paayap

**Question 2.** Approximately, what proportion or percentage of the plot was planted with [CROP]?

Ask the respondent to estimate the percentage of the plot planted with a specific crop. Consider Plot 1 above, where Aklan Rice would be planted on one half of the plot and paayap planted on the other half, so “50%” would be entered for each:

RECALL PLOT ID	PLOT NAME	CROP NAME	CROP CODE	1.	2.
				Was [CROP] planted in the entire area of the plot?  YES...1 >> 5 NO...2	Approximately, how much of the plot was planted with [CROP]?
				PERCENTAGE	
RR02	Mrs. Durante's Aklan Plot	Aklan Rice	5	2	50%
RR02	Mrs. Durante 's Aklan Plot	Paayap	1614	2	50%

**Question 3.** Why didn't you plant the entire plot with [CROP]?

Households may have several reasons why they did not plant the entire plot with a particular crop. Considering the example above, since the plot was divided into Aklan Rice and paayap sections, the reason would be coded as “1”, “was divided”. Limitations in terms of money or equipment for farming, or even natural disasters could also be cited as reasons. Consider the respondent's answer and choose the most appropriate reason. Record the response following the codes on the questionnaire. Follow the skip codes as necessary.

## Definition:

- **INTERCROPPED:** Intercropping is described in detail in **Section E, Question 1**.
- **DROUGHT:** Below-average rainfall severe enough to cause damage to crops.
- **LACK OF TOOLS OR EQUIPMENT:** Select this option if the household did not plant the entire crop because they did not have adequate tools or machinery to plant the entire area.
- **LACK OF SEEDS:** Select this option if the household did not plant the entire crop because they did not have enough seeds to plant the entire area.
- **FLOODS:** Above-average rainfall, often occurring very quickly, that is beyond the capability of the soil to absorb the water. Also, some flooding is required to grow rice, select “flooding” if the excess water is enough to damage the crops.
- **LACK OF FINANCING:** Select this option if the main reason the household did not plant the entire area of the plot was because of financial constraints. Financial constraints may cause the household not to have adequate equipment or seeds. If this is the case, select these options above. If there is a different financial constraint, select “lack of financing.”



- **PASTURE:** Select this option if part of the plot was not planted because it was being used to graze animals.
- **FALLOW:** Select this option if part of the plot was not planted because it was left fallow for the cropping season.
- **FOREST OR WOODLOT:** Select this option if part of the plot was not planted because it had some tree cover. However, remember our definition of a plot, and if necessary, re-evaluate what you are calling a plot if there is substantial tree cover.
- **WATER SURFACE:** Select this option if part of the plot was not planted because it was under a natural or artificially made body of water. However, remember our definition of a plot, and if necessary, re-evaluate what you are calling a plot if a substantial and continuous portion of the plot is underwater.
- **RESIDENTIAL LAND:** Select this option if there was a residential structure and living area on the plot (defined in **Section D, Question 24**).
- **SLASH AND BURN LAND:** Select this option if part of the plot was cleared through slash-and-burn techniques (defined in **Section D, Question 34**).

**Question 4.** Why was cultivation intercropped?

Ask the respondent their reason for intercropping. Based on the respondent's answer, choose the most appropriate reason and record the response using the codes provided in the questionnaire.

Definition:

- **SUBSTITUTE IF EITHER CROP FAILS:** Select this option if the household is planting two or more crops on one plot to hedge against the possibility of loss of one or more of the crops. If this happens, the household will still be able to harvest the surviving crop, rather than obtaining no harvest from the land.
- **IMPROVE SOIL FERTILITY:** Select this option if the reason for intercropping is because growing both crops together improves the nutrient content of the soil, and causes both crops to have a higher yield and/or superior-quality plants.

## SEEDS

**Question 5.** What was the total quantity of seeds used?

Ask the respondent for the quantity or amount of seeds used in local units or in Kilograms. Suppose the respondent provides a measure in local units, indicate how many kilograms make up each local unit. Convert this measure into kilograms before the interview is ended.

**Question 6.** What was the total amount paid for seeds?

Record the total value of the seeds purchased in peso. Suppose the respondent used a voucher to purchase the seeds, record only the amount actually paid by the respondent, and not the total value of the seeds received. If no payment was made (e.g., if the seeds were purchased on credit, or the entire seed stock was paid for using a voucher), enter "0".

**Question 7.** Did you use any seeds from the previous season?

Collect information related to the use of seeds acquired during the previous cropping season. If "no", code as "2", then skip to **Question 9**.

**Question 8.** What quantity of seeds used were from the previous season?

This question asks what percentage of seeds used, if any (a “yes” response to **Question 7**), were from the previous season. In this way, the questionnaire accounts for the possibility that some or no seeds were purchased that season.

### PRE-HARVEST LOSSES

**Question 9.** Were there any losses/damages of crops before the harvest?

Crops damaged or destroyed by disease, animals, etc., before they were actually harvested are considered pre-harvest losses. If “no”, code as “2”, then skip to **Question 17**.

**Question 10.** What were the causes of these losses/damages?

Ask the respondent to provide reasons for the pre-harvest losses. Record the response using the codes provided in the questionnaire, and list up to two main causes. BE SURE TO DISTINGUISH LOSSES DIRECTLY RESULTING FROM TYPHOON LANDO FROM OTHER TYPES OF LOSSES, even other typhoons, rains, or floods. If Typhoon Lando was responsible for at least some of the losses, continue to **Question 11**. If not, skip to **Question 14**.

Definition:

- **DROUGHT:** Below-average rainfall severe enough to cause damage to crops.
- **FLOODS:** Above-average rainfall, often occurring very quickly, that is beyond the capability of the soil to absorb the water, and causes damage to crops.
- **FIRE:** Select this option if the crop was destroyed by fire.
- **PESTS:** Select this option if the crop was destroyed by any kind of pests. These include insects, birds, rodents, and snails.
- **CROP THEFT:** Select this option if a portion of the crop was stolen from the field before the harvest.
- **DISEASES:** Select this option if plant diseases destroyed the crop before it could be harvested.
- **COMMUNITY PROBLEM:** Select this option if a community dispute or some level of social unrest prevented proper cultivation of the land, and caused crop loss.
- **LACK OF HIRED LABOR:** Select this option if there was inadequate hired labor to supplement household labor in the performing of preharvest cultivation tasks, and this neglected caused crop loss.

**Question 11.** What proportion/percentage of [CROP] was lost due to Typhoon Lando?

Ask the respondent what percentage of the crop was lost due to Typhoon Lando.

**Question 12.** Did you replant any of the crops lost on this plot due to Typhoon Lando?

Ask the respondent if they tried to make up for the loss due to Typhoon Lando by replanting a portion of the plot. This is important information, because later questions ask about the area harvested once the crop is ripe. Farmers may have also replanted more than once. For example, it will not make logical sense to record a pre-harvest crop loss, and also that 100% of the plot area harvested, unless there was some intervention (i.e., replanting a portion of the lost crop). If the answer is “no”, code as “2”, then skip to **Question 14**.

**Question 13.** What proportion/percentage of the total plot area did you replant because of losses related to Typhoon Lando?

This question asks, if a percentage of the plot was replanted because of losses related to Typhoon Lando, how much was replanted. This is not necessarily equal to the amount in **Question 11** (the amount lost), but it cannot be more than the amount given in **Question 11**.

**Question 14.** What proportion/percentage of [CROP] was lost for reasons OTHER THAN Typhoon Lando?

Ask the respondent what percentage of the crop was lost due to any other reason than Typhoon Lando.

**Question 15.** Did you replant any of the crops lost (for reasons OTHER THAN Typhoon Lando) on this plot?

Ask the respondent if they tried to make up for losses by replanting a portion of the plot. This is important information, because later questions ask about the area harvested once the crop is ripe. Farmers may have also replanted more than once. For example, it will not make logical sense to record a pre-harvest crop loss, and also that 100% of the plot area harvested, unless there was some intervention (i.e., replanting a portion of the lost crop). If the answer is “no”, code as “2”, then skip to **Question 17**.

**Question 16.** What proportion/percentage of the total plot area did you replant because of losses OTHER THAN those resulting from Typhoon Lando?

This question asks, if a percentage of the plot was replanted due to loss for any reason other than Typhoon Lando, how much was replanted. This is not necessarily equal to the amount in **Question 14** (the amount lost), but it cannot be greater than the amount given in **Question 14**.

## HARVEST

**Question 17.** Did you harvest any [CROP] on this plot in the 2015 rainy season?

Ask the respondent if any crop was harvested during the 2015 rainy season. If “yes”, code as “1” and skip to **Question 20**. If the entire crop was destroyed AFTER the harvest, this should still be recorded as “yes”.

**Question 18.** Why didn't you harvest any [CROP] on this plot?

If crops grown on the plot do not belong to the household and hence, cannot be harvested by the members of the household themselves, then “Not mine to harvest” would be the most appropriate response. Be sure to distinguish losses directly resulting from Typhoon Lando from other types of losses. If there are any losses due to Typhoon Lando, answer the next question (**Question 19**). If not, skip to **Question 34a**.

Definition:

- See **Question 10** for definition of **DROUGHT, RAINS AND FLOODS FIRE, PESTS, CROP THEFT, DISEASES, COMMUNITY PROBLEM, and LACK OF HIRED LABOR**.
- **NOT MINE TO HARVEST:** Select this option if the household is in some kind of sharecropping or outgrower scheme, which does not require (or prohibits) the household from harvesting the crop.
- **NOT READY FOR HARVEST IN 2015 RAINY SEASON:** Select this option if the crop was not yet ready for harvest during the period about which we are asking, i.e., the 2015 rainy season.

**Question 19.** What proportion/percentage of the total losses was due to Typhoon Lando?

If the respondent says that the household did not harvest any of the crops on this plot, and at least one of the reasons was because of losses resulting from Typhoon Lando, try to approximate the proportion of losses due to this typhoon. If Typhoon Lando destroyed the entire crop, enter 100%. **For this question, take note of an UNCONDITIONAL SKIP to Question 34a.**

**Question 20.** Of the area planted, what proportion was harvested?

Ask the proportion of the plot harvested during the 2015 rainy season. Suppose the household suffered losses, then it is likely that the area planted will be greater than the area harvested. Compare the response here to the responses to **Questions 1, 13, and 16**, to make sure they make logical sense. If the percentage given is less than 100%, go to the next question. If it is 100%, skip to **Question 23**.

**Question 21.** What was the reason it was less than the area planted?

Identify up to two reasons, as per the definitions given above, and use the codes to record the response. . If any part of the harvest was interrupted (and not completed) because of Typhoon Lando, answer the next question (**Question 22**). If not, skip to **Question 23**.

**Question 22.** What proportion of [CROP] was not harvested as a direct result of Typhoon Lando?

Suppose the area harvested was less than the area planted, and at least one of the reasons given for this in the response to **Question 21** was “Typhoon Lando,” ask the farmer to estimate how much was not harvested because of Typhoon Lando.

**Question 23. BEGIN:** When did you begin harvesting [CROP]? **END:** When did you finish harvesting [CROP]? Write the beginning and ending week, month, and year of the harvest.

**Note:** This question does NOT refer to the start and finish of the cropping SEASON (from planting to harvesting). Rather, it only pertains to when the household started to harvest the crop and when they were able to finish harvesting.

**Question 24.** What was the quantity harvested?

Ask the respondent for the quantity of the individual crop harvested on a particular plot. Take note that it is necessary that this measure be expressed in KILOGRAMS, which means all local units must be converted into kilograms before the interview is ended and before leaving the mesh. Record the quantity of the FRESH (undried) paddy.

**Question 25.** What is the estimated value of the harvested crop?

Collect information on the estimated value in peso of the harvest from the area described in **Question 16** at the time of that harvest; i.e., in the market during the harvest season. If the price changed throughout the season, estimate based on the average price. The respondent should provide an answer to this question EVEN IF HE OR SHE DID NOT SELL SOME OR ALL OF THIS CROP.

**Question 26.** Who in the household made the decisions concerning the use of the harvested crop?

Record up to two household members, using the Household Roster ID codes, who were the primary decision-makers about how to use the harvested crop.

## POST-HARVEST

**Question 27.** If rice was grown on the plot, what was the method of drying the rice?

Ask this question for rice crops only. Use the codes and options given.

Definition<sup>14</sup>:

- **SUN-DRYING:** Spreading grains under the sun, on mats and/or pavements.
- **MECHANICAL DRYING:** In this system, mechanical dryers are used to remove water from wet grains by forcing either ambient air or heated air through the grain bulk.

**Question 28.** Were there any post-harvest losses?

Post-harvest losses refer to crops lost after the harvest but before the crops can be sold. This question excludes losses before the harvest (in other words, while the crop is still in the field). If “no”, code as “2”, then skip to

**Question 31.**

**Question 29.** What was the reason for the loss?

If the respondent provides more than one reason for the loss, probe to find out the most predominant reason, i.e., that which caused the greatest loss. Record the response using the codes provided in the questionnaire. Suppose the respondent provides a reason that was not listed on the questionnaire (“OTHER”), code 10 and note down the reason in words. Be sure to distinguish losses directly resulting from Typhoon Lando from other types of losses. (However, this time, we will not ask additional questions relating to Typhoon Lando specifically, unless it was the predominant cause of loss.)

Definition:

- See **Question 10** for definitions of **DROUGHT, RAINS AND FLOODS, FIRE, PESTS, CROP THEFT,** and **DISEASES.**
- **ROTTING:** Select this option if excessively moist rice begins to decompose after harvest.
- **SPILLAGE OR WASTE FROM HARVESTING PROCESS:** Select this option if a portion of the crop was lost during the harvesting process, from being spilled or otherwise lost due to human negligence. If any losses occurred during post-harvest activities, such as drying, select this option.

**Question 30.** What proportion of the [CROP] was lost?

Enter the percentage lost.

**Question 31.** What was done with the residue from this crop?

Plant materials left on the field after harvesting the crop are called crop residue, which includes stalks, stems, seed pods, inedible leaves, etc. (e.g. dayami, ipa, tulyapis).

Ask the respondent what they did with the crop residue. List up to two options. Suppose the residue were sold (code 5), ask the succeeding questions as listed. In all other cases, skip to **Question 34a.**

<sup>14</sup> <http://www.knowledgebank.irri.org/step-by-step-production/postharvest/drying>



Definition:

- **CROP PRODUCES NO RESIDUE:** If, after harvesting, no plant material was left in the field, select this option.
- **RESIDUE WAS LEFT IN FIELD:** Select this option if the residue was left as-is in the field after the harvest.
- **COMPOST, MULCH, GREEN MANURE:**
  - **Compost:** Select this option if the crop residue was allowed to decompose and then was used as fertilizer.
  - **Mulching** is applying a material to the soil surface in order to reduce water loss, suppress weeds, modify soil temperatures, and generally improve crop productivity.<sup>15</sup>
  - **Green Manure:** Select this option if undecomposed crop residue (still-growing plants or plant parts) are plowed back into the soil to increase its fertility.
- **FOR GRAZING OWN ANIMALS:** Select this option if the household allows its own animals to graze on the residue.
- **FOR SALE:** Select this option if the household sells the crop residue.

**Question 32.** What was the quantity of residue sold?

Ask the respondent for the quantity of residue sold in kilograms. Convert local units to kilograms if necessary.

**Question 33.** What was the total value of the residue sales?

Ask the respondent for total value and record the response in peso. In cases where multiple sales were made, record the total (aggregate) amount.

## MECHANIZATION

In this sub-section, the respondent will be asked:

- a. If the household use machinery or equipment?
- b. If the equipment was not owned by the household, what was the TOTAL COST (in peso) of renting or leasing the equipment (inclusive of labor costs for operators) in the 2015 rainy season?
  - **Include IN-KIND payments**
- c. What was the rate at which the equipment was rented or leased, and operators or workers hired?

The questions will apply for the following activity or activities:

- land preparation;
- planting;
- weeding;
- all other non-harvest activities such as fertilizing, pesticide application, etc.; and
- harvest and post-harvest activities

Together, these questions comprise **Questions 34a and 34b through 38a and 38b.**

For “a” questions, if the answer is “no”, code “2”, then skip to the question for the succeeding activity.

For “b” questions, give responses in peso.

Remember that if the response to **Question 17** is “no”, there is no need to ask **Questions 38a and 38b.**

<sup>15</sup> <http://www.fao.org/docrep/007/y5259e/y5259e09.htm>

## Section F: Rice - Household Totals

In Section F, each line refers to a specific RICE CROP. However, unlike Section E, Section F asks questions for the entire rice crop in aggregate (i.e., the total grown on all plots by the household). Therefore, in this section, you are no longer recording information for each plot. There is no need to list each plot as you did in the previous sections.

FOR ALL RICE CROPS CULTIVATED IN THE 2015 RAINY SEASON, YOU SHOULD ENTER INFORMATION FOR THE FIRST TWO FIELDS:

1. CROP NAME
2. CROP CODE (from CROP/SEED CODES list)

ENTER THE DATA ON EACH PAGE FOR ALL RICE CROPS *BEFORE* MOVING ON TO THE QUESTIONS.

### SALES

**Question 1.** Did you sell any of the [RICE CROP] produced in the 2015 rainy season?

Record if the respondent sold any of the referenced rice produced during the 2015 rainy season. Code “2” if “no”, then skip to **Question 14**.

**Question 2.** Was the rice cultivated by the household on each individual plot sold together or sold separately?

If the rice cultivated on different plots was sold separately, the enumerator should ask about the rice sold on each plot on **DIFFERENT LINES OF THE QUESTIONNAIRE**. If the rice was sold all together, the enumerator should use **ONLY ONE** line to record **ALL** sales. In this case, also skip to **Question 4**.

**Question 3.** Which [PLOT] or [PLOTS] did this rice crop come from?

Enter the relevant Recall ID or IDs of all the plots from which the rice which was sold was harvested (regardless of whether it was sold separately or together).

**Question 4.** If fresh palay was sold, what was the **TOTAL** quantity sold?

Record the quantity of fresh palay sold in local units. Also indicate how many kilograms make up each local unit. Suppose the respondent provides a measure in local units, convert this into kilograms before ending the interview and leaving the mesh. Verify that the amount for each crop sold does not exceed the combined amount harvested on all relevant plots reported in **Question 24** in **Section E**.

**Question 5.** What was the price per kilogram at which [RICE CROP] was sold fresh?

Write the price in PHP per kg at which the fresh palay was sold. If any of the fresh palay was sold separately, at different prices, give the **AVERAGE** price per kilogram.

**Question 6.** If dried palay was sold, what was the **TOTAL** quantity sold?

Record the quantity of dried palay sold in local units. Also indicate how many kilograms make up each local unit. Suppose the respondent provides a measure in local units, convert this into kilograms before ending the interview and leaving the mesh. Verify that the amount for each crop sold does not exceed the combined amount harvested on all relevant plots reported in **Question 24** in **Section E**.

**Question 7.** What was the price per kilogram at which [RICE CROP] was sold dry?

Write the price in PHP per kg at which the dried palay was sold. If any of the dried palay was sold separately, at different prices, give the AVERAGE price per kilogram.

**Question 8.** If skin-dry palay was sold, what was the TOTAL quantity sold?

Indicate the quantity of skin-dry palay sold, in local units. Skin-dry palay refers to palay that is harvested only when the moisture content falls between “fresh” and “dried.” Also indicate how many kilograms make up each local unit. Suppose the respondent provides a measure in local units, convert this into kilograms before ending the interview and leaving the mesh. Verify that the amount for each crop sold does not exceed the amount harvested on all plots reported in **Question 24 in Section E**.

**Question 9.** What was the price per kilogram at which [RICE CROP] was sold skin-dry?

Write the price in PHP per kg at which the skin-dry palay was sold. If any of the skin-dry palay was sold separately, at different prices, give the AVERAGE price per kilogram.

**Question 10.** Was any portion of the quantity harvested sold under a contract growing/outgrower scheme?

If inputs (seed, fertilizer, etc.) were provided by a large farm (e.g. private company, corporation, or cooperative) to the respondent (whether provided freely or sold), and then promises to buy back the farmers crops, this is contract farming. It is also known as an outgrower scheme, and is very common for certain commercial crops. If the response is a “yes”, probe and ask if any relationship exists between the respondent and nearby large farms. If none of the rice was sold as part of an outgrower scheme, code “2”, then skip to **Question 12**.

**Question 11.** What quantity was grown under a contract growing/outgrower scheme?

Collect information on the amount sold under the contract scheme, and record the response in kilograms.

**Question 12.** Who in your household is responsible for negotiating the sale of [RICE CROP]?

Ask the respondent which members of the household were primarily responsible for the negotiations related to the sales of rice. These would refer to the household members who mainly dealt with the customers buying the rice. If the customer refers to a place, say, the local market, then the household members would have gone to the market to sell the rice. List two household members who were mainly responsible in the sales negotiations. Record using the Roster ID number listed in the Household Roster.

**Question 13.** Who in your household decided what to do with the earnings from sales of [RICE CROP]?

Ask the respondent who in the household decides with respect to the incomes from rice sales. Spending decisions of the household may sometimes be made jointly by the head and spouse (for example, HH1 and HH2; you should therefore use codes “HH1” and “HH2”), some decisions may be made only by the head (HH1) or only by the spouse (HH2), or by another member of the household. List the two household members who made the biggest decision using the Household Roster ID number listed in the Household Roster.

## STORAGE

**Question 14.** Do you have any of the harvest of [RICE CROP] from the 2015 rainy season in storage now?

This question asks if there is any rice in a storage facility, which could either be at home or at another location. Code “2” if “no”, then skip to the **NEXT ROW OR CROP**.

**Question 15.** How much of the harvest of [RICE CROP] do you still have in storage?

Record the amount rice still in storage at this time. Record this amount in kilograms. If the respondent gives the quantity in local units, convert if necessary. Note that this amount should not exceed the amount harvested as reported in **Question 24** in **Section E**.

**Question 16.** What is your main method of storage of the [RICE CROP] harvest?

Record the main type of facility or method used by the farmer to store the referenced rice crop using the codes listed in the questionnaire. In cases where more than one type of storage facility is used, ask follow up questions to determine which kind of facility is mostly used. For responses on the type of storage facility not included in the list, code "4", "OTHER" and note the type of storage facility in words.

Please note that rice is normally stored in bags/sacks. Listed below are three commonly used storage facilities:

- **HOUSE/FARM HOUSE:** Refers to the place of residence of the household or a structure near the farm used to store harvested crop, equipment, etc.
- **RICE MILL:** Refers to facilities owned by commercial rice millers.
- **RICE TRADER'S WAREHOUSE:** Refers to a place used for the storage of rice wherein the goods can be stored throughout the year and releasing them as and when they are needed.

**Question 17.** Did you do anything to protect the stored [RICE CROP]?

Ask the respondent what they did to keep the rice from rotting or pests. Code "2" if "no", then skip to **Question 19**.

**Question 18.** What did you do to protect the stored [RICE CROP]?

Record the method used by the respondent to protect the rice using the codes listed on the questionnaire. In cases where the respondent's answer is not on the list, code "9", "OTHER", and note the name of the method given by the respondent. "Pest Repellent Storage Structure" means that pest repellent is incorporated into the design of the storage structure; one example of this would be a granary on stilts, which are covered in a slippery material that prevents mice from climbing the stilts.

Definition:

- **SPRAYING:** Select this option if liquid pesticide was applied by spraying to deter or kill pests.
- **SMOKING:** Select this option if smoke was periodically applied to the stored rice to deter or kill pests.
- **SPREAD MANURE:** Select this option if manure was spread around the storage area to deter pests.
- **MOUSE TRAPS:** Select this option if mechanical ("snap") or glue traps were used to catch mice.
- **SOLID PEST REPELLANT:** Select this option if a pest repellent in solid form (such as a block or bar) was kept with the stored rice to deter or kill pests.
- **PEST REPELLANT STORAGE STRUCTURE:** (see above)
- **NETS:** Select this option if the stored rice was covered with nets to protect it from pests.
- **CATS OR OTHER ANIMALS:** Select this option if the household kept cats, or other natural predators of pests, as pets.

**Question 19.** When you store [RICE CROP], what is usually the main purpose of storing it?

Collect information on the main reason why the farmer stores the rice. Use the codes listed on the questionnaire. In cases where the respondent's answer is not on the list, code "4", "OTHER", and write the reason in words as provided by the respondent.

Definition:

- **FOOD FOR HOUSEHOLD:** Select this option if the household stored rice so that the household itself could consume it later as food.
- **TO SELL AT HIGHER PRICE:** Select this option if the household stored rice rather than selling it immediately, in anticipation of rice price increases and greater profits.
- **SEED FOR PLANTING:** Select this option if the household stored rice so that the seeds could be used the following season to start new plants.

## Section G: Extension Services

"Agricultural Extension Services" is a term that is somewhat difficult to define in a precise manner<sup>16</sup>. However, the Food and Agriculture Organization of the United Nations (FAO) provides the following guidelines<sup>17</sup>:

Extension is an informal educational process directed toward the rural population. This process offers advice and information for problem-solving. Extension also aims to increase the efficiency of the family farm, increase production, and generally increase the standard of living of the farm family.

- Extension is a process through which farmers work to improve the productivity of their agriculture, and improve their abilities to increase their livelihoods.
- Four main elements can be identified within the process of extension:
  - i) knowledge and skills,
  - ii) technical advice and information,
  - iii) farmers' organization, and
  - iv) motivation and self-confidence.

Sources of extension services can be the local or national government, an NGO (defined in Section B), a farmer's association or cooperative, a large-scale farm producer, messages on the radio or television, information obtained online, information obtained through published material, or information and advice from neighbors and/or fellow household farmers.

We will be asking about extension services related to RICE ONLY.

**Question 1.** Did you receive information or advice about agricultural activities related to rice cultivation from [SOURCE] during the 2015 rainy season?

The question refers only to advice or information received on agricultural activities related to rice cultivation. It is a yes-or-no filter question which determines whether or not you will ask additional questions about extension services from a given source. If the respondent did not receive advice from a given source, enter

<sup>16</sup> <http://www.fao.org/docrep/t0060e/T0060E03.htm>

<sup>17</sup> Ibid.



“2” and go to the next [SOURCE]. In cases where the respondent's response is not included on the list, use the “OTHER” line and write down the response as provided by the respondent.

**Question 2.** Did you receive any information or advice from [SOURCE] about...?

Ask the respondent about the different types of advice received by the household from the [SOURCE] on the following activities:

**1. AGRICULTURAL PRICES**

The pricing of agricultural commodities, including how to obtain market price information.

**2. AGRICULTURAL PRODUCTION**

The actual production of agricultural products, including land-preparation techniques, farming techniques, use of fertilizers and pesticides, harvesting, and post-harvest activities.

**3. AGRO-PROCESSING**

The subset of manufacturing that processes raw materials and intermediate products derived from the agricultural sector. Agro-processing industry thus means transforming products originating from agriculture, forestry, and fisheries<sup>18</sup> [i.e., produced by AGRICULTURAL PRODUCTION]. Note that this is distinct from AGRICULTURAL PRODUCTION.

**4. MARKETING**

How best to present goods for sale, to optimize profit.

**5. FISHING PRODUCTION**

Aquaculture, or the raising and production of fish.

**6. LIVESTOCK PRODUCTION**

The raising and production of farm animals such as cows, buffalo, pigs, chickens, etc.

**7. PREVENTION OF LIVESTOCK DISEASES**

This is separate from Livestock Production. Select this option if the extension services provided are specifically related to the prevention of disease in livestock production.

**8. RICE SUBSIDIES GIVEN BY THE GOVERNMENT**

Refers to information about rice subsidies for farmers provided by the government; for example, free rice seed distribution, fertilizer subsidies, etc.

Code “1” if “yes”, and code “2” if “no”.

To illustrate, a household may have received advice about rice prices, how to increase rice production, rice marketing, and rice subsidies from the government, and about rice processing from an NGO.

Responses should be indicated as follows:

Row 1: “Government extension” - 1s in columns A, B, D, and E

Row 2: “NGO” - 1 in column C

All the other boxes for “Government” and “NGO” should have 2s.

All other sources should have a “2” entered for **Question 1**, and no entries for any other questions:

18 <http://www.fao.org/docrep/w5800e/w5800e12.htm>

SECTION G: RICE-EXTENSION SERVICES						
SOURCE	1. Did you receive information/advice about agricultural activities related to rice cultivation from [SOURCE] during the 2015 rainy season?  YES..1 NO..2>>NEXT SOURCE	2. Did you receive any information/advice from [SOURCE] about?				
		YES.....1 NO.....2				
		A.	B.	C.	D.	E.
		RICE PRICES	RICE PRODUCTION TECHNIQUES	RICE PROCESSING	RICE MARKETING	RICE SUBSIDIES GIVEN BY THE GOVERNMENT
Government extension	1	1	1	2	1	1
NGO	1	2	2	1	2	2
Cooperative/Farmer's Association	2					

**Question 3.** Who in your household received advice from [SOURCE]?

This question asks which member of the household directly received advice from the source. Record the response using the Household Roster ID numbers. List up to four household members.

**Question 4.** How would you rate the advice received?

This question asks for the respondent's opinion regarding the quality of advice they were provided. Record the response using the codes listed in the questionnaire.

**Question 5.** Did you pay anything in order to receive the advice?

This question asks if they were required payment for the advice they were provided. Code "1" if "yes", then continue to the succeeding question. Code "2" if "no", then skip to **Question 7**.

**Question 6.** How much did you pay in total?

Record the amount, in peso, that the respondent paid for the extension advice received. Note that if the advice was received through a radio or television program, or via the internet, the respondent should not answer this question (field is grayed out).

**Question 7.** How many times did someone from [SOURCE] visit your farm during the 2015 rainy season?

Record the number of times the household's farm was visited by each [SOURCE] during the 2015 rainy season. Exclude visits made to the barangay in general, as well as information drives given for groups of people. If the source did not visit the household's farm even once, record "0". Note that, if the advice was received through a radio or television program, via the internet, or from a publication, the respondent should not answer this question (field is grayed out).

**THE INTERVIEW IS NOW OVER.**

**PLEASE THANK THE RESPONDENT AND REMEMBER TO INDICATE THE END TIME OF THE INTERVIEW.**

## **Crop Codes**

The “Crop or Seed Codes” are lists of all the possible varieties of crops and seeds, including rice, which the farmers participating in the recall questionnaire may grow on their plots. These crops are divided into the following categories:

- RICE
- CEREALS
- FRUIT VEGETABLES
- LEAFY VEGETABLES
- BEANS & LEGUMES
- ROOTS & TUBERS
- CONDIMENTS
- FRUITS
- COMMERCIAL CROPS
- NUTS
- CUTFLOWERS

## Part II: Annex

Figure A4.1: Images of Erosion Control and/or Water Harvesting Facilities



Terraces



Erosion Control Bunds



Gabions



Vertiver Grass



Water Harvest Bunds



Drainage Ditches

Figure A4.2: Images of Irrigation Methods in the Philippines



National Irrigation System (NIS)



Communal Irrigation System (CIS)



Tube well

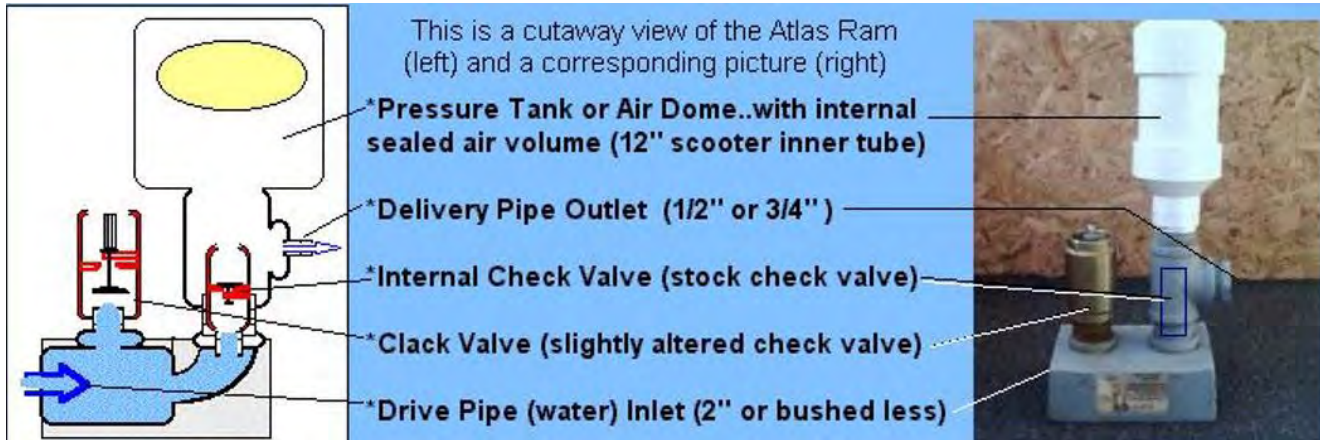


Dug well



Shallow Well Impounding Project (SWIP)





Surface/Ram Pump



Small Farm Reservoir (SFR)



Small Diversion Dam (SDD)

The images illustrate the type of erosion control and irrigation methods.  
Photo credit: Philippine Statistics Authority, 2016.



## References

- I.P. Abrol, J.S.P. Yadav, and F.I. Massoud. 1988. *FAO Soils Bulletin 39: Saline Soils and their Management*. Rome, Italy: Soil Resources, Management and Conservation Service FAO Land and Water Development Division, FAO. <http://www.fao.org/docrep/x5871e/x5871e04.htm> (accessed 13 March 2016).
- R. A. Anderson et al. 1979. *Parching Studies on Wild Rice*. Northern Regional Research Center, Federal Research, Science and Education Administration, U.S. Department of Agriculture, Peoria, IL 61604. <https://pubag.nal.usda.gov/download/25262/PDF> (accessed 2 November 2018).
- Apple Inc. 2015. *Map Plus (GIS Editor + Offline Map + GPS Recorder)*. iTunes. <https://itunes.apple.com/ph/app/map-plus-gis-editor-+-offline/id438868200?mt=8> (accessed 7 June 2016).
- . 2018. *iCloud*. <https://www.icloud.com/> (accessed 30 October 2018).
- . 2018. *Set up iCloud on all your devices*. <https://support.apple.com/en-ph/HT208681> (accessed 30 October 2018).
- . 2018. *Set up your iPhone, iPad, and iPod touch*. <https://support.apple.com/en-us/HT202033> (accessed 30 October 2018).
- Asian Development Bank (ADB). 2012. *R-PATA 8029: Improving Agricultural and Rural Statistics for Food Security. Workshop on Developing the Country Action Plans*. 2–4 May 2012. Manila, Philippines: Asian Development Bank Headquarters.
- . 2013. *Food Security in Asia and the Pacific*. <http://www.adb.org/publications/food-security-asia-and-pacific> (accessed 7 July 2016).
- . 2013. *Innovative Data Collection Methods for Agricultural and Rural Statistics: Technical Assistance Report*. Manila.
- . 2015. PowerPoint presentation developed for a training workshop in crop cutting. Mandaluyong City, Philippines: ADB.
- . 2016. Screen shot generated by ADB staff. Mandaluyong City, Philippines: ADB.
- . 2017. *Innovative Data Collection Methods for Agricultural and Rural Statistics*. Online Training Course. <http://cars.adbx.online/e-learning.html>.
- ASEAN Plus Three Food Security Information System (AFSIS). 2017. *Agricultural Land Information System (ALIS)*. <http://www.aptfssis.org/web-search?key=alis> (accessed 25 October 2018).
- O. Badi. 2013. *Rice Post-harvest Technology Training Program: Rice Quality*. Ministry of Agriculture, Animal Wealth and Natural Resources, Gezira State, Sudan; and Japan International Cooperation Agency (JICA). [http://www.jica.go.jp/project/english/sudan/001/materials/c8h0vm00007vrgs5-att/rice\\_quality\\_en.pdf](http://www.jica.go.jp/project/english/sudan/001/materials/c8h0vm00007vrgs5-att/rice_quality_en.pdf) (accessed 7 June 2016).
- . 2014. *Arthur Batut's Kite with Camera Mounted in the Middle*. Figure 6c, History of Remote Sensing, Aerial Photography. <http://www.oneonta.edu/faculty/baumanpr/geosat2/RS%20History%20I/RS-History-Part-1.htm> (accessed 29 July 2016).
- C. Brouwer et al. *Irrigation Water Management: Irrigation Methods. Training Manual No. 5. (Provisional edition)*. Rome, Italy: FAO Land and Water Development Division. <http://www.fao.org/docrep/s8684e/s8684e02.htm> (accessed 13 March 2016).
- J. B. Campbell and R. H. Wynne. 2011. *Introduction to Remote Sensing (Fifth Edition)*. New York, USA: Guilford Press.
- Chemins de MÉMOIRE. n. d. *Arthur Batut Museum in Labruguière*. <http://www.cheminsdememoire.gouv.fr/en/arthur-batut-museum-labruguiere> (accessed 29 October 2018).
- T. Chopel, K. Dukpa, and S. Tenzin. *Country Report: Bhutan. R-PATA 8029: Improving Agricultural and Rural Statistics for Food Security. Workshop on Developing the Country Action Plans*. 2–4 May 2012. Manila, Philippines: Asian Development Bank Headquarters. <https://wpqr4.adb.org/LotusQuickr/agstat-ap/Main>.

- nsf/0/441CB1C3B957C77F48257A69002F F328/\$file/BHU\_Country%20Report.pdf (accessed 11 July 2016).
- V. Dhar, DDG, and Agriculture Census Commissioner, Department of Agriculture & Cooperation, Ministry of Agriculture, Government of India. *Agriculture Census in India* (presentation, 24<sup>th</sup> APCAS, Viet Nam, 8-12 October 2012). [http://www.fao.org/fileadmin/templates/ess/ess\\_test\\_folder/Workshops\\_Events/APCAS\\_24/PPT\\_after/APCAS-12-31-Agri\\_Census\\_India\\_APCAS24.pdf](http://www.fao.org/fileadmin/templates/ess/ess_test_folder/Workshops_Events/APCAS_24/PPT_after/APCAS-12-31-Agri_Census_India_APCAS24.pdf) (accessed 8 July 2016).
- A. C. Durante et al. 2018. Improving Paddy Rice Statistics Using Area Sampling Frame Technique. *ADB Economics Working Paper Series*. No. 565. Manila: Asian Development Bank.
- Earth Observation Research Center (EORC), Japan Aerospace Exploration Agency (JAXA). 1997. *ALOS-2 Project / ALOS-2 Overview*. <http://www.eorc.jaxa.jp/ALOS-2/en/about/overview.htm> (accessed 27 July 2016).
- . 2016. *Observation by Sensor*. [http://www.eorc.jaxa.jp/en/hatoyama/experience/rm\\_kiso/mecha\\_howto\\_e.html](http://www.eorc.jaxa.jp/en/hatoyama/experience/rm_kiso/mecha_howto_e.html) (accessed 27 July 2016).
- European Space Agency (ESA). 2010. *GlobCover Portal*. [http://due.esrin.esa.int/page\\_globcover.php](http://due.esrin.esa.int/page_globcover.php) (accessed 7 June 2016).
- Fir0002. 2005. CC BY-SA 3.0. <https://commons.wikimedia.org/w/index.php?curid=313155>; <https://commons.wikimedia.org/wiki/Irrigation#/media/File:Sprinkler03.jpg> (accessed 4 October 2018).
- Fjcaldera. 2008. Own work. Public Domain. <https://commons.wikimedia.org/w/index.php?curid=5572592>; [https://commons.wikimedia.org/wiki/File:Unidad\\_5\\_Imagen\\_003.gif](https://commons.wikimedia.org/wiki/File:Unidad_5_Imagen_003.gif) (accessed 31 October 2018).
- Food and Agriculture Organization of the United Nations (FAO). 1974. *FAO Soils Portal: Key to the FAO Soil Units*. <http://www.fao.org/soils-portal/soil-survey/soil-classification/fao-legend/key-to-the-fao-soil-units/en/> (accessed 13 March 2016).
- . 1982. Statistics Division, Economic and Social Development Department. *The Estimation of Crop Areas and Yields in Agricultural Statistics. Economic and Social Development Paper No. 22*. Rome, Italy: FAO.
- . 1997. *The State of Food and Agriculture 1997. The Agro-processing Industry and Economic Development. FAO Agriculture Series No. 30*. Rome, Italy: FAO. <http://www.fao.org/docrep/w5800e/w5800e12.htm> (accessed 13 March 2016).
- . 2002. *General Status of the System of Food and Agriculture Statistics in LAO PDR. Improvement of Agricultural Statistics in Asia and Pacific Countries, GCP/RAS/171/JPN*. Bangkok, Thailand. <https://data.opendevlopmentmekong.net/dataset/dfa7456f-15c9-40e1-b769-2f83b5625a48/resource/29c4a5bb-28a6-489b-af8f-fc4dec0447c4/download/general-status-of-the-system-of-food-and-agriculture-statistics-in-lao-pdr> (accessed 8 July 2016).
- . 2002. *Land Tenure and Rural Development. FAO Land Tenure Studies 3*. Rome, Italy: Economic and Social Development Department, FAO. <http://www.fao.org/docrep/005/y4307e/y4307e05.htm> (accessed 13 March 2016).
- . 2010. *A System of Integrated Agricultural Censuses and Surveys, Volume 1 - World Programme for the Census of Agriculture 2010. FAO Statistical Development Series*. Rome, Italy. <http://www.fao.org/docrep/009/a0135e/A0135E00.htm> (accessed 11 July 2016).
- . 2012. *Country Presentation on the Lao Census of Agriculture 2010/11* (presentation, 24<sup>th</sup> APCAS, Viet Nam, 8-12 October 2012). [http://www.fao.org/fileadmin/templates/ess/ess\\_test\\_folder/Workshops\\_Events/APCAS\\_24/Paper\\_after/APCAS-12-11-\\_Lao\\_PDR\\_Census\\_01.pdf](http://www.fao.org/fileadmin/templates/ess/ess_test_folder/Workshops_Events/APCAS_24/Paper_after/APCAS-12-11-_Lao_PDR_Census_01.pdf) (accessed 8 July 2016).
- . 2016. FAOSTAT. <http://www.fao.org/faostat/en/#home> (accessed 13 March 2016).
- . 2018. FAOSTAT Database. <http://>

- www.fao.org/faostat/en/#data (accessed 8 November 2018).
- \_\_\_\_\_. n. d. *Chemical Properties of Soil*. [http://www.fao.org/fishery/static/FAO\\_Training/FAO\\_Training/General/x6706e/x6706e04.htm](http://www.fao.org/fishery/static/FAO_Training/FAO_Training/General/x6706e/x6706e04.htm) (accessed 13 March 2016).
- Food and Agriculture Organization of the United Nations (FAO) and the Ministry of Agriculture, Fisheries and Local Government of the Bahamas. 2004. *Hot pepper seed and crop production in the Bahamas Manual*. FAO project TCP/BHA/2802. Rome, Italy: FAO and the Ministry of Agriculture, Fisheries and Local Government of the Bahamas. <http://www.fao.org/docrep/007/y5259e/y5259e09.htm> (accessed 13 March 2016).
- \_\_\_\_\_. World Programme for the Census of Agriculture 2020. <http://www.fao.org/world-census-agriculture/wcarounds/wca2020/en/>.
- Global Administrative Areas. 2018. GADM database of Global Administrative Areas. <http://www.gadm.org/> (accessed 29 October 2018).
- Google Earth. 2018. *Download Google Earth Pro for PC*. <https://www.google.com/earth/download/gep/agree.html> (accessed 29 October 2018).
- \_\_\_\_\_. 2018. *Earth Pro on desktop*. <https://www.google.com/earth/desktop/> (accessed 29 October 2018).
- Group on Earth Observations Global Agricultural Monitoring (GEOGLAM). n. d. *About GEOGLAM*. <http://www.geoglam.org/index.php/en/> (accessed 15 July 2016)
- K. Guan, et al. 2018. Measuring Rice Yield from Space: The Case of Thai Binh Province, Viet Nam. *ADB Economics Working Paper Series*. No. 541. Manila: Asian Development Bank.
- International Rice Research Institute (IRRI). n. d. *Rice Knowledge Bank. Acronyms and Glossary of Rice Related Terminology*. <http://www.knowledgebank.irri.org/images/docs/acronyms-and-glossary-of-rice-related-terminology.pdf> (accessed 13 March 2016).
- \_\_\_\_\_. n. d. *Rice Knowledge Bank. Cocoon*. <http://www.knowledgebank.irri.org/step-by-step-production/postharvest/storage/grain-storage-systems/hermetic-storage-systems/cocoon> (accessed 13 March 2016).
- \_\_\_\_\_. n. d. *Rice Knowledge Bank. Drying*. <http://www.knowledgebank.irri.org/step-by-step-production/postharvest/drying> (accessed 13 March 2016).
- \_\_\_\_\_. n. d. *Rice Knowledge Bank. Field operations during fallow period*. <http://www.knowledgebank.irri.org/step-by-step-production/pre-planting/land-preparation/field-operations-during-fallow-period> (accessed 11 August 2016).
- \_\_\_\_\_. n. d. *Rice Knowledge Bank. Harvesting*. <http://www.knowledgebank.irri.org/step-by-step-production/postharvest/harvesting> (accessed 11 August 2016).
- \_\_\_\_\_. n. d. *Rice Knowledge Bank. How to plant rice*. <http://www.knowledgebank.irri.org/step-by-step-production/growth/planting> (accessed 11 August 2016).
- \_\_\_\_\_. n. d. *Rice Knowledge Bank. How to prepare the rice field for planting*. <http://www.knowledgebank.irri.org/step-by-step-production/pre-planting/land-preparation> (accessed 11 August 2016).
- \_\_\_\_\_. n. d. *Rice Knowledge Bank. Measuring moisture content*. <http://knowledgebank.irri.org/step-by-step-production/postharvest/milling/milling-and-quality/measuring-moisture-content-in-milling> (accessed 7 June 2016).
- \_\_\_\_\_. n. d. *Rice Knowledge Bank. Post Production Course - Module 04: Storage*. <http://www.knowledgebank.irri.org/postproductioncourse/index.php/storage/the-importance-of-good-storage> (accessed 13 March 2016).
- \_\_\_\_\_. n. d. *Rice Knowledge Bank. Post Production Course - Module 04: Storage*. <http://www.knowledgebank.irri.org/postproductioncourse/index.php/storage/advantages-of-hermetic-storage-systems> (accessed 13 March 2016).

- . 2007. *Rice Knowledge Bank. Rice Production Course*. <http://www.knowledgebank.irri.org/ericeproduction/> (accessed 11 August 2016).
- . n. d. *Rice Knowledge Bank. Storage systems*. <http://www.knowledgebank.irri.org/step-by-step-production/postharvest/storage/grain-storage-systems> (accessed 13 March 2016).
- . n. d. *Rice Knowledge Bank. Storage systems*. <http://www.knowledgebank.irri.org/step-by-step-production/postharvest/storage/grain-storage-systems#bulk-storage> (accessed 13 March 2016).
- . n. d. *Rice Knowledge Bank. Storage systems*. <http://www.knowledgebank.irri.org/step-by-step-production/postharvest/storage/grain-storage-systems#hermetic-storage> (accessed 13 March 2016).
- . 2013. *Satellite Images Map Rice Damage from Typhoon*. 26 November 2013. <http://irri.org/news/media-releases/satellite-images-map-rice-damage-from-typhoon> (accessed 12 July 2016).
- . 2018. *World Rice Statistics Online*. <http://ricestat.irri.org:8080/wrsv3/entrypoint.htm> (accessed 8 October 2018).
- J.A.D. TOOLS s.r.o. *Sickle - toothed edge 400 mm*. <http://uk.jad.cz/products/garden/scythes-sickles> (accessed 7 June 2016).
- JAXA. 2013. *AUIG2 ALOS-2 / ALOS User Interface Gateway*. [https://auig2.jaxa.jp/openam/UI/Login?goto=http%3A%2F%2fal2mwb01%3A80%2Fips%2Fhome](https://auig2.jaxa.jp/openam/UI/Login?goto=http%3A%2F%2Fal2mwb01%3A80%2Fips%2Fhome) (accessed 10 August 2016).
- . 2014. *ALOS-2/PALSAR-2 Level 1.1/1.5/2.1/3.1 GeoTIFF Product Format Description*. [http://www.eorc.jaxa.jp/ALOS-2/en/doc/fdata/PALSAR-2\\_xx\\_Format\\_GeoTIFF\\_E\\_r.pdf](http://www.eorc.jaxa.jp/ALOS-2/en/doc/fdata/PALSAR-2_xx_Format_GeoTIFF_E_r.pdf) (accessed 10 August 2016).
- . n.d. *About Advanced Land Observing Satellite-2 "DAICHI-2" (ALOS-2)*. <http://global.jaxa.jp/projects/sat/alos2/> (accessed 29 July 2016).
- S. Kimura. 2014. *ASEAN Food Security Information System (AFSIS) Project: Agricultural Land Information System (ALIS) to Support Area Sample Survey*. [http://www.fao.org/fileadmin/templates/rap/files/Project/Expert\\_Meeting\\_17Feb2014\\_/P1-2\\_Agricultural\\_Land\\_Information\\_system\\_\\_ALIS\\_.pdf](http://www.fao.org/fileadmin/templates/rap/files/Project/Expert_Meeting_17Feb2014_/P1-2_Agricultural_Land_Information_system__ALIS_.pdf) (accessed 12 July 2016).
- Land and Water, Inc. 2000. *Wetland Reservoir Subirrigation Systems. Schematic of weir-type hydraulic control structure used to regulate water table depth in subirrigated fields*. (Graphic by Leslie Zucker, Ohio State University Extension). [http://www.landandwater.com/features/vol44no3/vol44no3\\_1.html](http://www.landandwater.com/features/vol44no3/vol44no3_1.html) (accessed 13 March 2016).
- Midori. 2010. Own work, CC BY 3.0. <https://commons.wikimedia.org/w/index.php?curid=10574028>; [https://en.wikipedia.org/wiki/Rice\\_barn#/media/File:Rice\\_barn\\_Traditional\\_Sasak\\_Village\\_Sade.JPG](https://en.wikipedia.org/wiki/Rice_barn#/media/File:Rice_barn_Traditional_Sasak_Village_Sade.JPG) (accessed 5 October 2018).
- J. Murphy, D. J. Casley, and J. J. Curry. 1991. *Farmers' Estimations as a Source of Production Data. World Bank Technical Paper 132*. Washington, DC: World Bank.
- Natural Resources Canada (NRC). 2014. *Polarization in Radar Systems*. Last modified 13 November 2014. <http://www.nrcan.gc.ca/earth-sciences/geomatics/satellite-imagery-air-photos/satellite-imagery-products/educational-resources/9567> (accessed 4 August 2016).
- A. Nelson and M. K. Gumma. 2015. *A map of lowland rice extent in the major rice growing countries of Asia*. Los Banos, Philippines: IRRI. <http://irri.org/our-work/research/policy-and-markets/mapping/remote-sensing-derived-rice-maps-and-related-publications> (accessed 7 June 2016).
- N2YO.com. *Pattern of Orbit of ALOS-2*. <http://www.n2yo.com> (accessed 5 August 2016).
- P. Oakley and C. Garforth. 1985. *Guide to extension training*. Rome, Italy: FAO and Agriculture Extension and Rural Development Centre, School of Education, University of Reading, UK. <http://www.fao.org/docrep/t0060e/T0060E03.htm> (accessed 13 March 2016).
- I. Pavlov. 2018. *7-Zip*. <http://www.7-zip.org/> (accessed 29 October 2018).



- M. Petronzio. 23 April 2017. *9 incredible ways we're using drones for social good*. Yahoo News. <https://sg.news.yahoo.com/tech/9-incredible-ways-apos-using-145141911.html> (accessed 23 April 2017).
- QGIS. 2018. *QGIS: A Free and Open Source Geographic Information System*. <http://qgis.org/en/site/> (accessed 29 October 2018).
- Remote Sensing-based Information and Insurance for Crops in Emerging Economies (RIICE). n. d. *About RIICE*. <http://www.riice.org/> (accessed 15 July 2016).
- Remote Sensing Technology Center of Japan (RESTEC). 2014. [presentation].
- \_\_\_\_\_. 2015. [Lecture PowerPoint slides].
- P. Ronan. 2007. File:EM spectrum.svg. *Wikimedia Commons*. [https://commons.wikimedia.org/wiki/File:EM\\_spectrum.svg](https://commons.wikimedia.org/wiki/File:EM_spectrum.svg) (accessed 27 July 2016).
- A. Schneider. 2003-2018. *GPS Visualizer: Do-It-Yourself Mapping*. <http://www.gpsvisualizer.com/> (accessed 30 October 2018).
- S. Speck. 2008. *How Irrigation Works*. *HowStuffWorks*. <http://home.howstuffworks.com/irrigation3.htm> (accessed 13 March 2016).
- A.K. Srivastava. n. d. *Agricultural Statistics System in India*. Indian Agricultural Statistics Research Institute. [http://www.iasri.res.in/ebook/TEFCPI\\_sampling/AGRICULTURAL%20STATISTICS%20SYSTEM%20IN%20INDIA.pdf](http://www.iasri.res.in/ebook/TEFCPI_sampling/AGRICULTURAL%20STATISTICS%20SYSTEM%20IN%20INDIA.pdf) (accessed 8 July 2016).
- U.C. Sud. *Agriculture Census in India*. New Delhi, India: Indian Agricultural Statistics Research Institute - Indian Council of Agricultural Research (I.C.A.R.). [http://www.iasri.res.in/ebook/TEFCPI\\_sampling/AGRICULTURE%20CENSUS%20IN%20INDIA.pdf](http://www.iasri.res.in/ebook/TEFCPI_sampling/AGRICULTURE%20CENSUS%20IN%20INDIA.pdf) (accessed 8 July 2016).
- The Apache Software Foundation. 2018. *Apache OpenOffice 4.1.5 released*. <http://www.openoffice.org/> (accessed 29 October 2018).
- \_\_\_\_\_. 2018. *Download Apache OpenOffice*. <http://www.openoffice.org/download/> (accessed 29 October 2018).
- \_\_\_\_\_. 2018. *Why Apache OpenOffice*. <https://www.openoffice.org/why/index.html> (accessed 29 October 2018).
- The World Bank Group. 2012. *Malawi - Third Integrated Household Survey 2010-2011*. <http://microdata.worldbank.org/index.php/catalog/1003> (accessed 7 June 2016).
- \_\_\_\_\_. 2016. *Living Standards Measurement Study*. <http://surveys.worldbank.org/lsms> (accessed 7 June 2016).
- United Nations (UN). 2018. *SDG Indicators Metadata repository*. <https://unstats.un.org/sdgs/metadata/> (accessed 19 September 2018).
- \_\_\_\_\_. 2018. *Progress towards the Sustainable Development Goals. Report of the Secretary-General*. <https://unstats.un.org/sdgs/files/report/2018/secretary-general-sdg-report-2018--EN.pdf> (accessed 19 September 2018).
- United States Geological Survey (USGS). n.d. *What are the band designations for the Landsat satellites?* <https://landsat.usgs.gov/what-are-band-designations-landsat-satellites> (accessed 29 October 2018).
- Université Catholique de Louvain (UCLouvain) and European Space Agency (ESA). 2011. *GLOBCOVER 2009 Products Description and Validation Report*. [http://due.esrin.esa.int/files/GLOBCOVER2009\\_Validation\\_Report\\_2.2.pdf](http://due.esrin.esa.int/files/GLOBCOVER2009_Validation_Report_2.2.pdf) (accessed 7 June 2016).
- P. Q. Vinh, Deputy Director General, General Statistics Office, Government of Vietnam. *Rural, Agricultural and Fishery Census in Vietnam* (presentation, 26th APCAS, Bhutan, 15-19 February 2016). [http://www.fao.org/fileadmin/templates/ess/documents/apcas26/presentations/APCAS-16-6.2.5\\_-\\_Viet\\_Nam\\_-\\_Rural\\_\\_Agricultural\\_\\_and\\_\\_Fishery\\_Census\\_in\\_Viet\\_Nam.pdf](http://www.fao.org/fileadmin/templates/ess/documents/apcas26/presentations/APCAS-16-6.2.5_-_Viet_Nam_-_Rural__Agricultural__and__Fishery_Census_in_Viet_Nam.pdf) (accessed 25 October 2018).
- VMware, Inc. 2016. *VMware Player 7.1.4 and VMware Player Pro 7.1.4 Release Notes*. [https://pubs.vmware.com/Release\\_Notes/en/player/7/player-714-release-notes.html](https://pubs.vmware.com/Release_Notes/en/player/7/player-714-release-notes.html) (accessed 10 August 2016).



\_\_\_\_\_. 2017. *Download VMware Workstation 7.1.4 for Windows*. [https://my.vmware.com/web/vmware/details?dlg=wkst\\_714\\_win&baseCode=ZGolYnROakBiZGh0Kg==](https://my.vmware.com/web/vmware/details?dlg=wkst_714_win&baseCode=ZGolYnROakBiZGh0Kg==) (accessed 25 May 2017).

## **Use of Remote Sensing to Estimate Paddy Area and Production**

### *A Handbook*

A substantial portion of the world's rice is produced and consumed in the Asia and Pacific region. As much of the region's population depends on rice farming for consumption and livelihood, the demand for good quality statistics remains essential for effective policy formulation. Recent advances in remote sensing serve as a viable alternative to traditional methods of compiling agricultural statistics by responding to the emerging data requirements and overall needs of modern agriculture, especially for staple commodities such as rice.

This publication outlines the procedures, methods and tools developed for generating statistics on paddy rice area and production using remote sensing and GIS techniques. It is intended to encourage and assist national statistical systems in piloting and adopting satellite-based techniques as an alternative to existing data collection methods, while enabling other interested readers to comprehend whether the adoption of these methodologies can improve the quality and timeliness of agricultural statistics. The handbook also serves as a complement to a massive online open course developed by ADB for crop area estimation.

### **About the Asian Development Bank**

ADB is committed to achieving a prosperous, inclusive, resilient, and sustainable Asia and the Pacific, while sustaining its efforts to eradicate extreme poverty. Established in 1966, it is owned by 68 members —49 from the region. Its main instruments for helping its developing member countries are policy dialogue, loans, equity investments, guarantees, grants, and technical assistance.



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