The Dot Sampling Method

March 29, 2016

KAMIKURA, Kenji

Senior Statistician

Statistics Department

MAFF Japan

Preface

Concerning agricultural production survey, it is common to ask farmers to get data of planted area, namely through interpersonal hearing method. This hearing method is popular in many countries such as developing countries, but it has a week point that you cannot evaluate a validity of the data, as you get the data through hearing from persons without any evidence. It has been often happened that such data doesn't show the real situation. As for the frequency of planted area surveys in one year, the reality is that many of you cannot conduct them even once a year, though you should do several times a year. Under these situations, with the advent of Google Earth, the Dot Sampling method has been developed and you have been able to estimate a plated area of certain crops simply and efficiently in a target area. In order to carry out the Dot Sampling Method, the Excel Macros have been developed and anybody can conduct the survey easily. Though area survey has long been a big obstacle to implement production survey so far, the Dot Sampling Method has removed the obstacle all at once.

Area Survey with the Dot Sampling method has characteristics such that its survey object is not a person but a land, it doesn't require population composition, as well as it is easier to be conducted and non-sampling errors hardly occur, as it is not a variable survey but an attribute survey.

Also, the Dot Sampling Method widely exhibits its power in not only in an area survey but also other surveys such as a yield survey.

This document has compiled the essence related to the development of the Dot Sampling Method taken from domestic and foreign books, magazines, documents for meetings, training materials for government staff from various countries. This document aims to provide every person with an opportunity to know the Dot Sampling Method. Moreover, we expect that readers of this document understand the power of the Dot Sampling Method and discover lots of possibilities the Dot Sampling Method has.

We are delighted if this document is useful for you to study methodologies of statistical surveys or disseminate survey methods through international technical cooperation.

Contents

Preface

Contents

Chapter 1　Dot Sampling Method

1.1　Concept of the Dot Sampling Method…… 1

1.2　Examples of what you can do with the developed Excel Macros

1.2.1 Putting any number of dots on a target region…… 2

1.2.2 Putting any number of dots on rice fields in a target region…… 2

1.2.3 Using it as a two-dimensional ruler to measure area …… 2

1.3　Characteristics of the Dot Sampling Method

1.3.1 It is an efficient and powerful method based on traditional theory…… 3

1.3.2 To be applicable to both attribute and variable survey……5

1.3.3 To be applicable to minor crops …… 6

1.3.4 To be applicable to mix crops …… 6

1.3.5 To be applicable to dyke survey …… 6

1.3.6 To be applicable to complicated geography or slope……7

1.3.7 To require small number of enumerators, even unskilled ones……7

1.3.8 To be conducted repeatedly any times a year……7

1.3.9 To have possibility to further develop in the future …… 7

Chapter 2　Area Survey Using the Dot Sampling Method

2.1　Concept of area survey……9

2.2　Procedure of survey

2.2.1 Step1 To put sample dots on Google Earth ……10

2.2.2 Step2 Preparatory survey on Google Earth ……12
2.2.3 Step3 Field survey……13
2.2.4 Step4 Estimation of area……13
2.3 Procedure of survey for the second time …… 14
2.4 Size of the sample required for the Dot Sampling Method……14
2.5 Way of involvement by statistical organizations in surveys……18
2.6 Examples: results of preparatory surveys on Google Earth
2.6.1 Preparatory survey, Thailand……18
2.6.2 Preparatory survey, Lao PDR……20
2.6.3 Prefecture survey, East Timor …… 20
2.7 Area Survey using the Method as a two-dimensional ruler……21

Chapter 3 Yield Survey Using the Dot Sampling Method

3.1 Application of the Dot Sampling Method to yield survey …… 23
3.2 Procedure of survey
3.2.1 Step1 Selection of sample spots for crop cutting …… 24
3.2.2 Step2 Crop cutting, threshing, drying, weighing …… 25
3.2.3 Step3 Estimation of average yield/ha in a target region…… 26

Chapter 4 Examples of Rice Production Survey Using the Dot Sampling Method

4.1 Planted area survey… ……27
4.2 Yield survey …… 29
4.3 Production survey ……30

Chapter 5　Mystery of the Dot Sampling Method

5.1 Better precision than theoretical precision …… 31
5.2 Sampling survey or measuring survey …… 33

Chapter 6　Dissemination of the Dot Sampling Method and Similar Methods Overseas

6.1 Situation of similar methods overseas ……34
6.2 Dissemination of the Dot Sampling Method in international technical cooperation activities …… 35

Chapter 7　Frequently Asked Questions on the Dot Sampling method

……37

Afterword …… 41

Reference …… 42

Chapter 1　Dot Sampling Method

Detailed and specific explanation on the Dot Sampling Method is given in chapter 2 and after. In this chapter you learn at first the concept of the Dot Sampling Method. And then you learn both the basic functions of Excel Macros developed for efficiently conducting surveys using the Dot Sampling Method and the various characteristics of the Dot Sampling Method.

1.1 Concept of the Dot Sampling Method

In this document, the Dot Sampling Method is defined as a method that puts dots randomly on a map and survey the dot itself or plots near the dot.

Originally, the Dot Sampling Method has started as “the method which conducts attribute surveys by counting dots,” but in this document the Dot Sampling Method includes “the method which conducts variable surveys near dots.”

In a case that the Dot Sampling Method is applied to rice planted area survey, you put dots at regular intervals on the map of Google Earth and you estimate total area of rice planted field in a target region from sharing rate of dots which fall on rice planted spots.

In another case that you select crop cutting fields and spots based on locations of dots, you can estimate the yield easily as the fields have been already selected by the probability proportional to rice planted area.

The reason why the name of the Dot Sampling Method include “sample” is that dots themselves on the map are thought to be sample spots. Please note that samples are not extracted from a population which has been compiled before conducting surveys like prevailing methods, such as area frame method.

Note: Attribute survey method is also the method for opinion poll. Regarding opinion poll, you ask selected sample person if he or she supports the cabinet or not in order to estimate a cabinet support

rate nationwide. In the same way, regarding area survey using the Dot Sampling method, you ask selected sample dot if it is fallen on rice planted spot or not in order to estimate a rice planted area rate nationwide.

1.2 Examples of what you can do with the developed Excel Macros

Before taking up the main subject of the Dot Sampling method, we will mention following three activities which you can conduct with the Excel Macro. You can put sample dots at equal intervals in a grid pattern only by inputting six values into the Excel Macro.

1.2.1 Putting any number of dots on a target region

You can put dots of any number in any place on Google Earth by putting 6 values in the Excel Macro. For instance, you can put 1,000 dots in a country on Google Earth by inputting data of total land area, 1,000 as the number of dots and range of rectangle covering the country into Excel Macro.

1.2.2 Putting any number of dots on rice fields in a target region

You can put 200 dots on rice fields of 400km^2 in a prefecture by inputting 400km^2 of total area or rice fields, 200 dots and range of rectangle covering the prefecture into Excel Macro.

1.2.3 Using it as a two-dimensional ruler to measure area

You can put a dot every 0.01km^2 on Google Earth by inputting data of 0.01km^2 as area, one as number of dots and range of a target region into Excel Macro. Thus you can estimate area by counting the number of dots fallen on concerning region.

Note 1: Concerning 1.2.3, you can call this method a two-dimensional ruler by measuring area by counting the number of dots, while normal ruler

is called one-dimensional rules by measuring length by counting the number of divisions. This method is as same as dot grid method which has already been adopted as dot grid plate for measuring area.

Note 2: Six values are as follows:

Values to determine number of dots per area

1) Any area (square measure)

2) Number of dots putting in the area of 1)

Values to determine a range of rectangle for putting dots

3) Any latitude on the north of the northernmost of a target region

4) Any longitude on the west of the westernmost of a target region

5) Any latitude on the south of the southernmost of a target region

6) Any longitude on the east of the easternmost of a target region

Note 3: A shape of range where dots are put is rectangle surrounded by input latitudes and longitudes while dots of any number are put in target area on Google Earth

Note 4: The Excel Macro for the Dot Sampling Method is available to anybody. For those who want to get the Excel Macro files, please make contact with Kenji Kamikura (kkamikura@hotmail.com).

1.3 Characteristics of the Dot Sampling Method

1.3.1 It is an efficient and powerful method based on traditional Theory

The Dot Sampling Method is one of traditional survey methods. With the Method, you can conduct surveys efficiently. The Method has been thought to be a suitable method for crop production survey because of reasons below.

1) You don’t need to prepare for listing of target population from which you'll extract your sample,

2) Sample dots are selected by probability proportional to size of each field,

3) You can conduct area survey easily as it is an attribution method,

4) You can easily conduct compilation, estimation and calculation of precision,

5) Non-sampling error hardly happens.

But it was difficult to put the Method into practice, as it was almost impossible to get a map which enables you to put any number of dots with any intervals on the map and to prepare for guide maps for guiding enumerators to sample dots which are necessary for practicing the Method. However, the advent of Google Earth has made it possible to carry out those activities. In addition, in order to conduct field survey, with Google Earth you have only to visit to the sample dots which are thought to have fallen on cultivated land, as you can check the land usages of sample dots on computer's screen such as forest, lake, building, road, and so on. Even if there are 10,000 sample dots, the number of sample dots for field survey can be reduced to 500 dots when the cultivated land ratio is five percent. You can say that old traditional survey method was reborn as a powerful and new method linking with latest information technology.

Note: There are some statisticians, saying almost the same idea as the Dot Sampling method.

One is Frank Yates, statistician, England, who says in his book "Sampling Methods for Censuses and Surveys, 1949" as follows:

 # If we have areas demarcated on a map, such as fields, and a point is located at random on the map, the probabilities of the point falling within the boundaries of the different fields are clearly proportional to the areas of the field. Consequently, areas can be selected at random with probabilities proportional to their size by the simple procedure of taking random points on the map."(35p)

 # All that is required for acreage is to determine the proportion of points which fall in areas of the given type. The method is therefore particularly attractive when carrying out surveys of the areas of crops, etc., by aerial survey, since it avoids all the measurements of

area which would be required if an ordinary random sample of areas were taken. (*p35*)

Another one is Kei Takeuchi, statistician, Japan, who says in his book written in 2010, as follows.

 # As the number of dots N increases, dots scatter all over the inner part of a square and finally scatter thoroughly in a uniform manner. If you write a figure of S square units within a square of 1 square unit, $\frac{n}{N}$ *becomes almost equal to S no matter what kind of figure it is, when the number of dots within the figure is n.(69p)*

 # It is rather difficult to measure each area of every rice fields and total the area of respective rice fields in a certain map when there are lots of rice fields in various sizes. Better simple way is that estimating area by counting the number of dots fallen on rice fields after putting lots of dots randomly inside the map. If the number of dots which have fallen on rice fields is n out of N dots, total area of rice fields in the map is estimated $\frac{n}{N}$ *of area of the map.(70p)*

1.3.2 To be applicable to both attribute and variable survey

The Dot Sampling Method is applicable to both attribute and variable survey.

You can conduct attribute survey if you check whether sample dot is fallen on rice plated spot or not and calculate the ratio of the number of sample dots on rice planted spot to number of total sample dots. The Random Digit Dialing method used for opinion poll and the method for election exit survey is attribute survey.

You can conduct variable survey when you weigh the rice harvested from a spot around a sample dot, utilizing the nature of dot which is selected by probability proportional to size.

1.3.3 To be applicable to minor crops

Even an area of minor crops can be grasped, as sample dots are selected in proportional to planted area. Every dot has same probability, so the appearance ratio of each crop is to be proportional to its planted area. Regarding the number of necessary sample dots, it can be calculated according to required precision.

1.3.4 To be applicable to mix crops

With area survey using the Dot Sampling Method, you don't need special correspondence for mixed crops.

There are two types of mixed crops. One is more than one crops are planted randomly in one spot. Another one is more than one crops are planted separately in a field.

For instance, in case when maize and soybean are planted randomly in a field, you count maize as well as soybean, namely, planted area are counted two times.

In case when more than one crop are planted separately, you just count a crop of the spot which the dot falls on.

Note: As planted area are decided in an above mentioned way, please note that you need to conduct crop cutting in a normal method focusing on a said crop when sample spot for crop cutting falls on a spot where more than one crop are planted randomly. In this way, you can estimate a production of said crop in a target area as follows:

(average yield in the target area) x (planted area in the target area)

1.3.5 To be applicable to dyke survey

With the Dot Sampling Method, you can estimate both planted area excluding dyke and area of dyke separately. This is because sample dots are selected by probability proportionate to size of planted area and area of dyke. Therefore you don't need to conduct dyke survey separately.

Note: In many cases, results of planted area survey often include dyke. Therefore, crop production is apt to be overestimated when you estimate production with yield multiplied by area. In this case you need to estimate production by using either area without dyke or yield calculated with dyke.

1.3.6 To be applicable to complicated geography or slope

At the field survey, you only identify whether said crop is planted or not. You don't measure area. So, it doesn't matter if the geography is complicated. On a sloped area, angle of slope doesn't affect the results, as sample dots are put according to area of projection plane.

1.3.7 To require small number of enumerators, even unskilled ones

With the Dot Sampling Method, you need small number of enumerators. Only one person can conduct field survey, because you do not need to measure area. Even unskilled ones can conduct a survey, because what you need to do is only identify an attribution of sample dots, for instance identify if rice is planted or not (See 2.2).

1.3.8 To be conducted repeatedly any times a year

If you fix sample dots for several years, you can conduct surveys with the Dot sampling Method repeatedly any times a year, as you only need to visit same sample dots that you visited previous time without finding out where to visit (See 2.3).

1.3.9 To have possibility to further develop in the future

You can say that the Dot Sampling Method is a simple but profound method with possibility to further develop in the future.

The Dot Sampling Method has a possibility to have affinity with drone. It is

expected that drone would take pictures of spots of sample dots automatically by letting a drone read coordinates of latitude and longitude of sample dots. Thus you might be able to conduct field survey on a desk.

The Dot Sampling Method has a possibility of development from the view point of actual measurement nature which the Dot Sampling Method possesses.

Functions which Google Earth being equipped with, such as time slider and measurement of area, might have possibility to develop more efficient survey with the Dot Sampling Method.

Thus, there seems to be possibilities to develop a system of crop production survey which is suitable for new age together with past experience and new technology as well as knowledge of mathematics.

Chapter 2 Area Survey Using the Dot Sampling Method

In this chapter, concerning area survey using the Dot Sampling method, we learn concept of area survey and procedure of survey as well as procedure of survey for the second time which is much easier than the survey in the first time, size of the sample required for the Dot Sampling Method and a way of involvement by statistical organizations in surveys. And also we look at three examples of preparatory surveys on Google Earth. In addition, we learn the way to use the Dot Sampling Method as a two dimensional ruler or a ruler for measuring area.

2.1 Concept of area survey

The basic idea of the Dot Sampling Method is, for instance, as being described in Chapter 1, you put n sample dots in a target area and count the number of sample dots which fall on rice planted spots. If the number of dots which falls on rice planted spots is n_1, then you estimate rice planted area $(\hat{T})$ by multiplying area of the target region (W) by the ratio $(\hat{p}=\frac{n_1}{n})$. Please note that with the Dot Sampling Method, you put sample dots systematically in a grid pattern which is easy to manage dots and generates more precise results than putting them in simple random way.

Note 1: Estimation formula is as follows:

Rice planted area $\hat{T}=\frac{n_1}{n}\times W=\hat{p}W$

Standard error $\mathrm{SE}=\sqrt{\frac{\hat{p}\times\hat{q}}{n}}$ when $\hat{q}=1-\hat{p}$

Note 2: CV for estimated value is as follows:

Coefficient of variation $\mathrm{CV}=\frac{SE}{\hat{p}}$

2.2 Procedure of survey

There are following 4 procedures for area survey using the Dot Sampling

Method.

Step 1 is to extract sample dots. You decide the number of sample dots, input density of sample dots (values of area and number of dots) and values of latitude and longitude which decide a range of target area into the table on Excel sheet. Click buttons according to the instruction on the sheet. Sample dots will be displayed on Google Earth.

Step 2 is examining attributions of sample dots on Google Earth. You categorize attributions of sample dots into cultivated land and others such as forest, river, road, building which you clearly don't need to visit for a field survey. Thus sample dots are classified into two categories, one is sample dots which you need to conduct field survey to examine their attribution and another is sample dots which you don't need to conduct field survey.

Step 3 is conducting field survey to visit sample dots and examine their attributions. In the case of rice planted area survey, you check whether rice is planted or not at a spot of each sample dot.

Step 4 is estimating area.

The following are the details of 4 procedures in the case of a rice planted area survey as an example.

2.2.1 Step 1　To put sample dots on Google Earth

In order to put sample dots on Google Earth you use Excel Macro which has been developed for putting them efficiently.

Before starting you prepare a computer with Google Earth, three Excel Macro files of LL Sheet for the dot sampling、LL Table Maker、Save Range As KML File.

First, you open the file of LL Sheet for the dot sampling and input an appropriate file name for saving, following six values from 1) to 6).

1) Area of target region
2) The number of sample dots putting in the target region
3) Any latitude on the north of the northernmost of a target region
4) Any longitude on the west of the westernmost of a target region

5) Any latitude on the south of the southernmost of a target region

6) Any longitude on the east of the easternmost of a target region

Concerning the value of area of target region of 1) such as a countries land area, you can get it from administrative data or other sources.

You need to calculate the necessary number of sample dots for inputting value of 2). The way of the calculation is described in 2.4.

You need to use decimal degrees for inputting latitude and longitude from 3) to 6) which you can get Google Earth or other sources.

Note1: A purpose of inputting values of 1) and 2) is to determine dot density or number of dots per area.

Note2: Values from 3) to 6) determine a rectangle shape of range for putting dots which covers all area of target region. Values of 3) and 4) provide coordinates of northwest starting point of systematic sampling and values of 5) and 6) provide coordinates just before southeast ending point.

Note3: Dots are put into rectangle form in a range surrounded by input latitude and longitude.

Note4: The number of dots which are fallen in target region defined in 1) is almost as same as the number of dots defined in 2) with high probability, though it depend on the starting point of systematic sampling.

Suppose you would like to put 100 sample dots in Tsubameshi, Niigata Prefecture, you open a file “LL Sheet for the dot sampling” and input 6 values as follows:

You enter Tsubameshi as a name of the file in cell (1). You enter 110.94 as area of Tsubameshi in cell (2). You enter 100 as the number of sample dots in cell (3). You put 37.73 as latitude on the north of the northernmost of a target region in cell (4). You enter 138.78 as longitude on the west of the westernmost

of a target region in cell (5). You enter 37.59 as latitude on the south of the southernmost of a target region in cell (6). You enter 138.98 as longitude on the east of the easternmost of a target region in cell (7).

LL Sheet for the dot sampling

T-1 Basic data to generate sample dots (Sampling Design)

Target area	Size of the Target area km^2	Sample size	Starting point (latitude)	Starting point (longitude)	Finishing point (latitude)	Finishing point (longitude)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Tsubameshi	110.94	100	37.73	138.78	37.59	138.98

1-(1) Click here to **check data** in T-1 table

2. Sampling based on the "Sampling design"

2-(1) Click here to **complete T-2 table**

2-(2) Click here to **make a KML file**

After finishing filling in cells, you click on the buttons according to instructions. "LL Table Maker" file and "Save Range As KML" file starts automatically followed by appearance of a table "Sample dots (Coodinate Values)" and Google Earth starts automatically. Finally Sample dots will appear on Google Earth automatically.

2.2.2 Step 2 Preparatory survey on Google Earth

Preparatory survey is conducted on Google Earth. You examine attribution of each sample dot on Google Earth and distinguish sample dots which possibly have fallen on cultivated land and you need to visit for a field survey from sample dots which clearly have fallen on forest, river, road, building and you don't need to visit for a field survey. In addition at this stage survey you could examine land usage in target area.

According to the results of preparatory survey for Tsubameshi described in 2.2.1, cultivated land is estimated 6,000ha which may be more than actual value, as it includes all sample dots which have possibility to have fallen on cultivated land. In order to get final estimation, you have to conduct field survey to

examine actual attributions of sample dots as described in 2.2.3.

Results of Step 2（Preparatory Survey on Google Earth）

category	sampe dpts	share (%)	estimation (ha)
cultivated land and unclear usage	53	54	6,000
dyke	6	6	679
non-cultibated land	39	40	4,415
Total	98	100	11,094

2.2.3 Step3 Field survey

Step 3 is conducting field survey to visit sample dots which you are to visit as a result of step2 and examine their attributions.

Before visiting fields, you need to print out guide maps which enumerators bring to lead them to the fields. If computer or smartphone are available, you could send KML file, which you made in step1, to enumerators. Enumerators open KML files which could lead them to the fields on Google Earth.

Enumerators visit sample dots which has been categorized to be visited for field survey in step 2 and examine attributions of the sample dots. In the case of rice planted area survey, enumerators check whether rice is planted or not at a spot of each sample dot.

In the case of Tsubameshi mentioned in step2, you need to visit 53 sample dots to examine their attributions, as 53 dots have been categorized dots to be visited for field survey.

As explained in 2.3, please note that you visit only 43 dots at the second survey instead of 53 dots, if 10 dots out of 53 dots are classified to non-cultivated area as a result of field survey.

2.2.4 Step４　Estimation of area

Please see estimation formula shown in 2.1. You can estimate rice planted

area by area of target area times a ratio of n_1 to n when n is total number of sample dots in target area and n_1 is the number of dots which fall on rice planted spot.

2.3 Procedure of survey for the second time

You can conduct a second survey and after more efficiently than first survey, as explained below.

Firstly, as you can use same sample dots which you used at a previous survey, you don't need to select sample dots thereafter and what you need to do is only to examine attribution of sample dots without selecting new sample dots.

Secondly, you can visit only sample dots which have fallen on cultivated land to examine attribution of dots, as you already know which sample dots have fallen on non-cultivated land from the first survey.

Also, it is easy to conduct planted area survey several times a year because of reasons above.

2.4 Size of the sample required for the Dot Sampling Method

The number of sample dots required for the preparatory survey mentioned in step 2 for the area survey using the Dot Sampling Method is calculated with two factors: aimed precision and population coefficient of variation.

$$\text{The number of necessary sample dots} = \frac{(population\ CV)^2}{(aimed\ precision)^2} = \frac{(population\ standard\ deviation)^2}{(aimed\ standard\ error)^2}$$

Note: Though you cannot get a value of population p at the time of survey, population CV can be estimated using results of past survey or pretest.

Please note that necessary number of sample dots is for the preparatory survey explained in 2.2.2. The number of sample dots for field survey is less than

that for preparatory survey, which has been categorized to be visited for field survey in step 2

The next table shows the necessary number of sample dots for preparatory survey calculated by the formula above as well as the theoretical number of sample dots for field survey calculated by the formula “the number of sample dots for preparatory survey x $\frac{p}{100}$” by values of p and CV. Please note that as the value of p become smaller, the number of necessary sample dots for preparatory survey increases sharply but the number of necessary sample dots for field survey increases not so sharply. This is one of characteristics of the Dot Sampling Method. You can keep high precision with small number of sample dots for field survey.

Note1: In the next table, the number of necessary sample dots for field survey is a theoretical value for the number of sample dots which fall on rice planted spots in case of, for instance, rice planted area survey. At the time of actual field survey, you need to visit all sample dots which have possibilities to fall on rice planted spots, so the number of which is somewhat more than theoretical value.

Note2: In the case of preparatory survey in Tsubameshi shown in Step2, just 100 Sample dots have been distributed in Tsubameshi. But now, let’s make a sampling design for the survey, looking at the next table. According to the past survey, share of rice planted area in Tsubameshi is 40 %, so the number of necessary sample dots for preparatory survey is 150 according to the next table. And the theoretical number of necessary sample dots for field survey is 60 according to the next table, but actually you have to visit somewhat more than 60 sample dots, as you have to visit every sample dots which has been categorized to have possibility to be fallen on rice planted spot.

Note3: You could calculate the actual number of sample dots for field survey with some of prior information. If you get prior information that share

of rice field excluding dyke in Tsubameshi is 50 %, you calculate the number of sample dots which are possibly on rice planted area is 75 out of 150 sample dots. Thus, if you have got prior information, you can calculate both the number of necessary sample dots for preparatory survey and the approximate actual number of sample dots for field survey, which is one of the advantages of the Dot Sampling Method.

Number of Necessary Sample Dots by Aimed Precision in case of Preparatory Survey and Field Survey

Share of rice planted area in a target region	Aimed Precision CV = 3%		Aimed Precision CV = 5%		Aimed Precision CV = 10%	
	Preparatory survey	Field survey	Preparatory survey	Field survey	Preparatory survey	Field survey
p %						
1	110,000	1,100	39,600	396	9,900	99
2	54,444	1,089	19,600	392	4,900	98
3	35,926	1,078	12,933	388	3,233	97
4	26,667	1,067	9,600	384	2,400	96
5	21,111	1,056	7,600	380	1,900	95
6	17,407	1,044	6,267	376	1,567	94
7	14,762	1,033	5,314	372	1,329	93
8	12,778	1,022	4,600	368	1,150	92
9	11,235	1,011	4,044	364	1,011	91
10	10,000	1,000	3,600	360	900	90
20	4,444	889	1,600	320	400	80
30	2,593	778	933	280	233	70
40	1,667	667	600	240	150	60
50	1,111	556	400	200	100	50
60	741	444	267	160	67	40
70	476	333	171	120	43	30
80	278	222	100	80	25	20
90	123	111	44	40	11	10

Note: Calculation fomulas are as follows:

Sample size for Preparatory Survey = $\frac{Variance\ of\ p\ in\ Population}{Aimed\ Standard\ Error^2}$

$$= \frac{\frac{p}{100} \times \left(1 - \frac{p}{100}\right)}{\left(\frac{p}{100} \times \frac{CV}{100}\right)^2} = \frac{p \times (100 - p)}{\left(p \times \frac{CV}{100}\right)^2}$$

Number of dots for Field Survey = Sample size for Preparatory Survey $\times \frac{p}{100}$

2.5 Way of involvement by statistical organization in surveys

Before you conduct a rice planted area survey in your country, you need to decide which organization is to conduct surveys in your government according to the situation of your government.

Main activities for each organization to do are as follows:

(Step1) 1) To put sample dots on Google Earth

(Step2) 2) To conduct preparatory survey

(Step3) 3) To send hard copies of maps to show sample dots or to send KML files to put sample dots on Google Earth to enumerators

4) To visit sample dots, check whether rice is planted or not at a spot of each sample dot and report its number

5) To compile results of field survey

(Step4) 6) To estimate rice planted area

(Other) 7) To manage samples such as replace sample dots periodically

Activities from 1) to 3) and from 5) to 7) may be carried out by a central organization or a local organization. Activity 2) may be carried out by a local organization more efficiently than by a central organization, as a local organization has much more information than a central organization. Activity 4) is to be carried out by enumerators or a local organization.

2.6 Examples: results of preparatory surveys on Google Earth

You can carry out preparatory surveys for any countries, as preparatory survey can be carried out on Google Earth. In this section, we learn results of preparatory surveys conducted for three countries. Please note that these are results of preparatory surveys, so no field surveys have been carried out yet to visit and check sample dots to identify the planted crops for getting results.

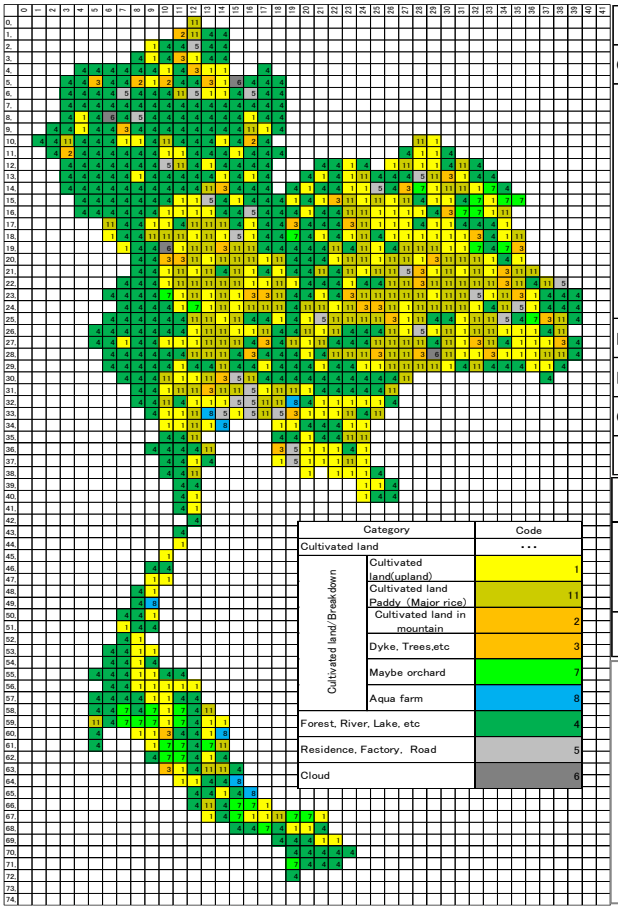
2.6.1 Preparatory survey, Thailand

In order to study to see if the Dot Sampling Method is useful, preparatory survey for rice field area in Thailand was conducted in 2013.

On Google Earth 999 sample dots were put in Thailand. The number of sample dots which may have fallen on rice field was 184. The number of sample dots which may have fallen on dyke was 31. So the number of sample dots which were necessary for conducting field survey, was 215 or 184+31.

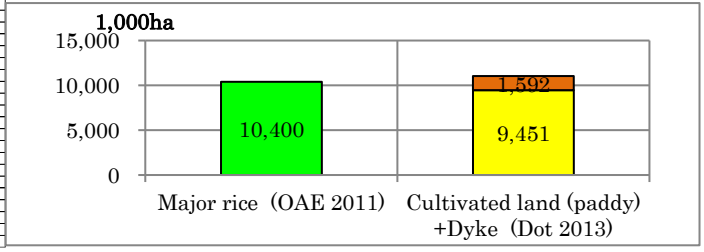
If you calculate rice field area from the results of the preparatory survey as an experiment, rice field area including dyke is calculated to be 11,043,000 ha, as the ratio of rice field is 21.5 % and national land area is 51,312,000ha. However, official statistics shows rice field area including dyke is 10,400,000ha in 2011.

You cannot compare the results of preparatory survey with that of official statistics as preparatory survey has examined only spots which have possibility of rice field and you need to conduct field survey to visit each sample dot to estimate area. However, official statistics which Thai government has estimated using lots of monetary resources, 10,400,000ha, is similar to results of preparatory survey which one person conducted on Google Earth, 11,034,000ha.



Category		Number of dots	Rate(%)	Area(ha)	SE	CV
Cultivated land		517	51.8	26,554,859	1.6	3.1
Cultivated land/Breakdown	Cultivated land(upland)	246	24.6	12,635,387	1.4	5.5
	Cultivated land Paddy (Major rice)	184	18.4	9,450,859	1.2	6.7
	Cultivated land in mountain	5	0.5	256,817	0.2	44.6
	Dyke, Trees,etc	43	4.3	2,208,625	0.6	14.9
	Maybe orchard	32	3.2	1,643,628	0.6	17.4
	Aqua farm	7	0.7	359,544	0.3	37.7
Forest, River, Lake, etc		451	45.1	23,164,877	1.6	3.5
Residence, Factory, Road		27	2.7	1,386,811	0.5	19.0
Cloud		4	0.4	205,453	0.2	49.9
Total		999	100.0	51,312,000	…	…

Category		Number of dots	Rate(%)	Area(ha)	SE	CV
Paddy field	Pure planted area (Major rice)	184	18.4	9,450,859	1.2	6.7
	Dyke, Trees,	31	3.1	1,592,264	0.5	17.7
Total		215	21.5	11,043,123	1.3	6.0



Source: Issei Jinguji, Dot Sampling Method for Area Estimation, Feb. 2014

2.6.2 Preparatory survey, Lao PDR

A staff member of Lao government conducted preparatory survey for rice field area in Savannaket prefecture during a training course 2014 in Japan.

Hundred Sample dots were put in Savannaket prefecture. The results were that the number of sample dots which have some chance of falling on rice field was ten which were necessary to be conducted field survey.

Preparatory survey has examined only spots which have possibility of rice field and you need to conduct field survey to visit each sample dot to estimate area. However, if you calculate rice field area from the results of the preparatory survey as an experiment, rice field area is calculated to be 217,740ha, as the ratio of rice field is 10 % and area of Savannaket prefecture is 2,177,400ha. On the other hand, official statistics shows rice field area is 212,840ha in 2013.

Category	Number	Share (%)	Estimate (ha)	SE (point)	CV
Paddy	**10**	**10**	**217,740**	3.0	0.30
Dyke	2	2	43,548	1.4	0.70
Residential Land	7	7	152,418	2.6	0.36
Road	2	2	43,548	1.4	0.70
River	1	1	21,774	1.0	0.99
Forest	75	75	1,633,050	4.3	0.06
Cutivated Land	3	3	65,322	1.7	0.57
Total	100	100			

Note1: Area of Savannaket: **2,177,400**ha

Note2: Agricultural Statistics 2013: Paddy Area: **212,840**ha

source： Mr.Senpachanh Khounthikoummane, Lao PDR, August, 2014

2.6.3 Preparatory survey, East Timor

Preparatory survey on area of districts in East Timor was conducted in 2014 with the Dot Sampling Method.

Fifteen hundreds Sample dots were put in East Timor on Google Earth. The results were that the number of sample dots which seemed to have fallen on

Lautem District was 184.

Let's estimate area of Lautem District from the results of the preparatory survey as an experiment. Area of Lautem District is estimated to be 1,830km^2 (=14,919×184/1,500), as the ratio of the District is 12.3%(=184/1,500) and area of national land is 14,919km^2. On the other hand, Wikipedia shows area of the District is 1,813km^2.

The preparatory survey shows that error is 17km^2(=1,830 – 1,813km^2), namely, actual precision is 0.9%(=17/1830) which is far better than theoretical precision 6.9%.

A Precision of area estimation with the Dot Sampling Method has a tendency to be extremely better than theoretical one. There are several reasons why it becomes better than theoretical precision which are expected to be further studied theoretically.

District	Sample Dots (A)	Share of Districts (B)	Estimated Area	Area by Wikipedia	Difference (E) (=C−D)	Precision (F) (=E/C)	Theoretical Value	
							Standard Error	Precision
	number	%	㎢	㎢	㎢	%	%point	%
Lautem	184	12.3	1,830	1,813	17	0.9	0.85	6.9
Baucau	150	10.0	1,492	1,506	−14	0.9	0.77	7.7
Viqueque	188	12.5	1,870	1,877	−7	0.4	0.85	6.8
Manatuto	182	12.1	1,810	1,782	28	1.6	0.84	6.9
Dili	39	2.6	388	367	21	5.4	0.41	15.8
Ailiu	73	4.9	726	737	−11	1.5	0.56	11.4
Manufahi	128	8.5	1,273	1,323	−50	3.9	0.72	8.5
Liquiçá	60	4.0	597	549	48	8.0	0.51	12.6
Ermera	75	5.0	746	768	−22	3.0	0.56	11.3
Ainaro	83	5.5	826	804	22	2.6	0.59	10.7
Bobonaro	140	9.3	1,392	1,376	16	1.2	0.75	8.0
Caova Lima	117	7.8	1,164	1,203	−39	3.4	0.69	8.9
Oesusse	81	5.4	806	814	−8	1.0	0.58	10.8
Total	1,500	100		14,919	0			

Source : Kenji KAMIKURA、Dot Sampling Method using Google Earth -What you can do with the Dot Sampling Method-、Developing Partners Coordinating Meeting, World Bank, Timor-Leste, November, 2014

2.7 Area Survey using the Method as a two-dimensional ruler

In this section, we learn the way to use the Dot Sampling Method as a two dimensional ruler or a ruler for measuring area. You can measure area using a two dimensional ruler by counting the number of dots in a similar manner that

you measure length by counting divisions on a scale. Some of you may have been already familiar with Point Grid Plate which is a transparent film with points arranged in grid pattern. Putting a Point Grid Plate on map, you count the number of points which are on target area and estimate the area by multiplying the number and coefficient (=area per one point) together.

You can apply area estimation method with a Point Grid Plate to the Dot Sampling Method as a two dimensional ruler.

For example, in case that you put dots in the ratio of one dot per 10a on Google Earth, the area is estimated 30a, if the number of dots within target area is three.

Suppose you would like to put one dots per 10a, namely 1,000 dots in one km^2, you open a file "LL Sheet for the dot sampling" and input data as follows: You enter file name such as "1 dot=0.1ha" in cell (1). You enter 1 in cell (2). You enter 1,000 in cell (3). You put 36.032451 as latitude on the north of the northernmost of a target region in cell (4). You enter 140.1226 as longitude on the west of the westernmost of a target region in cell (5). You enter 36.026 as latitude on the south of the southernmost of a target region in cell (6). You enter 140.1329 as longitude on the east of the easternmost of a target region in cell (7).

LL Sheet for the dot sampling

T-1 Basic data to generate sample dots (Sampling Design)

Target area	Size of the Target area km^2	Sample size	Starting point (latitude)	Starting point (longitude)	Finishing point (latitude)	Finishing point (longitude)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1 dot = 0.1 ha	1	1,000	36.032451	140.1226	36.026	140.1329

Chapter 3 Yield Survey using the Dot Sampling Method

In this Chapter, you learn the way of utilizing the Dot Sampling Method for yield survey. If you apply the Dot Sampling Method to yield survey, you can dramatically streamline the process of selecting samples in which you have taken a lot of time.

3.1 Application of the Dot Sampling Method to yield survey

You can apply the Dot Sampling Method to selecting spots for crop cutting using the characteristics of the Dot Sampling Method that sample dots are selected with probability proportional to size, though you don't use the Dot Sampling Method for variable survey such as yield survey, as the Dot Sampling Method is used for attribute survey in principle.

Major advantages of applying the Dot Sampling Method to yield survey is that you can select sample spots for crop cutting even when you don't know rice planted area of each village or you don't have a list of farmers. With a conventional method, you select sample fields with probability proportional to size. You have been managing to select spots for crop cutting in a way such as: at first you have to calculate accumulated rice planted area of villages and select villages with probability proportional. Secondly, you make a list of farmers of selected villages, and systematically select farmers from the list. Thirdly, you select field of selected farmers systematically. Fourthly, you select spots for crop cutting. Please note that making a list of farmers to select farmers and field is a temporary practical way, as it is difficult to select sample field precisely with probability proportional to size. With the Dot Sampling Method, a spot which a sample dot falls on is exactly a crop cutting spot. If you need to conduct crop cutting at more than one spot in one field, you conduct crop cutting at a spot which a sample dot falls on and at other spots around the spot in a preset way. With the Dot Sampling Method, you can select sample rice field with perfect probability proportional to size as well as you are freed from complicated

sampling process.

As the fields for crop cutting are selected with probability proportional to size, you can estimate average yield by simple average without taking into account a size of rice filed for crop cutting sample. Another merit is that you can easily manage sample dots including rotation of sample dots, as you can select samples easily.

3.2 Procedure of survey

3.2.1 Step1 Selection of sample spots for crop cutting

At first, you select sample spots for crop cutting.

In order to select sample spots, you select necessary number of sample spots systematically from the sample dots which were used for rice planted area survey and have fallen on rice planted spots

Note1: You calculate size of the sample in a same way as usual.

For instance, in case that coefficient of variation of rice yield in a target region is 32% and aimed precision is 10%, the number of necessary sample dots is 10 as calculated below:

$$\text{Sample size} = \frac{(population\ CV)^2}{(aimed\ precision)^2} = \frac{32^2}{10^2} \fallingdotseq 10$$

Note2: In case that you haven't conducted rice planted area survey with the Dot Sampling method, you have to use Excel Macro explained in chapter2 as an alternative method as follows:

Before starting you prepare a computer with Google Earth, three Excel Macro files of LL Sheet for the dot sampling、LL Table Maker、Save Range As KML File.

Suppose you would like to put 10 sample dots for crop cutting in Tsubameshi, Niigata Prefecture, you open a file "LL Sheet for the dot sampling" and input data as follows:

You enter TsubameshiY as a name of the file in cell (1). You enter 52 as rice planted area of Tsubameshi in cell (2). You enter 10 as the

number of sample dots in cell (3). You put 37.73 as latitude on the north of the northernmost of a target region in cell (4). You enter 138.78 as longitude on the west of the westernmost of a target region in cell (5). You enter 37.59 as latitude on the south of the southernmost of a target region in cell (6). You enter 138.98 as longitude on the east of the easternmost of a target region in cell (7).

After finishing filling in cells, you click on the buttons according to instructions. "LL Table Maker" file and "Save Range As KML" file starts automatically followed by appearance of a table "Sample dots (Coodinate Values)" and Google Earth starts automatically. Finally Sample dots will appear on Google Earth automatically. As sample dots are put within whole target area on Google Earth, you conduct crop cutting at the sample dots which have fallen on rice planted spots.

LL Sheet for the dot sampling

T-1 Basic data to generate sample dots (Sampling Design)

Target area	Size of the Target area km^2	Sample size	Starting point (latitude)	Starting point (longitude)	Finishing point (latitude)	Finishing point (longitude)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
TsubameshiY	52	10	37.73	138.78	37.59	138.98

1-(1) Click here to check data in T-1 table

2. Sampling based on the "Sampling design"

2-(1) Click here to complete T-2 table

2-(2) Click here to make a KML file

3.2.2 Step2 Crop cutting, threshing, drying, weighing

You conduct crop cutting at a spot which a sample dot falls on. If you need to conduct crop cutting at more than one spot in one field, you conduct crop cutting at a spot which a sample dot falls on and at other spots around the spot in a preset way. You conduct crop cutting in a same way as farmers do. After reaping rice-plants, you thresh, dry and weigh them.

3.2.3 Step3 Estimation of average yield/ha in a target region

You estimate average yield by simple average without taking into account a size of rice filed for crop cutting sample, as the fields for crop cutting are selected with probability proportional to size.

Note: Estimation formula is as follows:

Yield/ha $\bar{X}=\frac{\sum X_i}{n}$

Standard error $s_{\bar{X}}=\sqrt{\frac{s^2}{n}}$ when $s^2=\frac{1}{n-1}\sum(X_i-\bar{X})^2$

Chapter 4 Example of Rice Production Survey Using the Dot Sampling Method

In this chapter, you learn the example of rice production survey.

Following case is the results of the rice production survey using the Dot Sampling Method in a target area of 20 hectares conducted in the JICA Training Course 2015 in Japan. The survey took two days: one day for an estimation of rice planted area and one day for an estimation of average rice yield and production.

Rice production survey is conducted with a package of planted area survey explained in Chapter2 and yield survey explained in chapter3.

Namely, rice production in a target area is calculated:

(average rice yield in a target region) x (rice planted area in a target region)

4.1 Planted area survey

On the training, groups of trainees put 80 sample dots in a target area of 20 hectares on Google Earth.

At first they conducted preparatory survey on Google Earth. They judged from Google Earth that 23 dots fell on non-cultivated field such as building, road and river which they don't need to conduct field survey.

Secondly, they judged remaining 57 dots to be necessary for them to visit to confirm if dots fell on rice planted spots or not. After conducting field survey, they found out that 50 out of 57 dots fell on rice planted spots.

The results are shown in the table below: rice planted area, precision and standard error are estimated 12.5ha, 8.7% and 1.1ha respectively.

Category	Code No.	Number of dots	Share	Estimated Area	Variance	Standard error	Precision (%)	Error (ha)
		n = 80	p	20 × p	p × (1−p)	$\sqrt{\frac{p \times (1-p)}{n}}$	$\frac{standard\ error}{p}$	Estimated area × precision
Non-cultivated land	1	23	0.288	5.8	0.2048	0.051	17.6	1.0
Dyke	3	3	0.038	0.8	0.0361	0.021	56.6	0.4
Abandond cultivated land	10	3	0.038	0.8	0.0361	0.021	56.6	0.4
Unplanted land	11	1	0.013	0.3	0.0123	0.012	99.4	0.2
Rice	**12**	**50**	**0.625**	**12.5**	**0.2344**	**0.054**	**8.7**	**1.1**
Other crops	13	0	0.000	0.0	0.0000	0.000		
Total		80	1.000	20.0	0.0000	0.000	0.0	0.0

4.2 Yield survey

Concerning Yield survey, rice yield per hectare was estimated with crop cutting method. Trainees selected sample spots for crop cutting with probabilities proportional to size. As they used the Dot Sampling Method, they were able to select sample spots for crop cutting without procedures such as preparing list of farmers in a target region and selecting sample rice fields.

Trainees had to follow procedures described in step 1 of 3.2, but in the Training course, they selected six sample spots for conducting crop cutting from the one field which was borrowed from a farmer for the training. The results were shown in following table: average yield in the target area is 9.28t/ha, precision is 6.4%, sampling error is 0.59t.

Sample number (n = 6)	Symbol	Yield(t/ha)
No1	X_1	11.08
No2	X_2	9.95
No3	X_3	9.68
No4	X_4	8.39
No5	X_5	9.66
No6	X_6	6.89
Sample mean (Estimated Yield)	$\bar{X}$	9.28

Item	Symbol	Formula	Results
Sample variance	s^2	$\frac{1}{n-1}\sum(X_i-\bar{X})^2$	2.10
Sample standard deviation	s	$\sqrt{s^2}$	1.45
Sample coefficient of variation(%)	CV_X	$\frac{s}{\bar{X}}$	15.62
Sample mean variance	$s_{\bar{X}}{}^2$	$\frac{s^2}{n}$	0.35
Standard error (sample error)	$s_{\bar{X}}$	$\sqrt{s_{\bar{X}}{}^2}$	0.59
Sample mean coefficient of variation(%)	$\mathrm{CV}_{\bar{X}}$	$\frac{s_{\bar{X}}}{\bar{X}}$	6.38

Note: Concerning selecting sample spots for crop cutting, with the Dot sampling method, you have two methods for selecting samples described in step 1 of 3.2: one is you select 6 dots out of 50 dots which have fallen on rice planted spots used for planted area survey. Another way is select six sample dots on Google Earth with using Excel Macro. But in the JICA Training Course 2015, one field was borrowed from a farmer for the training and six groups of trainees conducted actual crop cutting for training at selected six spots there.

4.3 Production survey

From the results of planted area survey and yield survey, production of rice in a target district and the precision are estimated 116t and 10.8% respectively as show in following table.

	Yield (t/ha)	Planted area (ha)	Production (t)	Calculation
Estimation	9.28	12.5	116	9.28×12.5
C.V. (%)	6.4	8.7	10.8	$\sqrt{6.4^2 + 8.7^2}$
Survey Method	Crop Cutting, Selection of sample spots with Probability Proportional to Size using the Dot Sampling Method	Attribute survey with the Dot Sampling Method	Production = Yield × Area	

It took only two days for you to conduct rice production survey: one day for rice planted area survey and one day for rice yield survey and estimation of rice production in a target district of 20 ha. The reasons why you can conduct production survey in such a short time which you have needed considerable days to conduct so far, are you can conduct area survey in dramatically short time with the Dot Sampling Method and you don't need to make a list of farmers to select sample farmers, fields and spots for crop cutting.

Chapter5　Mystery of the Dot Sampling Method

The more you learn the Dot Sampling Method, the more you encounter its mysterious characters. In this chapter you learn two mysterious cases.

5. 1　Better precision than theoretical precision

The first mystery is that precision of the result with the Dot Sampling Method are always better than theoretical precision. Standard errors of sample means are always several times better than theoretical values. In another word, a estimated value is stable and its valiance is always smaller than theoretical value.

The following table was made by Mr. Issei Jinguji and is a good example of this mystery. He conducted land use survey in Shiga prefecture using 1,000 samples with the Dot Sampling Method 16 times on Google Earth. According to the results of 16 times surveys, variance of estimated cultivated are is extremely smaller than theoretical variance with simple random sampling. In this case, relative efficiency, $\frac{V_{simple}}{V_{systematic}}$, is 3.7 times, which means the precision of the results of cultivated area using systematic sampling with 1,000 samples are as same the precision of the results using simple sampling with 3,700 samples. In the case of the results of the Lake Biwa survey, relative efficiency is more than 26 times.

	Non-cultivated Land	Lake Biwa	Cultivated Land	Cultivated Land without Dyke	Dyke within Cultivated Land
Test 1	70.6	16.5	13.0	12.2	0.8
Test 2	68.3	16.9	14.8	14.0	0.8
Test 3	69.6	16.8	13.6	12.6	1.0
Test 4	70.2	16.7	13.2	11.9	1.2
Test 5	69.7	17.0	13.4	12.4	1.0
Test 6	70.2	16.5	13.2	12.2	1.0
Test 7	69.5	17.0	13.6	12.7	0.9
Test 8	69.9	16.9	13.2	12.4	0.8
Test 9	70.3	16.5	13.2	12.1	1.1
Test 10	69.7	16.9	13.5	12.2	1.2
Test 11	69.8	16.8	13.5	12.8	0.7
Test 12	68.2	16.8	14.9	14.0	0.9
Test 13	69.6	16.7	13.7	13.0	0.7
Test 14	70.0	16.1	13.9	12.9	1.0
Test 15	70.3	16.4	13.3	12.3	1.0
Test 16	68.9	16.6	14.4	13.5	0.9
Average of 16 Tests by Systematic Sampling	69.7	16.7	13.6	12.7	0.9
Official Value	70.2	16.7	13.1	12.5	0.6
Standard Deviation by Systematic Sampling	0.65	0.23	0.57	0.62	0.15
Coefficient of Variation by Systematic Sampling	0.93	1.38	4.16	4.89	16.00
Standard Error by Simple Sampling	1.45	1.18	1.09	1.05	0.30
Coefficient of Variation by Simple Sampling	2.1	7.1	8.0	8.3	32.5
Relative Efficiency	5.0	26.3	3.7	2.9	4.1

Source: Issei JINGUJI, December, 2015

Concerning attribute survey such as the Dot Sampling Method, theoretical variance is calculated with $\frac{\hat{p}\hat{q}}{n}$ under the condition of simple sampling. As the formula for calculating variance in case of systematic sampling has not been developed yet, variance of estimated values based on systematic sampling is to be calculated referring to the formula for simple sampling or results of surveys conducted repeatedly. Though actually conducting surveys repeatedly is difficult to carry out, you can simulate surveys any number of times by preparatory survey on Google Earth as mentioned above. Now you can confirm the superiority of the Dot Sampling Method with systematic sampling, but how much relative efficiency the Dot Sampling Method has in general is necessary to be studied more.

5.2 Sampling survey or measuring survey

The second mystery is that the Dot Sampling Method might be under a category of measuring method rather than sampling method.

This idea comes from the assumption that the Dot Sampling Method is a same method as measuring area by Point Grid Plate, as dots are arranged with grid pattern with the Dot Sampling Method like Point Grid Plate. This idea also explains the reason why precision of the Dot sampling method is better than theoretical precision, as error of the Dot Sampling Method is mere measuring error rather than sampling error.

Actually, increasing the number of sampling dots could be similar to improving resolution of satellite image or increasing fineness of scale. So, you could dare say that the Dot sampling method is measurement method rather than sampling method. In the case of area survey using Point Grid Plate, in order to reduce measuring error, it is recommended to measure area three times and the average of three values are determined as area, this means that area survey using Point Grid Plate has nothing to do with sampling error

The theoretical concept of the Dot Sampling method mentioned above is expected to be developed by experts such as mathematicians.

Chapter 6 Dissemination of the Dot Sampling Method and Similar Methods Overseas

Focusing on characteristics of an attribute survey as written in 1.1, it is an opinion poll method that is similar to the Dot Sampling Method. So the idea of the Dot Sampling Method can be said to have been prevailing widely, as opinion polls has been conducted in many countries. In case of an opinion poll, the targets of survey are persons. If you change the targets of survey from persons to lands, then it will become the method of an area survey with the Dot sampling Method.

Concerning the Dot Sampling Method overseas, it has not been prevailing, though it is a traditional method. The reason is that maps had not been developed to put any number of sample dots on a map. In Europe and the United States, they have developed surveys with a method that puts dots on a map. However, any surveys aren't attribute surveys. They don't select sample dots directly as a survey spots for conducting attribute survey like the Dot Sampling Method, but they select dots for sample spots and measure area at the last process of the survey.

In most of developing countries, sampling surveys have not been prevailing because of adopting reporting system, so surveys using dots have not prevailed.

In this chapter, we learn situation of similar methods overseas and dissemination of the Dot Sampling Method in international technical cooperation activities.

6.1 Situation of similar methods overseas

Concerning the situation of methods similar to the Dot Sampling Method overseas, Mr. Issei JINGUJI has depicted in detail in the document "About the Dot Sampling Method (Japanese version)", December 2015.

In the United States, they have historically adopted method such as selecting points, interviewing farmer of farm including a selected point as a sampling unit (Yoshirou TSUMURA, 1956).

In EU, they select samples for area survey by compiling master points with 2km×2km, selecting Primary sampling unit and selecting secondary sampling unit（see the Web site of LUCAS http://ec.europa.eu/eurostat/web/lucas/methodology）.

Conducting Global Strategy to improve Agricultural and Rural Statistics, FAO has introduced the way to select samples using dots as one of master sampling method. FAO also introduced the technical assistance on the Dot Sampling Method conducted in Tanzania as one example of the technical assistances conducted by Japan in the report “Technical Report on Improving the Use of GPS, GIS and Remote Sensing in Setting Up Master Sampling Frames”（FAO,2015）. FAO published the report ”CROP MONITORING FOR IMPROVED FOOD SECURITY” ,FAO&ADB Bangkok 2015, explaining the Dot Sampling Method in detail.

6.2 Dissemination of the Dot Sampling Method in international technical cooperation activities

The Dot Sampling Method has been introduced in international technical cooperation activities conducted by Japan.

Concerning JICA Group Training Program “Planning and Designing of Agricultural Statistics” which is conducted for government staff member in charge of agricultural statistic from countries in Asia, Africa and other regions, every year more than a dozen trainees come to Japan and they have been learning the Dot Sampling Method since 2011. The dot Sampling Method have got high evaluations from trainees who were learned to conduct rice production survey in the training, saying that, with the Dot Sampling Method, crop production survey is conducted easily and possible to conduct without human and budgetary resources.

In the Project “Improving Food Security Information in Africa” supported by Japan from 2013 to 2016 and conducted through Africa Rice to improve food security and reduce poverty in sub-Saharan Africa through improving the availability and reliability of rice production statistics in support of the objectives

of the Coalition for African Rice Development (CARD) initiative, the Project adopted the Dot Sampling Method as one of survey methods.

The Japan funded project “Strengthening Agricultural Statistics and Food Security Information in CARD Countries through South-South Cooperation” conducted through FAO to contribute to the success of CARD initiative in terms of creation of reliable statistics to evaluate CARD’s progress from 2013 up to now also adopted the Dot Sampling Method as one of survey methods.

Chapter 7　Frequently Asked Questions on the Dot Sampling method

This chapter is a list of frequently asked questions (Q) and answers (A) arisen during the development and dissemination process of the Dot Sampling Method.

Q　Is resolution of Google Earth too low to use for area survey?

A　Resolution of Google Earth doesn't have to do with the results of a survey, because the main role of Google Earth in the Dot Sampling Method is to guide enumerators to the spots of sample dots.

However, in the case of another role of the Dot Sampling Method that helps to separate sample dots which are necessary to conduct field survey and dots which are unnecessary as mentioned in chapter 2, more sample dots may be categorized into dots which are necessary to conduct field survey and you need more time to conduct area survey if resolution of Google Earth is low to clarify them. In most cases, resolution of Google Earth is high enough so that you can conduct preparatory survey properly.

A　Are images of Google Earth old?

Q　According to the Web site of Google Earth, images of Google Earth are to be updated every one to three years. As they are not so old, you can use them for area survey(http://www.google.co.jp/intl/ja/earth/help/).

But it may actually happen that a spot which is rice filed on Google Earth turns to be a residential land at the time of field survey. In this case, no problem happens, as present land use is clarified by a field survey.

On the contrary, in case of a spot which is forest land on google Earth and is categorized a dot which is unnecessary to conduct field survey, problem happens if the spot has cultivated and changed to be rice field. Therefore it is

recommended that you conduct a preparatory survey after getting information on a target area as much as possible.

Q Is it difficult to distinguish rice field from upland field on Google Earth?

A Yes, it is sometimes difficult, though you can distinguish rice field from upland field to a considerable extent by the existence of dyke or a shape of field.

But you don’t need to worry about its difficulty, because actually you conduct filed survey to clarify sample dots which are categorized to be necessary to conduct a field survey at the time of a preparatory survey.

Q Is it possible to distinguish orchard from other land usages on Google Earth?

A Yes it is possible. It has been confirmed from experience that you can judge orchard to some extent from the shape of planting pattern and shape of trees. Also you often clarify it with the function of street view of Google Earth.

As you conduct field survey to clarify sample dots which are categorized to be necessary to conduct a field survey at the time of a preparatory survey, you don’t need to worry, even if you cannot categorize land usage precisely on Google Earth.

Q Do you need GPS when you visit sample spots on field survey?

A It has been confirmed from experience that you manage to make it to sample spots without GPS. There is no reason to deny using GPS, but a survey without GPS might be more efficient than with GPS, thinking of time and effort for data entry into GPS.

If an enumerator is able to use a computer or smartphone in the field, it is more efficient to conduct a field survey while looking at a screen of Google Earth with KML file you made automatically in chapter 2.

If an enumerator cannot use a computer or smartphone in the field, an

enumerator has to bring hardcopies of maps of Google Earth beforehand and conducts a field survey. When an enumerator visits unfamiliar place, he needs at least two hardcopies of map, namely one for general view to guide him to a vicinity of field and another for more enlarged view around sample dot.

Please note that it is necessary to improve capacity of enumerators to read maps who cannot read maps and cannot reach at a field.

Q Does systematic random sampling generate big bias for estimation, if there are roads or canals in the east and west direction or the north and south direction?

A In order to verify bias, preparatory surveys were conducted 16 times on Google Earth with 500 sample dots in Oogata village, Akita, Japan on Google Earth where many roads, canals and dyke are oriented in the east and west direction or the north and south direction. When we compared variance by simple random sampling with systematic random sampling to see relative efficiency, the results were as same as the case in Shiga prefecture mentioned in chapter 5, though attributions of samples were sometimes exchanged dramatically like Othello game.

Q Is there no need for stratification?

A Main purpose of stratification is increasing precision under a certain number of samples by setting the number of samples by stratification. But it takes time and labor for you to conduct practical activities such as stratifying and deciding the number of samples by stratification. Even if you conduct stratified sampling, it is generally known that stratification doesn't have large effect which depends on availability of prior information which is necessary for stratification and the way of stratification.

On the contrary, in case of the Dot Sampling Method, you put sample dots with same intervals in the target region without stratification. Therefore practical activities have been simplified. Besides, you can achieve the purpose

of survey design to increase efficiency significantly by reducing the number of sample dots for a field survey thorough a preparatory survey which has significance like stratification by identifying which samples are necessary for field survey or not.

Q What are merits for the Dot Sampling Method compared with ratio estimation?

A Ratio estimation has a merit that precision becomes high and you can reduce the number of samples for field survey when auxiliary variable has strong correlation with a survey item.

In comparison with ratio estimation, the Dot Sampling Method is confirmed by the simulation results that precision is as same as ratio estimation with same number of samples for field survey, as systematic sampling has been known from experience that precision with systematic sampling is better than theoretical precision.

In addition, the Dot Sampling Method has a characteristic that you can efficiently estimate any survey items, as the Method doesn't need auxiliary variable.

Please note that the Dot Sampling Method has merits that you can estimate area of various crops easily with the Dot Sampling Method as you don't need to increase necessary resources for field survey or tabulation even for various crops and that non-sampling error hardly happens with the Dot Sampling Method.

Afterword

Compiling the essence of the Dot Sampling Method from materials created so far related to the development of the Method, I feel again the greatness of power and possibility in the Dot Sampling Method. On the other hand, not a few people really think that the Dot Sampling Method is too simple and different from traditional method developed thus far to adopt the Method.

I am thinking of developing the Dot Sampling Method for more people to understand the Method and apply it to actual statistical survey.

The Dot Sampling Method has been developed by cooperation of people who are engaged in international technical cooperation. The Excel Macros for the Dot Sampling Method had not been developed without cooperation of experts engaging in technical assistance in Tanzania and staff of MAFF Japan. In addition, demonstration experiments were conducted with a cooperation of trainees of training in Japan from other countries. The current Dot Sampling Method is a compilation of cooperation of many people and projects adopting the Dot Sampling Method as one of methods such as “Improving Food Security Information in Africa” conducted through Africa Rice and “Strengthening Agricultural Statistics and Food Security Information in CARD Countries through South-South Cooperation” conducted by FAO.

I would like to express my sincere gratitude for your efforts in developing the Dot Sampling Method. I would be glad if you continuously give me your opinions and suggestions towards the development of the Dot Sampling Method.

Reference

JINGUJI, Issei: ドット標本調査法について～その基本的考え方、効率性、信頼性についての検討～, December 2015

JINGUJI, Issei: Google Earth を利用したドット標本調査法による土地利用面積調査について、法政大学 日本統計研究所, October 2014

KAMIKURA, Kenji: 「農」の統計に係る開発途上国に対する技術協力、齊藤昭編著「農」の統計にみる知のデザイン第 10 章、農林統計出版, April 2013

JINGUJI, Issei: Dot Sampling Method for area estimation, CROP MONITORING FOR IMPROVED FOOD SECURITY, FAO & ADB, 2015 (http://www.fao.org/fileadmin/templates/rap/files/Project/Expert_Meeting__17Feb2014_/P1-1_Dot_sampling_method_for_planted_area_estimation_using_Google_earth___land_use_survey__FAO_RAP_17_Feb_2014.pdf)

JINGUJI, Issei: How to Develop Master Sampling Frames using Dot Sampling Method and Google earth, December 2012 (http://www.fao.org/fileadmin/templates/ess/global_strategy/PPTs/MSF_PPTs/5.MSF_Dot_sampling_method_on_Google_Earth_Jinguji.pdf)

KUGA, Nobunori: An Experiment on Accuracy and Precision of Dot Sampling Method, February 2014

KAMIKURA, Kenji : What you can do with the Dot Sampling Method using Google Earth, Fifth meeting of the Regional Steering Committee for Asia and the Pacific for the Global Strategy to Improve Agricultural and Rural Statistics Bangkok, Thailand, 9 December 2015

KAMIKURA, Kenji: Package of Agricultural Production Survey, AfricaRice, Cotonue, Benin, March 2013
(https://wpqr4.adb.org/LotusQuickr/agstat-ap/Main.nsf/0/6716E47F1793360B48257B5D002EC9F4/$file/Package%20of%20Agricultural%20Production%20Survey.pdf)

KAMIKURA, Kenji: Estimation of Planted Area using the Dot Sampling Method, FAO APCAS 24, October 2012
(http://www.fao.org/fileadmin/templates/ess/ess_test_folder/Workshops_Events/APCAS_24/Paper_after/APCAS-12-21-_Planted_Area_using_Dot_Sampling.pdf)

TSUMURA, Yoshirou: 標本調査法、岩波全書, June 1956

TAKEUCHI, Kei: 偶然とは何か、岩波新書、June 2010

YATES, Frank: Sampling Methods for Censuses and Surveys, Charles Griffin & Co. Ltd., 1949