Review
of
the Dot Sampling Method
for
a Planted Area Survey
and
a Yield Survey

: Solutions to

Widely Misunderstood Matters

19-20 June 2019

The FAO Validation Workshop of the Project
“Strengthening Agricultural Statistics and Food Security Information
in CARD Countries through South-South Cooperation”
Nairobi, Kenya

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Preface

This document is compiled to share the idea of Dot Sampling Method among the participants of the Project.

You have learned the Method during the Project and found out lots of possibilities the Method has. However, I am afraid some of you may have misunderstood the Method.

In this document, you will review the true nature of the Method, which is based on a traditional method.

In the first section of this document, you visually review the concept of the Method.

In the second section, you brush up three different ways of usage for “LL Sheet for the dot sampling”.

In the third section, you learn how to solve five issues which you might encounter on a planted area survey with the Dot Sampling Method.

1) Can you conduct a planted area survey every month with the Method?
2) Can you apply the Method to minor crops?
3) Can you examine attribution of a sample dot on Google Earth for a preparatory survey?
4) Can you introduce the Method into a statistical system in your country?
5) Can you estimate planted area using the Dot Sampling Method much better than using the hearing method to farmers?

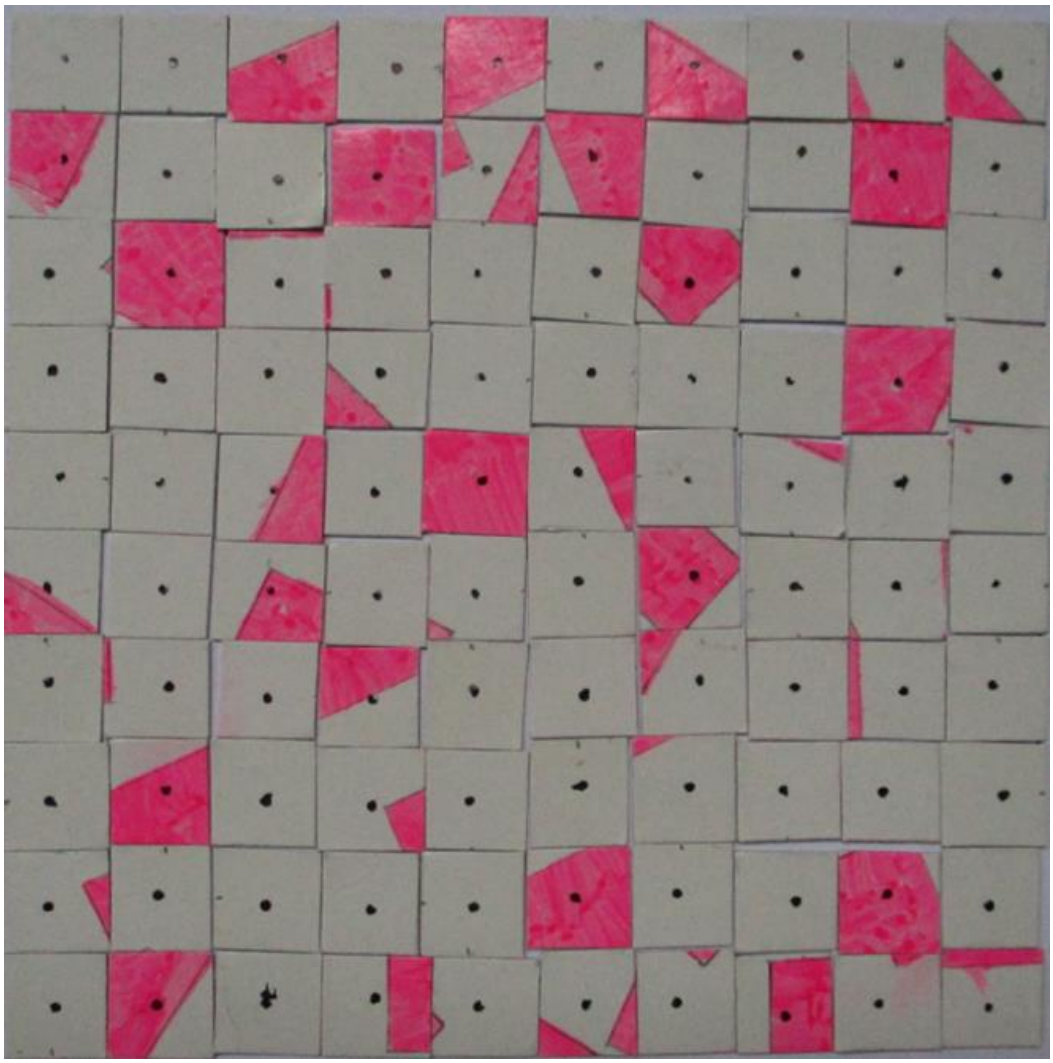
In the fourth section, you reconfirm how to select sample spots for crop cutting with the Method with perfect PPS, probabilities proportional to size, without preparing a list of farmers with planted area in the target region.

In the fifth section, as a case study, you can review the result of a production survey using the Dot Sampling Method in Tsukuba Hamlet at the time of a study course “JICA Knowledge Co-Creation Program on Agricultural Statistics Planning and Designing.”

1 Concept of the Dot Sampling Method

The figure below shows a target region of 100 ha (W).

You are going to estimate the total area of red fields using the Dot Sampling Method.



Let's estimate the area of red fields above.

1) you put 100 sample dots (n) in a target region;

2) you count the number of sample dots which fall on red fields

=> the number of sample dots(n_1) is 18;

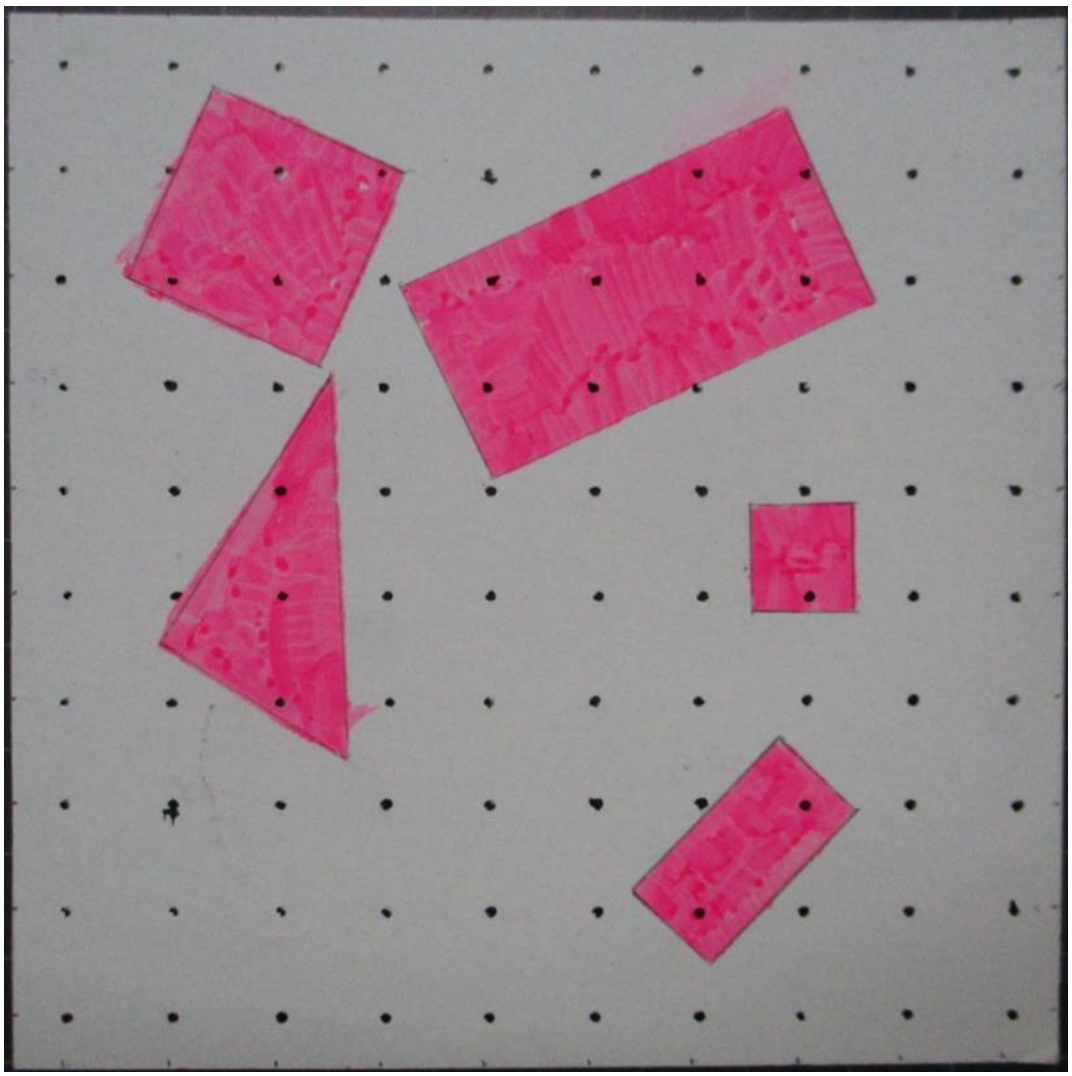
3) you estimate the red field area （$\hat{T}$） by multiplying the area of the target region (W) by the ratio （$\hat{p}=\frac{n_1}{n}$） .

=> $\hat{T} = \hat{p} \times W = \frac{18}{100} \times 100\text{ha}$ = 18ha (Precision= 21.3%, See page 12)

(The precision is 6.7%, when you put 1,000 sample dots in a target region.)

The total area of red fields in below picture is as same as that in the picture above. You could divide the picture below to make the picture above.

The area of red fields is 18ha (= 4ha + 8ha + 3ha + 1ha + 2ha).



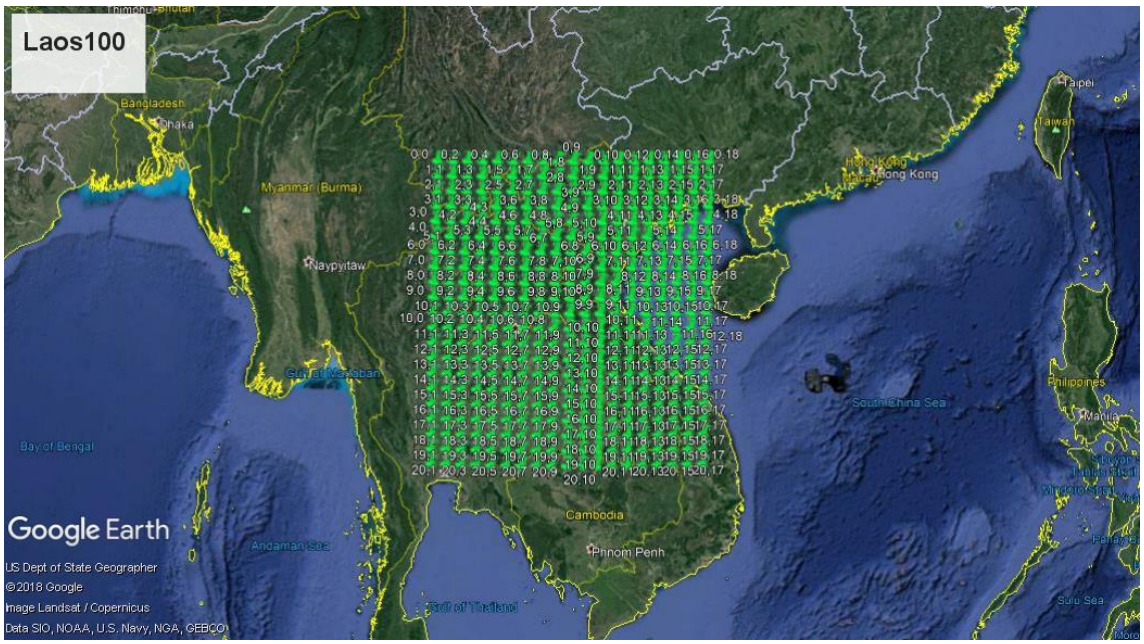
2 Review of ways how to use “LL Sheet for the dot sampling” : Three examples

2.1 Putting sample dots on a target region on Google Earth

Suppose you want to put 100 dots in Lao PDR (238,000 km^2), you fill in T-1 Table as below.

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)
Laos100	*238000*	*100*	22.52	100	13.88	107.72



Note: In some cases, you have to draw a boundary line of the target region on a map.

Fortunately, on Google Earth, international boundary lines and large administrative dividing lines are available. In other cases, you need to download shapefiles of the administrative boundaries such as GADM, the Database of Global Administrative Areas, a high-resolution database of country administrative areas.

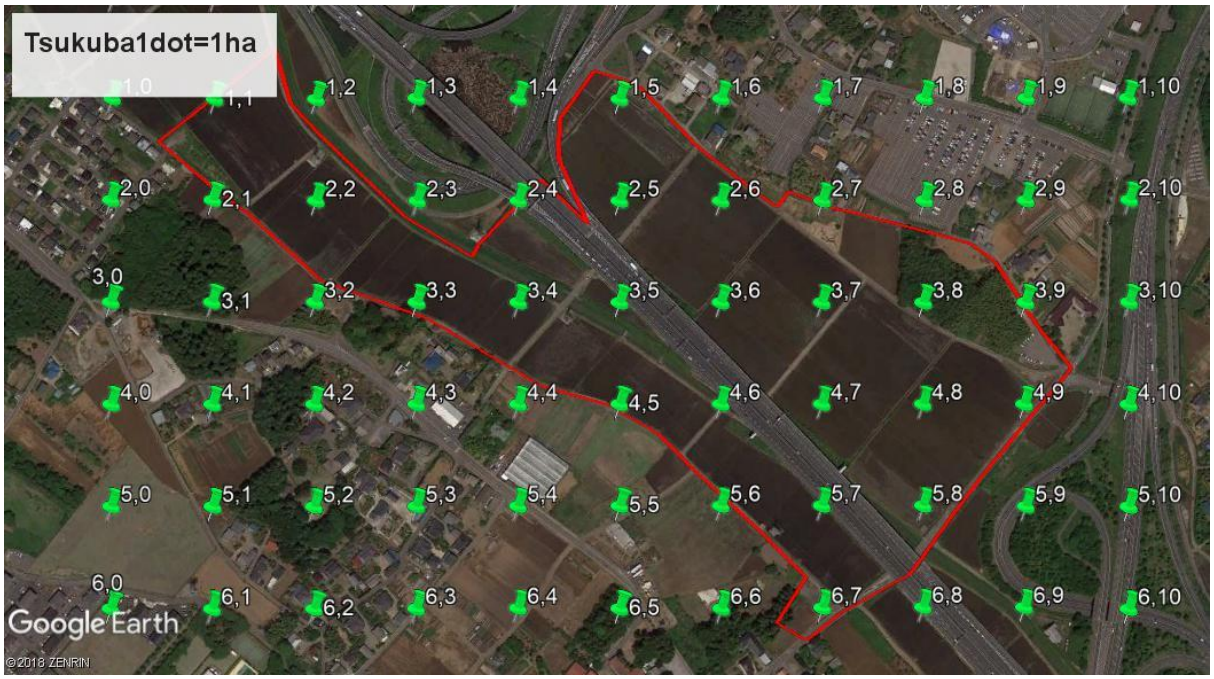
You could even create polygon of your own on Google Earth so that you can set any shape of a target region.

2.2 Putting one dot per hectare

Suppose you want to put 1 dot per 1 ha (=0.01km^2) in a target region, you fill in T-1 Table as below.

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)
Tsukuba1dot=1ha	*0.01*	*1*	36.032451	140.1226	36.026	140.1329



Note 1: This method is a modern version of a Point Grid Plate Method which may be familiar to you as it is a traditional method for measuring area.

Note 2: You could use this method as a two-dimensional ruler or ruler for measuring area.

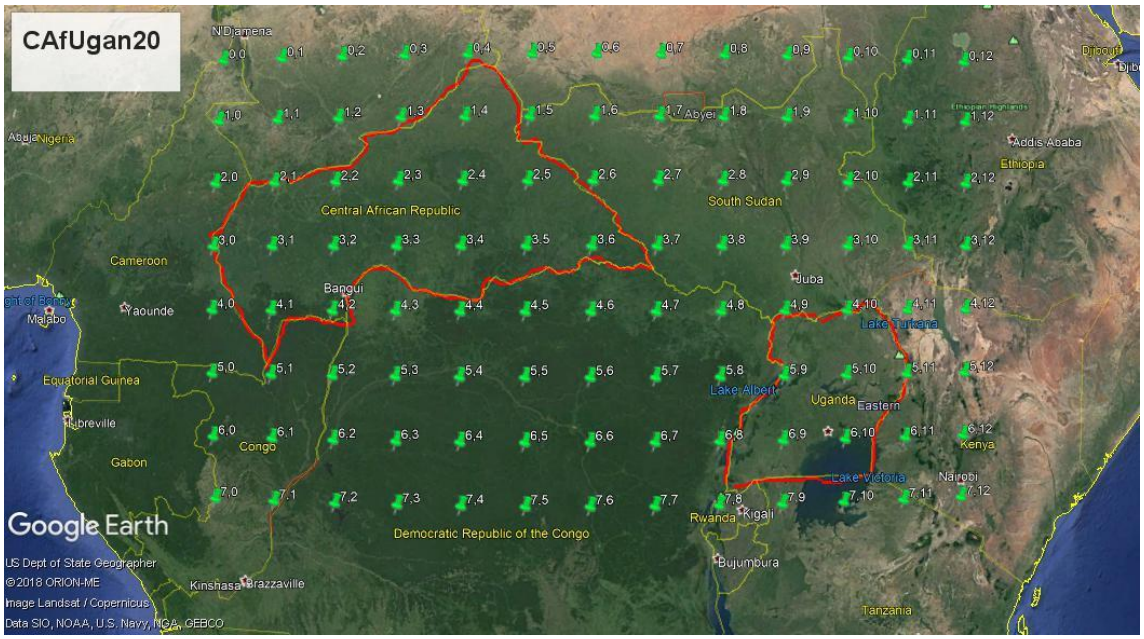
2.3 Putting sample dots on scattered target regions on Google Earth

(Case1)

Suppose you want to put totally 20 dots in Central African Republic (623,000km^2) and Uganda (241,000km^2), you fill in T-1 Table as below.

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)
CAfUgan20	***864000***	***20***	11.05	14.36	−1.56	35.07



(Case2)

Suppose you want to put 6 dots on rice fields in Tsukuba Hamlet, you fill in T-1 Table as below, when the total area of rice fields in Tsukuba Hamlet is 0.1225km^2.

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)
JICA 6 (0.1225)	*0.1225*	*6*	36.032451	140.1226	36.026	140.1329

3 How to solve five issues which you might encounter on a planted area survey with the Dot Sampling Method

3.1 Can you conduct a planted area survey every month with the Method?

(Solution)

The Method is the only one solution for conducting planted area survey every month with less monetary and human resources. Once you put sample dots on the target region, you can use the same sample dots for years afterwards.

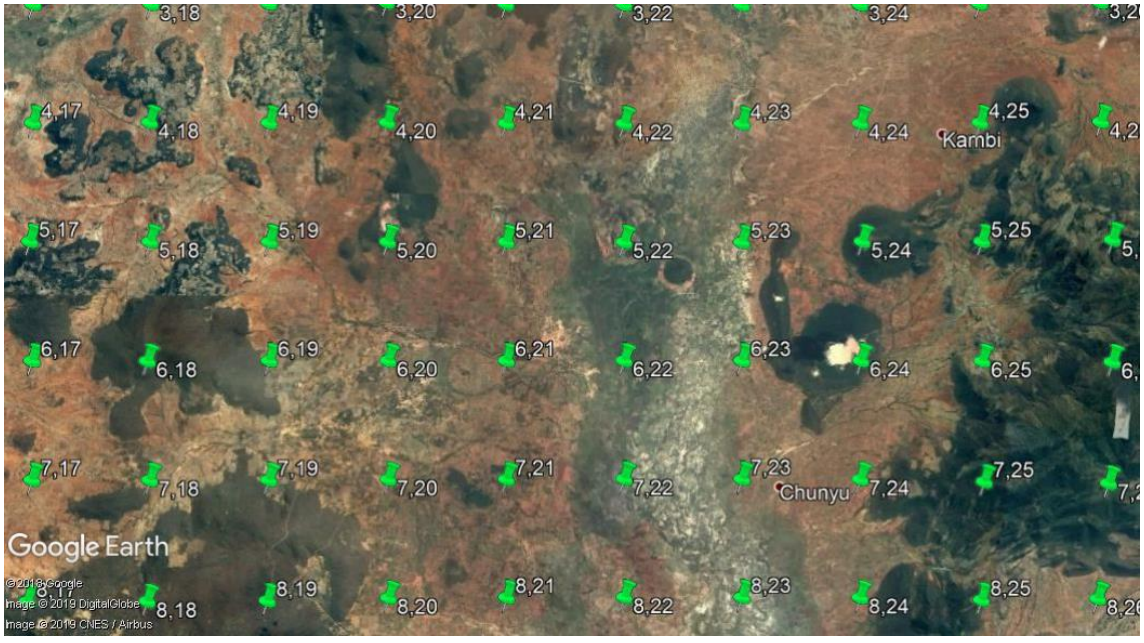
(Explanation)

The following is an example of a project to conduct a planted area survey every month, so that you can get planted area of each crop every month in the target district.

1) First step (In the first year of the project)

You put 1,000 sample dots in the target district. And you decide sample dots to visit which have possibility to fall on cultivated land.

(Suppose the share of cultivated land is 40% of the target district, the number of sample dots to visit is 400 in a district.)



2) Second step (From the second year of the project)

An extension worker in a village visits same sample dots every month to examine which crops are planted at the sample dots.

(Suppose there are 80 villages in a district and 400 sample dots to visit in a district, the average number of sample dots to visit in a village is 5.)

3) Third step

You estimate planted area of each crop every month.

(Suppose 80 sample dots fall on rice, you can estimate the planted area of rice with the precision of 10.7%.) (See page 12)

3.2 Can you apply the Method to minor crops?
(Solution)

The method can apply to minor crops. You can estimate planted area of minor crops in a target region with the Dot Sampling Method.

(Explanation)

With the Method, 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 the planted area of the crop.

You only need to put the number of dots required for the survey.

Two tables on following 2 pages show the number of sample dots required for a survey.

1) The first table shows the **number of sample dots** required by aimed precision for a preparatory survey.

2) The second one shows **precision** by the number of sample dots for a preparatory survey.

Note: Two tables on following two pages are for a preparatory survey.

In case of a field survey, you visit only sample dots which have possibilities to fall on the target crop planted spots, so the number of sample dots you visit at the time of a field survey is less than the number shown in two tables for a preparatory survey.

The Number of Sample Dots Required by Aimed Precision for a Preparatory Survey

Share of rice planted field in a target region	Aimed Precision		
Share = p%	CV = 3%	CV = 5%	CV = 10%
1	110,000	39,600	9,900
2	54,444	19,600	4,900
3	35,926	12,933	3,233
4	26,667	9,600	2,400
5	21,111	7,600	1,900
6	17,407	6,267	1,567
7	14,762	5,314	1,329
8	12,778	4,600	1,150
9	11,235	4,044	1,011
10	10,000	3,600	900
20	4,444	1,600	400
30	2,593	933	233
40	1,667	600	150
50	1,111	400	100
60	741	267	67
70	476	171	43
80	278	100	25
90	123	44	11

Note: Calculation fomulas are as follows:

$$\text{Sample size for Preparatory Survey} = \frac{(population\ standard\ deviation)^2}{(aimed\ standard\ error)^2}$$

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

Precision by the Number of Sample Dots for a Preparatory Survey

Share of rice planted field in a target region	Precision by the Number of Sample Dots (%)					
p %	100 dots	200 dots	500 dots	1000 dots	5000 dots	10000 dots
0.5	141.1	99.7	63.1	44.6	19.9	14.1
1	99.5	70.4	44.5	31.5	14.1	9.9
2	70.0	49.5	31.3	22.1	9.9	7.0
3	56.9	40.2	25.4	18.0	8.0	5.7
4	49.0	34.6	21.9	15.5	6.9	4.9
5	43.6	30.8	19.5	13.8	6.2	4.4
6	39.6	28.0	17.7	12.5	5.6	4.0
7	36.4	25.8	16.3	11.5	5.2	3.6
8	33.9	24.0	15.2	10.7	4.8	3.4
9	31.8	22.5	14.2	10.1	4.5	3.2
10	30.0	21.2	13.4	9.5	4.2	3.0
15	23.8	16.8	10.6	7.5	3.4	2.4
20	20.0	14.1	8.9	6.3	2.8	2.0
30	15.3	10.8	6.8	4.8	2.2	1.5
40	12.2	8.7	5.5	3.9	1.7	1.2
50	10.0	7.1	4.5	3.2	1.4	1.0
60	8.2	5.8	3.7	2.6	1.2	0.8
70	6.5	4.6	2.9	2.1	0.9	0.7
80	5.0	3.5	2.2	1.6	0.7	0.5
90	3.3	2.4	1.5	1.1	0.5	0.3

Note: Calculation are as follows:

$$\text{Precision} = \frac{Standard\ error}{p} \times 100\ (\%)$$

$$\text{Standard Error} = \sqrt{\frac{p(100-p)}{n}}$$

where
n = number of sample dots
p = Share of rice planted field in a target region

3.3 Can you examine attribution of a sample dot on Google Earth for a preparatory survey?

(Solution)

The Method works well, even if you cannot examine attribution of dots on Google Earth.

(Explanation)

Please don't worry. The role of a preparatory survey is not to examine attribution of sample dots but divide sample dots into two categories.

First category is sample dots which you need to conduct a field survey and another category is sample dots which you don't need to conduct a field survey.

If you cannot examine attribution of a dot, you categorize the dot into a sample dot which you conduct a field survey.

3.4 Can you introduce the Method into a statistical system in your country?

(Solution)

At a first step, you could use the method for evaluation of the appropriateness of the official data of a pilot village, instead of introducing the Method into a statistical system in your country.

(Explanation)

You could make a plan of a project titled "Evaluation of the appropriateness of the official data on rice planted area of a pilot village."

In the project you validate the official data on rice planted area of a pilot village through conducting a rice planted area survey using the Dot Sampling Method in a pilot village. You may conduct a workshop and compare the official data with the result of the project and study the better methodology of a rice planted area survey.

3.5 Can you estimate planted area using the Dot Sampling Method much better than using the hearing method to farmers? (Solution)

The hearing method has not solved lots of problems yet such as; farmers don't know the true value with evidence; you cannot choose sample farmers properly because of lack of population. But the Dot Sampling Method has solved these problems already.

(Explanation)

You might think that it is common to ask farmers to get data through interpersonal hearing method.

This hearing method is popular in some cases, but it has a weak point that you cannot evaluate a validity of the data, as it is often happened that farmers don't know the true value.

There are many advantages in using the Dot Sampling Method as follows.

1) You can get figures without bias, as survey object is not a person but a land.

2) You don't have to develop a statistical population for a survey, as the Method doesn't require a population.

3) You conduct a planted area survey any time you like with less monetary and human resources, as you can use same sample dots for years.

4) You can calculate precision of the results, and it is empirically more precise than theoretical precision.

4 Review of production survey with the Dot Sampling Method

4.1 Estimating production

A production survey consists of two surveys: a yield survey and an area survey.

Production survey = Yield survey + Area survey

Note: “Yield” is used as “production per unit area”

In order to estimate the amount of production in a region, you multiply **average yield** in the region and total **planted area** in the region together.

Total production in the target region
=
Average yield in the target region
×
Total planted area in the target region

(Point to notice)

Please exclude a dyke area from a total planted area in order to avoid overestimating production, when an average yield is calculated without dyke. (See the table on page 19)

On the contrary, please include a dyke area into a total planted area, when an average yield is calculated with dyke.

4.2 Selecting sample spots for crop cutting with the Dot Sampling Method

One of most important activities of a yield survey is to select sample spots for crop cutting.

In order to get an average yield of the target region, you need to select sample spots for crop cutting with PPS, probabilities proportional to size.

With the Dot Sampling Method, you can select sample spots with perfect PPS without preparing a list of farmers with planted area in the target region. You can dramatically streamline the process of selecting samples as well as estimating the average yield by simple average.

Suppose you are going to select 6 sample spots for crop cutting using the Dot Sampling Method. You have two ways of option as follows.

(First option)

Suppose you know the results of a planted area survey and 49 dots (Code No12 in the figure below) out of 80 dots fall on rice planted spots, you extract six sample dots for crop cutting out of 49 dots using systematic sampling method.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
0																			
1																			
2		1	12	1						12	1								
3		1	12	1	1					12	12	12							
4				12	12	1			1	12	12	12	12	1	4				
5					4	12	12	1	12	1	12	12	12	12	1	1	1		
6							12	12	1	1	1	12	12	12	12	12	1	1	
7									12	12	12	1	12	12	12	12	12	12	13
8											12	12	1	12	12	12	12	12	
9												4	12	1	12	12	12		
10													1	12	1	12			
11														1	12	1			
12														13					
13																			

(Second option)

If you haven't conducted a planted area survey with the Dot Sampling Method, you can use an alternative way.

Suppose you know that area of rice field in the target area is 0.1225 km^2, you fill in necessary data in "LL Sheet for the dot sampling".

Then you visit every dot in the target area and check the attribution of each dot at the field, and you find six dots on rice fields.

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)
JICA 6 (0.1225)	*0.1225*	*6*	36.032451	140.1226	36.026	140.1329

5 Case Study

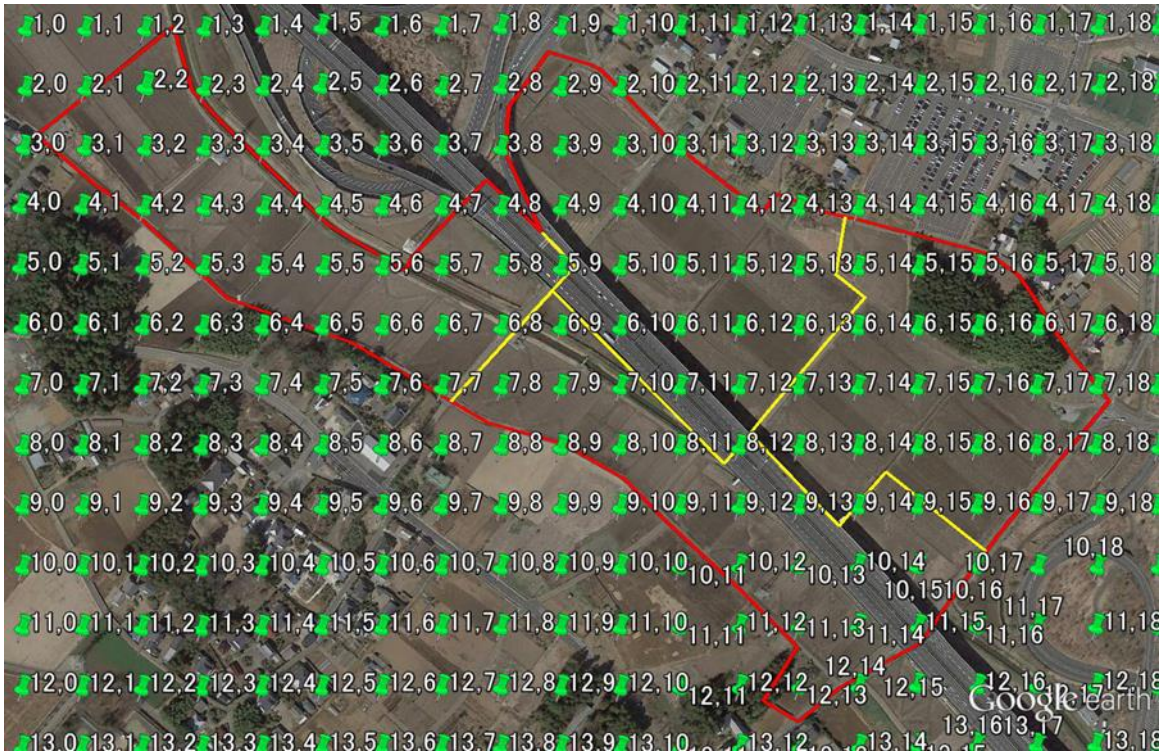
The followings are the result of a production survey using the Dot Sampling Method in Tsukuba Hamlet at the time of a study course “JICA Knowledge Co-Creation Program on Agricultural Statistics Planning and Designing.”

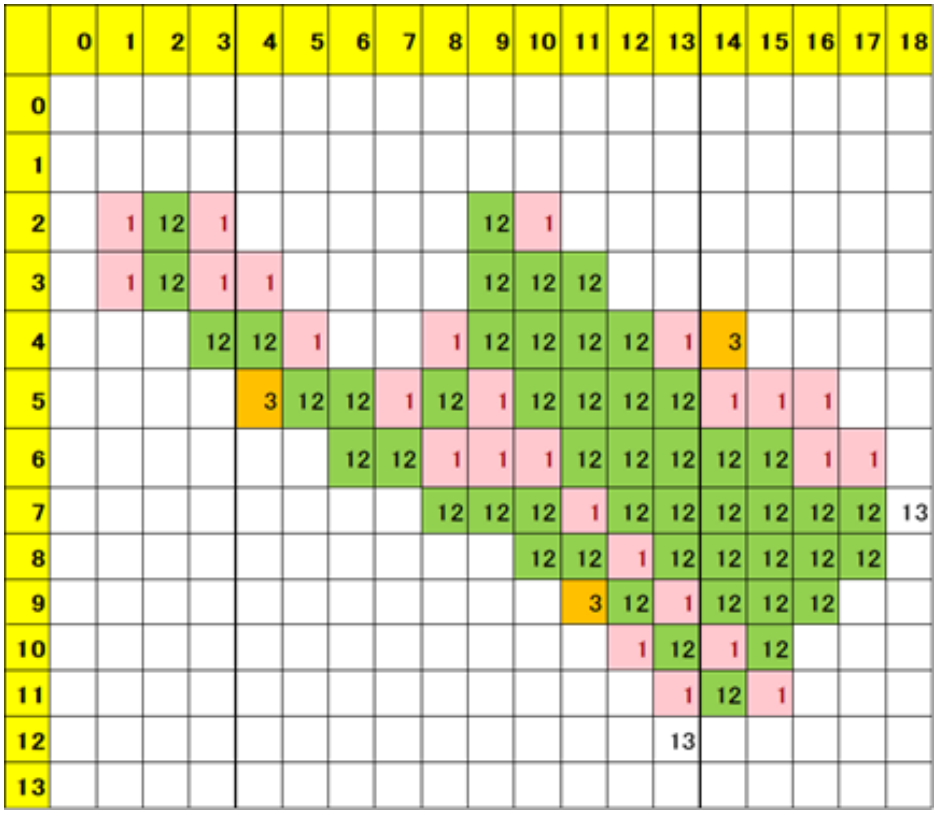
5.1 Planted Area Survey

You conduct planted area survey by putting 80 sample dots in Tsukuba Hamlet.

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)
JICA Training	*0.2*	*80*	36.032451	140.1226	36.026	140.1329





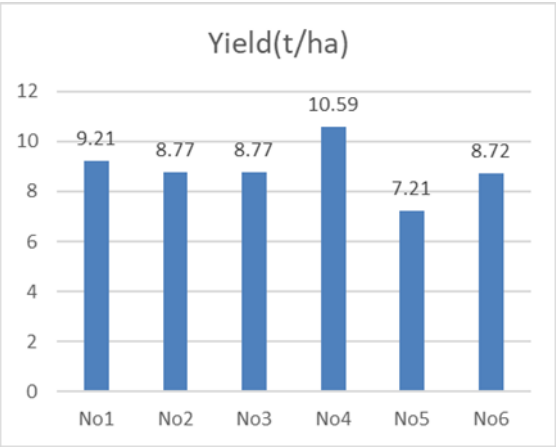
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
0																			
1																			
2		1	12	1						12	1								
3		1	12	1	1					12	12	12							
4				12	12	1			1	12	12	12	12	1	3				
5					3	12	12	1	12	1	12	12	12	12	1	1	1		
6							12	12	1	1	1	12	12	12	12	12	1	1	
7									12	12	12	1	12	12	12	12	12	12	13
8											12	12	1	12	12	12	12	12	
9												3	12	1	12	12	12		
10													1	12	1	12			
11														1	12	1			
12														13					
13																			

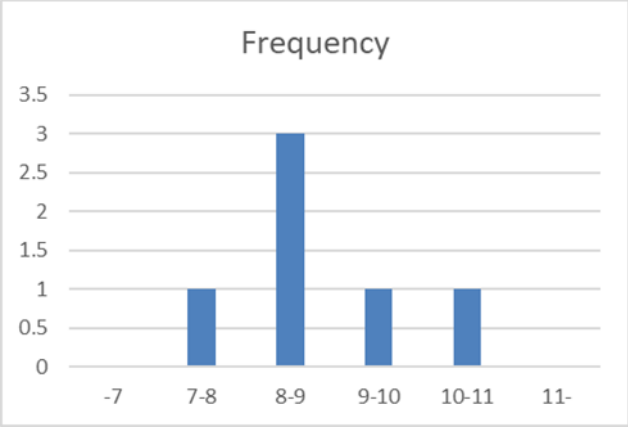
Category	Code	Number of sample dots	Share(p)	Estimate (ha)	pq	SE=√pq/n	CV(%)	SE(ha)
Non-cultivated land	1	26	0.325	6.50	0.2194	0.052	16.1	1.05
Dyke	3	3	0.038	0.75	0.0361	0.021	56.6	0.42
No cropping land (idled lot. More than 2 years)	10	0	0.000	0.00	0.0000	0.000	#DIV/0!	0.00
No cropping land (temporary)	11	0	0.000	0.00	0.0000	0.000	#DIV/0!	0.00
Rice	**12**	**49**	**0.613**	**12.25**	**0.2373**	**0.054**	**8.9**	**1.09**
Other crops	13	2	0.025	0.50	0.0244	0.017	69.8	0.35
Total		80	1.000	20.0	0.0000	0.000	0.0	0.0

5.2 Yield Survey

You conduct a yield survey by selecting 6 sample spots for crop cutting. (See page 16)

Sample number (n = 6)	Symbol	Yield(t/ha)	$(X_i - \bar{X})$	$(X_i - \bar{X})^2$
No1	X_1	9.21	0.33	0.11
No2	X_2	8.77	−0.11	0.01
No3	X_3	8.77	−0.11	0.01
No4	X_4	10.59	1.71	2.93
No5	X_5	7.21	−1.67	2.78
No6	X_6	8.72	−0.16	0.03
Total	$\sum X_i$	53.27	$\sum (X_i - \bar{X})^2$	5.87
Sample mean (Estimated Yield)	$\bar{X}$	8.88	$s^2 = \frac{1}{n-1}\sum (X_i - \bar{X})^2$	1.17
			$s = \sqrt{s^2}$	1.08
			$CV_{\bar{X}} = \frac{s}{\bar{X}} \times 100$	12.21





Sample mean variance	$s_{\bar{X}}{}^2$	$\frac{s^2}{n}$	0.20
Standard error (sample error)	$s_{\bar{X}}$	$\sqrt{s_{\bar{X}}{}^2}$	0.44
Sample mean coefficient of variation(%)	$CV_{\bar{X}}$	$\frac{s_{\bar{X}}}{\bar{X}}$	4.98

5.3 The Results

You estimate production of rice in Tsukuba Hamlet.

	Yield (t/ha)	Planted area (ha)	Production (t)
Estimation	**8.88**	**12.25**	**109**
C.V. (%)	**4.98**	**8.9**	**10.2**
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

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