SAMPLING FRAME OF SQUARE SEGMENT BY POINTS FOR RICE AREA ESTIMATION

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ABSTRACT

Rice is staple food for most Indonesian peoples. This commodity plays an important role in the economy of Indonesia. Because of this the government of Indonesia should be careful in drawing a certain policy, especially relating to the context of rice crop development planning. An accurate and timely data are needed to support the policy of rice crop development planning. Statistical services on agriculture are based on different approaches, as a result of both historical reason and available techniques, to provide reliable figures. Most often, the applied systems are based on: village statistics, census, sampling survey based on list frame or area frame, and administrative by products. Area Frame Sampling is one of the methodologies to estimate rice crop area and furthermore rice crop production. In this method, crop area estimate are extrapolated from sample to population, where sampel data is directly obtained from field observation. Data communication from field level to central level by SMS gateway is involved to support timely generation of reliable information on the crop area. In the present paper, we mainly try to review the approach of area frame sampling for rice estimate that has been developed in Indonesia for several years. The discussion would be focused on area frame construction, field survey, data communication and some results.

***Key Words**: area frame sampling, rice statistics*

1. Background

Agricultural sector is renewable resources which has an important role in the national economics structure, especially in developing countries like Indonesia. At present, food commodity especially rice still has an important role regarding to daily life of the people and also as a part of economic activity which can accommodate a lot of labors to employ on it. Rice is a staple food for Indonesian people and frequently called as a political commodity due to its vital role, it is to say that unstable of the national rice stock would be followed by unstable of the national politics condition. Improvement of the rice production has been conducted by government through various efforts in order to increase not only harvested area but yield as well. Becouse of the rapid growing cycle of rice dynamic, the accurate and timeline information are needed as an input for decision making to define appropriate management from farm level up to national level.

At the present, the data of rice area is reported manually from the sub-district level by using SP-IA list and assimilated up to the national level. The results tend to bias due to the subjective factor and many iterations of combining statistics. For that reason, the methodology development is needed in order to get more accurate and objective figure of rice statistics. One

of the methods in deriving agricultural statistics is sampling technique in which a partial observation of agriculture is conducted for extrapolating the whole population.

Area frame sampling of square segment by points (AFS) is a statistical procedure to measure the quantity of rice area in a geographic region of interest by observing sampel points inside square segments as a small part of the population. The procedure has adopted SARI Project in technical cooperation between EU, BPPT, MoA, and CBS from 1998 to 2000 (BPPT-EU, 2001), then the improvement of survey method and data communication from farm level to central level is still being continued. In the present paper discuses the principle of area frame sampling and its implementation.

2. Methods

The technique of area frame by points which has been operational application is the French TER-UTI survey (Porchier, 1990) and European LUCAS (EC, 2003). The construction of area frame of square segment by points is essentially the same as normal area frame, except that only a set sample of points inside a segment is visited instead of the whole segment and no fields must be delineated. Based on the observation of sample points, area estimates are computed and used as a valid generalisation without studying the entire area under investigation. The discussion in this paper would be focused on area frame construction, field survey, data communication and some results of pilot study in Indramayu District, West Java.

2.1. Area Frame Construction

In the area frame construction not only Indramayu District was built but also other districts of West Java Province were built in the coincidence works. Then the administrative boundary was used to cut-off study area of Indramayu District. Land use map was used to delimitate and stratify the study area.

Stratification aims to divide a population (Ω) of size N into H non-overlaping sub-population (Ω_h-strata) of size N_h in order to get more eficience in both level of accuration and cost (Taylor, at al, 1997). Considering the classes of present land use on the maps and with the intention to obtain only two strata for each District - a bigger number of strata would in fact give us a too big sample dimension, the study area is divided into 3 katagories (Mubekti, and Hendrarto, 2010).

- Strata-0 or “non-rice” is the polygons with no rice field content, such as forest, settlement, water body etc.
- Strata-1 or “Rice” is the polygons which have high expected percentage of rice field content, i.e. irrigated rice field and rainfed rice field
- Strata-2 or “possibly Rice” is the polygons which have low expected percentage of rice content, i.e. up-land arable.

Figure 1 shows the spatial stratification in the study area.

The result of the stratification shows that the total area of Indramayu district is 207,675 hectares consisted of 142,950 hectares strata-1, 2,800 hectares strata-2, and 61,925 hectares strata-0. The area of sampling frame is the addition between strata-1 and strata-2, while strata-0 is not included from sampling frame.

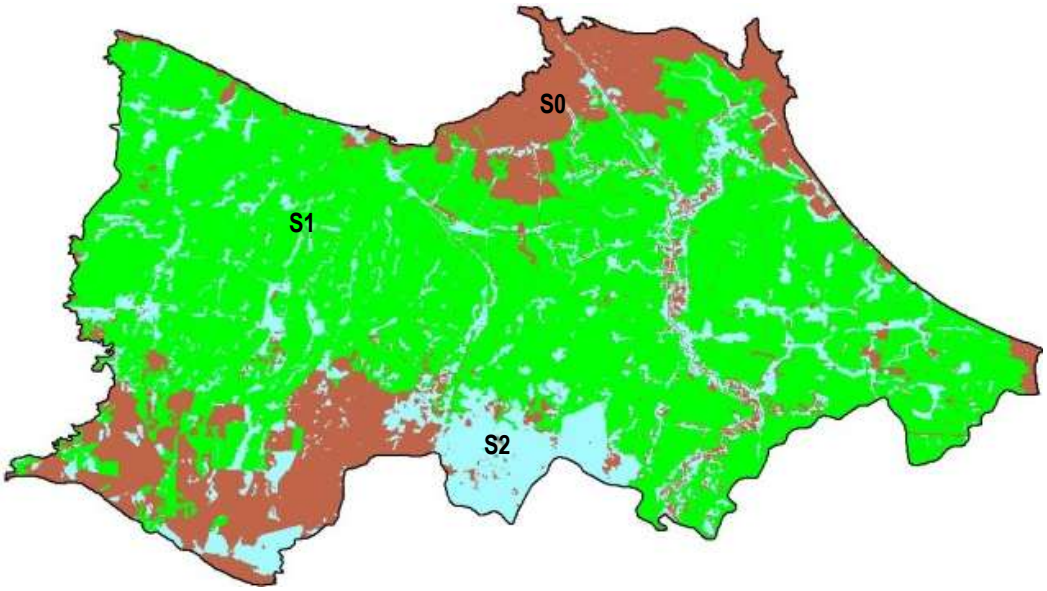

Figure 1. *Stratification map of study area*

Since the area frame refers to square segment, then a fishnet of elementary unit sized 500 m x 500 m is set by converting the stratification map so as to make easier sampling (***Figure 2***). The result of the set fishnet shows that the total of the area frame is 5.830 cells consisting of 5.718 cells strata-1 and 112 cells strata-2.

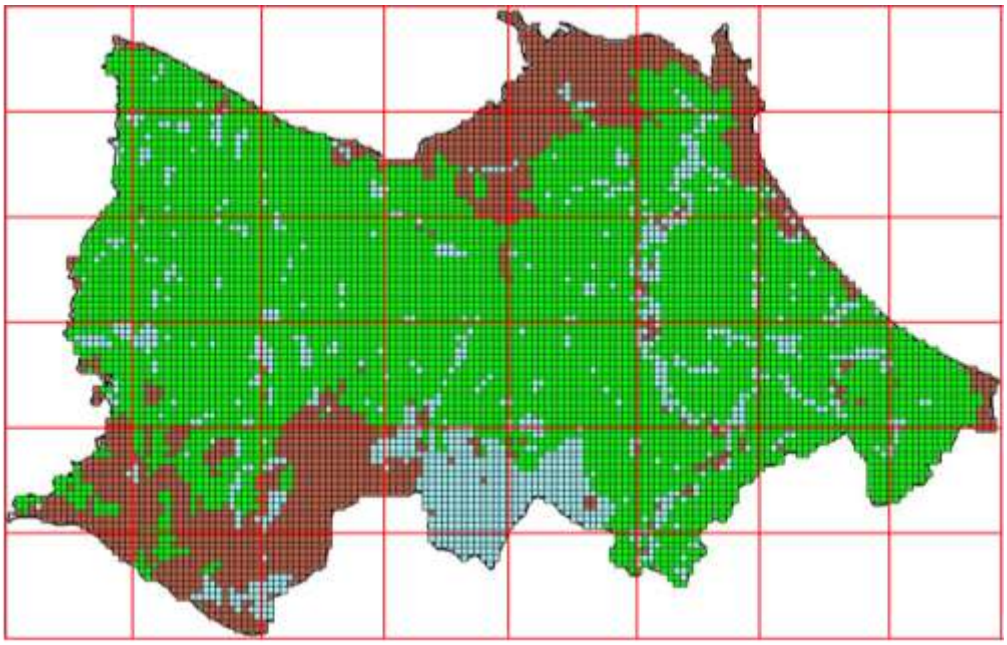

Figure 2. *Grid cell map of study area*

In the statistical inference estimation process the sample dimension is always a crucial point. The statistician has to find the best solution to fit the cost of the survey with acceptable data estimation accuracy. In that cases are also to be considered the difficulties arising from the operative point of view since it is certainly a huge task to make the process starting from planning, training, field survey, up to data analysis. Due to these operative problems the sample

dimension was set considering the minimum acceptable dimension. In this study the dimension of sample segments is approximately 1 % of the area frame. Because of very small sample segment in strata-2, it is decided to use only one stratum where strata-1 and strata-2 are combined all together.

After defining sample dimension it was analyzed the methodology to randomly extract the elementary units. In spatial statistics it is very important to manage samples geographically distributed in the whole study area. The selected method is known as "Systematic Aligned Sampling with a distance threshold" (Gallego, 1995). The GIS Arc-View software was employed to extract sample segments.

This method involves the division of area frame into blocks of segments and the selection of a fixed number of segments in each block repeating the same "replicate". The replicate is a fixed pattern or location of selected segments in one block. The same selected segment positions in each block are used.

The used block was 10 x 10 Km wide containing 400 segments of 500 m x 500 m and in each block 10 segments were drawn. Only the segments that exceed a distance threshold between each other were kept and sequentially numerated. The general rule is to use the first 4 positions to obtain the desired sample dimension. The extraction method refers to 'Systematic Random Sampling' using distance thresholg. If it is need modification the location number 5, number 6 can be added and so on. ***Figure 3***, illustrates the distribution of extracted sample segments on land use map. Total number of extracted sample (n) are 52 segments spread over 29 sub-districts out of the total 31 sub-districts available in Indramayu district. Each extracted sample segment is attributed with code number and geographical co-ordinate at bottom-left corner.

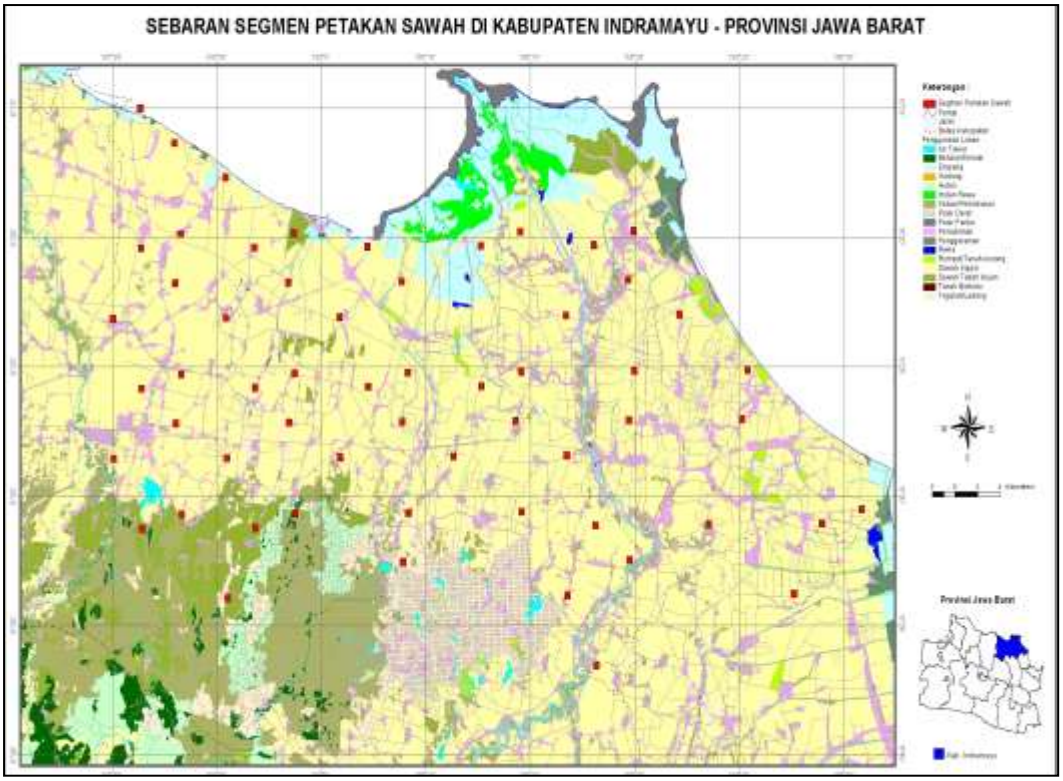

Figure 3. *Distribution map of sampel segment*

Next step is to locate sample points which 25 sample points will be allocated inside each segment. The implementation is to make grid cell of 100 m x 100 m size on the extracted sample segments. The center of each grid cell is to be sample point for field observation. The surveyor will only write down the land use in each of the 25 points instead of drawing and further digitizing all the field in the segment. For the whole of Indramayu district there are 52 (segments) x 25 (points) = 1300 sample points.

2.2. Field Survey

In the study, the boundary of the segments is not physical feature but based on geographical boundary, so that, it needs supporting material to identify location of sample segments and observation points when the field survey is done. Land use map (scale 1:25000) and aerial photograph or high resolution of satellite image (scale 1:2500) are used as supporting material where all sampel segments and observation points are plotted on it. The result can be used as a field map for survey guidance ***Figure 4***. illustrates how to plot sample segments on land use map and observation points on aerial photograph regarding to their geographical coordinates.

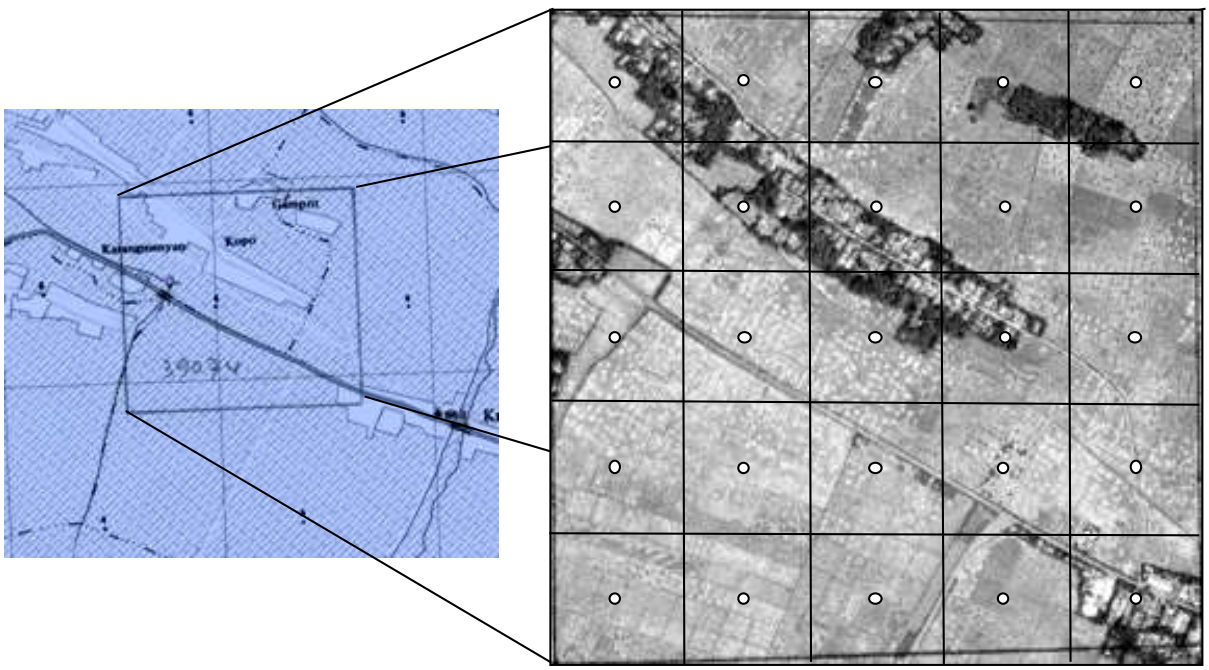

Figure 4. *Illustration of sampel plot on land use map*

By using the above guidance the surveyors can look for the location of sample segments and observation points based on the features available on the maps, such as road, settlement, irrigation canal etc. The aim of the survey is to collect rice data directly from the field by observing rice growing stage in each point inside the sample segment. A simple training of surveyors is needed in order to know (1) how to find point location on the field, (2) how to fill the form, and (3) how to send field data.

The field survey activity conducted by the available agricultural field officers come to each observation point and write down the stage of rice crop on the form (see ***Figure 5***), as follows:

- Vegetative-1 (V-1), which the approximate stage of rice is 1-35 days after transplanting
- Vegetative-2 (V-2), which the approximate stage of rice is 35-55 days after transplanting

- Generative (G), which the approximate stage of rice is 55 days up to harvest
- Harvested (P), which is the stage of rice from harvested up to land preparation
- Land Preparation (PL), which is the rice field being prepared
- Others (LL) if the land is not for rice crop cultivation
- B if rice field is not cultivated (bare)
- H is harvested rice in between two surveys

Knowing the above rice growing stages is important because the calculation of rice area and the prediction of rice harvested area will refer to those stages.

FORMULIR LAPORAN
SURVAI FASE PERTUMBUHAN TANAMAN PADI
KABUPATEN KARAWANG

Nomor Segmen	321774102

Survai yang Lalu	
Tanggal Survai	
Kode Survai (Bl Thn)	

Utara

	A	B	C	D	E
1					
2					
3					
4					
5					

Selatan

Survai Saat Ini	
Tanggal Survai	27 Sept 2011
Kode Survai (Bl Thn)	911

Utara

	A	B	C	D	E
1	P	PL	PL	V1	V1
2	LL	PL	V1	V1	V2
3	LL	PL	V1	V1	V2
4	LL	PL	V1	V1	V2
5	PL	PL	V1	V1	G

Selatan

Rekapitulasi Fase Pertumbuhan

PL =	07
V1 =	10
V2 =	03
G =	01
P =	01
LL =	03
B =	00
H=	00

Format SMS

AFS	Kode Survai	No Segmen	PL	V1	V2	G	P	LL	B	H
AFS	0911	321462106	07	10	03	01	01	03	00	00

Contoh:
Ketik: AFS 0911 321462106 07 10 03 01 01 03 00 00
Kirim ke Nomor : 0813-1975-8855

Karawang 27 September 2011
Surveyor

PL :	Persiapan Lahan (Olah Tanah)	P :	Padi sedang/sudah dipanen
V1 :	Fase Vegetasi Awal	LL :	Lain-lain tutupan lahan
V2 :	Fase Vegetasi Akhir	B :	Bera (Jika dalam 2 Survai berurutan tidak ada aktifitas penanaman)
G :	Fase Generatif	H :	*Harvested*, jika ada panen antara waktu 2 Survai (yang lalu dan saat ini)

(SUHENDI.)

Figure 5. *Illustration of field survey form of rice growing stages*

2.3. Data Cummunication and Analysis

In order to accelerate the delivery of data from the field to the central (Jakarta) server, a communication system have been developed by using short message service (SMS). The structure of SMS communication system is shown in ***Figure 6***. Surveyors send field data via SMS corresponding to the result of recording the amount of each stage per segment as soon the observation of all points finished. All field data will be stored in the SMS server for advanced processing. The address of the system can be visited in: http:neonet.bppt.go.id/padi/.

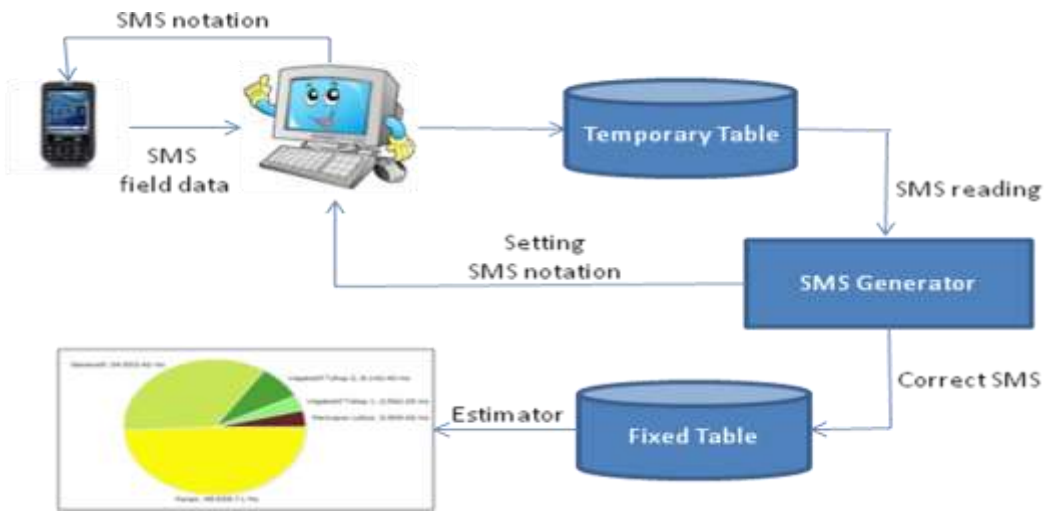

Figure 6. *Structure of SMS communication system for AFS*

The extrapolation formula of sample to the population is also inserted in the sms server system. Therefore, the field data submitted by the surveyors would be immediatly calculated by the system to estimate rice crop production. The mathematical formulation for rice production estimate is given below:

- Rice Area (A)

D_j = Total area of strata j
n_j = sample dimension in strata j
m = number of strata
p_{ij} = proporsion of rice area in segment i strata j
A_j = Total area of rice in strata j j
D, Total area of the frame in the study area

The average proporsion of rice area in strata j and its variance are calculated by the formulation, as folow:

$$\bar{p}_j = \frac{1}{n_j}\sum_{i=1}^{n_j} p_{ij} \qquad \delta^2_{\bar{p}_j} = \frac{1}{n_j(n_j-1)}\sum_{i=1}^{n_j}(p_{ij}-\bar{p}_j)^2$$

Total rice area in strata j and its variance are calculated by the formulation, as follow:

$$A_j = D_j\bar{p}_j \qquad Var(A_j) = D_j^2\delta^2_{\bar{p}_j}$$

The estimation of total rice area in the study area is the addition of rice area in all strata. The mathematical formulation of rice area and its variace, as follow:

$$A = \sum_{j=1}^{m} A_j$$

The standard error is calcualted from the root of the variance, then the coefisien variation is stated as the percentage between standard error and estimated area of rice.

3. Results

Each time the field survey is conducted and field data are sent to the SMS server by the surveyors, then the results of rice estimate can immediately be seen in the web-site (http:neonet.bppt.go.id/padi/).

The ***Attached Table*** is a sampel of field survey data conducted on 3-10 September 2012 for Indramayu District of West Java Province. This district has area 207.675 hectars devided into 3 strata, namely 142.950 hectars of S-1, 2.800 hectars of S-2, and 61.925 hectars of S-0. S-0 is non-agricultural land so that is not sampled. Because of small area of S-2 it is considered to merge with S-1 into one strata, then the area of sample frame is 145.750 hectars.

Next process is to estimate rice area based on the proportion of each growing stage as shown in ***Table 1***. The proportion of each growing stage is calculated from ratio between total observed point and total sampel point. The area of each growing stage is the multiplication between proportion and area of sample frame.

Tabel 1. *Illustration of rice area estimation in Indramayu District*

Rice growing stage	Total observed points	Proportion (%)	Area (Ha)
Land Preparation (PL)	17	1,3	1.895
Vegetatif-1 (V1)	17	1,3	1.895
Vegetatif-2 (V2)	74	5,7	8.308
Generative (G)	73	5,6	8.162
Harvest (P)	412	31,7	46.203
Other land cover (LL)	340	26,2	38.187
Uncultivated rice field (B)	367	28,2	41.102
Harvest in between 2-survey (H)	38	2,9	2.226
Harvest next 2-month			16.470
Harvest next 4-month			20.260

Note: Total sampel in study area is 1300 points

Since the period of rice growing cycle is 105 days, then we can predict rice harvest area for the next two-month and four-month refered to the area of growing stages. For example, the prediction of rice harvest area for next two-month is the sum between the area of vegetative-2 and generative stages, that is 16.470 hectars. Furthermore, the area of rice harvest area for next four-month is the sum between the area of land preparation, vegetative-1, vegetative-2, and generative stages, that is 20.260 hectars.

The extraction of sample segment is done by probability sampling where the selected sample segments are the representation of rice field population, then the above results are unbiased estimate.

4. Conclusion

1. There are various types of approaches on agricultural statistics, which one of them is area frame sampling
2. Area frame of square segment by points is a simple approach to implement on rice statistics
3. it is a scientifically sound approach based on statistical analysis and unbiased by subjectivity
4. By using SMS system for data communication allow to get near real time results
5. It is based on low technology and does not need high investment costs
6. implementation costs are very low once it has become a routine activity
7. With slight adaptations it can be applied to other crops

5. Success achieved and issues for further research

1. Related institutions, i.e. MoA, CBS and UKP4 (Presidential Office for Develoment Monitoring), give a high attention to support the method for National level implementation
2. The pilot project of the method is mainly dedicated for district level, so that is still need an adaptation for up-scale or down-scale level in respect to sampel size and segment size
3. The method will be improved for not only rice statistics but also secondary food crops statistics
4. The integration method between rice area estimate and yield estimate is the further research, where the existing sampling frame of yield estimation is based on house hold frame will be area frame, instead.

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Attached Table. Field data of AFS survey based on selected sample segment

No	Sub-District	Segment	Growing stages							
			PL	V1	V2	G	P	LL	B	H
1	Sindang	321470803	0	0	0	0	20	5	0	0
2	Kandanghaur	321470603	0	0	0	0	21	4	0	0
3	Kandanghaur	321466406	0	0	0	0	22	3	0	22
4	Kandanghaur	321470504	0	0	23	0	0	2	0	0
5	Losarang	321466503	0	0	0	0	23	2	0	11
6	Losarang	321470601	0	0	0	0	0	25	0	0
7	Bangodua	321462403	0	0	0	0	20	5	0	0
8	Cantigi	321470704	0	0	0	0	0	21	4	0
9	Bangodua	321462304	0	10	0	0	6	4	5	0
10	Sliyeg	321466601	0	0	0	0	24	1	0	0
11	Sliyeg	321466604	0	0	0	0	5	20	0	0
12	Kertasemaya	321462503	0	0	0	0	13	12	0	5
13	Krangkeng	321462603	0	0	0	0	0	2	23	0
14	Krangkeng	321458406	0	0	0	0	0	25	0	0
15	Anjatan	321470401	0	0	0	24	0	1	0	0
16	Juntinyuat	321466704	0	0	0	0	20	0	5	0
17	Juntinyuat	321466701	0	0	0	0	18	7	0	0
18	Cikedung	321462201	0	0	0	0	0	5	20	0
19	Cikedung	321462204	0	0	0	0	0	8	17	0
20	Anjatan	321466206	0	0	0	20	0	5	0	0
21	Anjatan	321470403	0	0	18	0	0	7	0	0
22	Haurgeulis	321462006	0	0	0	0	0	0	25	0
23	Haurgeulis	321466204	0	0	0	0	0	2	23	0
24	Haurgeulis	321466203	0	0	0	0	0	8	17	0
25	Haurgeulis	321466201	0	0	0	0	0	5	20	0
26	Gabuswetan	321466303	0	0	0	0	23	2	0	0
27	Gabuswetan	321466304	0	0	0	0	16	9	0	0
28	Gantar	321462003	0	0	0	0	0	6	19	0
29	Terisi	321466401	0	0	0	0	23	2	0	0
30	Gantar	321462106	0	0	0	0	0	5	20	0
31	Gantar	321462004	0	0	0	0	0	14	11	0
32	Gantar	321457906	0	0	0	0	0	8	17	0
33	Balongan	321466706	0	0	0	0	0	25	0	0
34	Widasari	321462406	0	0	0	0	25	0	0	0
35	Kroya	321466301	0	0	0	0	0	0	25	0
36	Kroya	321462206	0	0	0	0	0	3	22	0

37	Kroya	321462103	0	0	0	0	0	5	20	0
38	Kroya	321462104	0	0	0	0	0	0	25	0
39	Cikedung	321462306	0	0	0	0	0	5	20	0
40	Lohbener	321466606	0	0	0	0	23	2	0	0
41	Lelea	321466501	0	0	0	0	12	1	12	0
42	Lelea	321466504	0	0	0	0	6	2	17	0
43	Losarang	321466404	0	0	0	0	25	0	0	0
44	Losarang	321466403	0	0	0	0	0	25	0	0
45	Tukdana	321458206	0	0	0	0	12	13	0	0
46	Tukdana	321462401	0	0	0	0	25	0	0	0
47	Patrol	321470506	0	0	0	0	9	16	0	0
48	Patrol	321470404	0	2	22	0	0	1	0	0
49	Sukra	321474601	17	5	0	0	0	3	0	0
50	Sukagumiwang	321458203	0	0	0	0	21	4	0	0
51	Bongas	321470503	0	0	6	15	0	4	0	0
52	Bongas	321470501	0	0	5	14	0	6	0	0
TOTAL			**17**	**17**	**74**	**73**	**412**	**340**	**367**	**38**