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Full Length Research Paper

Comparing interview and objective measurement based survey methods for crop area, yield and production estimation: the case of rice in Fogera district, Ethiopia

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The World Bank (2010) in its global strategy to improve agricultural and rural statistics considers crop area, crop production, and crop yield as three key variables that should be part of the minimum core data set that all countries should be able to provide. In this regard, FAO through project 'Strengthening Agricultural Statistics and Food Security Information in CARD Countries' has developed actual measurement based survey method to be used in developing countries. The study tried to generate the aforementioned statistics in relation to rice production in the Fogera district for the year 2016/17. Interview and the FAO recommended survey methods were used in the study under similar sampling design. The reliability of these methods were compared via the size of estimated values and the associated coefficient of variations. The estimated CV for all the three statistics from both methods was below 20%. This result inferred usefulness of both methods with proper data collection procedures. The yield and production volume estimates obtained from the interview (4.1ton/ha, 117128tons) and the measurement (3.3ton/ha, 98150tons) methods differs significantly (p< 0.001). The observed significant differences between the corresponding estimates signify importance of actual measurement based method for estimating production statistics.

Keyword: Actual measurement, interview, estimation, precision, grain moisture.

INTRODUCTION

Rice, despite being a recent introduction to the Ethiopian farming system, is among the most important cereals grown in the country. The country is characterized with immense potential for growing the crop. In recognition to its importance, the Government of Ethiopia (GoE) has developed national strategy for rice research and development to guide the integrated and focused promotion of the rice sector in the effort to ensure food security in the country (MoARD, 2010). Unpopularity of the crop in the past has made statistics on rice production, productivity and area coverage not to be well known. Therefore, generating statistics on various aspects of the crop has paramount importance for the development of the sector. The World Bank (2010) in its global strategy to improve agricultural and rural statistics considers crop area, crop production, and crop yield as three key variables that should be part of the minimum core data set that all countries should be able to provide.

In Ethiopia, the Central Statistical Agency (CSA, 2011) is mandated for production of official agricultural statistics. The agency uses a combination of interview and objective measurements as survey methodology. But most of the rice growing areas in Ethiopia are below the reporting level, zone, of the agency and thus rice is not well captured in the agency surveys. As the result most of the rice production statistics in use are estimated based on the information obtained from the producers via direct interview or are aggregated reports of the development agents working at local level. It is well known that these type of statistics are highly subjected to biases.

Pertaining to above facts, this study tries to test FAO recommended statistical survey method mainly for estimating crop area, yield and production in the developing countries. The objective of this study was to estimate the above mentioned rice production characteristics using both interview and actual the FAO recommended survey methodology. At plot level, the FAO methodology tried to extract the effective area by

excluding any uncultivated land. This helps to minimize the possible upward biases in estimating the size of cultivated area and downward biases in the productivity. Concerning the yield estimation, the methodology demanded adjustment for moisture content. This will adjust the possible upward biases due to moisture content above the recommended level and the down ward biases due to over drying. Finally, by optimizing the precision level of both the cultivated area and yield estimates the methodology tries to avail a better estimate of production which is the cross product of area and yield estimates.

STUDY AREA, SAMPLING METHODOLOGY AND DATA COLLECTION

The entire Fogera district was considered for this study. Fogera is located between11º46 to 11º59 latitude North and 37º33 to 37º52 longitude East. It has an area of 1111.4 square kilometer distributed in its 28 villages (kebeles) and currently 19 of them are rice producing. The target population of the study were these19 rice producing villages of the woreda.

Two stage simple random sampling design was used for the survey. The primary stage sampling units (PSUs) were enumeration areas (241 EAs) constructed by CSA for the last census enumeration and belongs to the 19 rice producing kebeles. The second stage sampling units were rice producing households in each of sampled PSUs. For each sampled PSUs, a fresh list of rice producing households was made before the actual survey started. The selection of PSUs was done using simple random sampling while the selection of households in each sampled PSU was conducted using systematic sampling.

Adopting the observed variability in yield measurements from similar survey conducted in Uganda the overall sample size was determined to be 120 rice producing households. Considering the data collection cost and administration convenience it was decided to study 10 households per EA. This in turn dictates to study 12 EAs. All the 120 sample households were considered for the interview method. From the 10 sample households in each of the 12 EAs five households were sub sampled for the actual area measurement and the crop cutting survey. The sub sampling was done using simple random sampling technique. All the rice plots each sample household cultivated in 2016/2017 cropping season were considered in the crop area survey. But for the crop cutting survey, one plot was selected among the rice plots the sample household cultivated in survey year using simple random sampling technique. (Table 1).

From each crop cutting sample plots two 1mX1m square spots were selected and harvested by enumerators. Selection of the spot-1 was done by moving 30 steps along the edge from a corner of the sample rice plot and enter the plot for 30 steps then place the 1mX1m square frame. For the spot-2, start at the diagonal corner of starting point of spot 1 and find spot 2 using the same procedure as for spot 1.

The interview was mainly conducted with the heads of sample houeseholds and the actual yield and area measurements were made by enumerators with the consensus of the sample households. The necessary field data editing, coding and verification activities were done by supervisors. The filed-in questionnaires were keyed to computer using a data entry template designed for CSPro 6.3.

Estimation

Information about the household head demographic characteristics, agronomic practice, rice cultivated area, and production was collected by interviewing farmers. As well cultivated area, and yield were collected based on objective measurements. The district values of the characteristics were estimated using the appropriate sampling weight and estimation formulas which corresponds to each of the survey methods entertained (Table 2).

RESULT AND DISCUSSION

Producers Socio-demographic characteristics

Rice is the major income source for nearly 90 percent of the households in the district. In 2016/17 cropping year 45087 households were engaged in rice production and 95 % of them were male headed. Half of the heads were illiterate. Few households have about three decades of rice farming experience while half of the heads were below 40 years old (Table 3). The dominant (75%) rice ecology in the district is lowland rain-fed while the remaining ecology is upland. Only two rice varieties namely X-Jigna (75%) and Gumera (25%) were in use. 90% of the planting method used was broadcasting though few households have exercised transplanting and row sowing. Mechanical harvesting system was not yet introduced. About 85% and 33% of the producers have used inorganic fertilizer and pesticides respectively. As 90% of the respondents the season crop growing condition was rated as normal and above (Table 4).

Result from the interview based method

In Fogera framers have land registration certificate. In most case farmers in the district do at least two crops beside rice (Minilik et al- 2013). This means they share their farm land among cultivated crops. Usually farmers approximate the land size under each of the cultivated crops in relation to the total land size. Almost all farmers use local farm area and production measurement units. Usually conversion from local to standard measurement units is error pruning activity which introduces biases in the estimates produced. There is also a tendency that

Table 1 Number of sample EAs, households, plots and crop cutting spots by survey type

Survey type	Enumeration Area (EA)	Household per EA	Total Household	plots per household	Total plots	Spots per Plot	Total sample spots
Interview	12	10	120	all	-	-	-
Area survey	12	5	60	all	-	-	-
Crop cutting	12	5	60	1	60	2	120

Table 2. Estimators used by methodology and estimated characterstics

Statistics	Estimator	Variance	CV
Interview method			
Crop area	$\hat{A} = N * \frac{\sum_{j=1}^{m} \hat{a}_j}{m} = N \frac{\sum_{j=1}^{m} Nh_j \bar{a}_j}{m}$	$Var(\hat{A}) = N(N-n)\frac{S_a^2}{a} + \frac{N}{n}\sum N_i(N_i-n)\frac{s_{ia}^2}{n_i}$	$CV(\hat{A}) = \frac{\sqrt{Var(\hat{A})}}{\hat{A}} * 100$
Production	$\hat{P} = N * \frac{\sum_{j=1}^{m} \hat{p}_j}{m} = N \frac{\sum_{j=1}^{m} Nh_j \bar{p}_j}{m}$	$Var(\hat{P}) = N(N-m)\frac{S_p^2}{m} + \frac{N}{n}\sum Nh_i(Nh_i-n_i)\frac{s_{ip}^2}{n_i}$	$CV(\hat{P}) = \frac{\sqrt{Var(\hat{P})}}{\ddot{P}} * 100$
Yield	$\hat{Y} = \frac{\hat{P}}{\hat{A}}$		$CV(\hat{Y}) = \sqrt{CV(\hat{P})^2 - CV(\hat{A})^2}$
Objective measurement			
Crop area	$\hat{A} = N * \frac{\sum_{j=1}^{m} \hat{a}_j}{m} = N \frac{\sum_{j=1}^{m} Nh_j \bar{a}_j}{m}$	$Var(\hat{A}) = N(N-n)\frac{S_a^2}{a} + \frac{N}{n}\sum N_i(N_i-n)\frac{s_{ia}^2}{n_i}$	$CV(\hat{A}) = \frac{\sqrt{Var(\hat{A})}}{\hat{A}} * 100$
Yield	$\hat{Y} = N * \frac{\sum_{j=1}^{m} \hat{y}_j}{m} = N \frac{\sum_{j=1}^{m} Nh_j \bar{y}_j}{m}$	$Var(\hat{Y}) = N(N-n)\frac{S_y^2}{n} + \frac{N}{n}\sum N_i(N_i-n)\frac{s_{iy}^2}{n_i}$	$CV(\hat{Y}) = \frac{\sqrt{Var(\hat{Y})}}{\hat{Y}} * 100$
Production	$\hat{P} = \hat{A} * \hat{Y}$		$CV(\hat{P}) = \sqrt{CV(\hat{Y})^2 + CV(\hat{A})^2}$

farmers go beyond their plot and pretend as if they farm their plot only. This fact, may introduce a down ward biases in the cultivated area and upward biases in yield estimate produced. Sometimes farmers respond as if they farm the whole plot while there is a considerable uncultivated land inside the plot. This is a possible factor that introduces an upward biases in the cultivated area and downward biases in yield estimate produced. Based on the respondents information, the total rice cultivated area for 2016/17 cropping year was estimated to be 28424.62 hectares with 14.2% CV. The average estimated rice area per household was about 0.6 hectare. Similarly, the total volume of rice produced in 2016/17 cropping season was estimated to be 117128 tons with 17% CV. The overall average production per household is estimated at 2.42 tons. The average household level production varies from EA to EA and it ranges from 1.1 to 4.2 tons. The district average rice yield for the 2016/17 cropping year was estimated at 4.12 tons per hectare with a CV of 9.35% (Table 5).

Results from the measurement based method

Having better estimate of cultivated area and yield can be seen as guaranty to get a better estimate of production. To this effect, the measurement based methodology tried to extract the effective cultivated plot area by excluding any uncultivated part of the plot. This helps to minimize the possible upward biases in estimating the size of cultivated area and downward biases in yield. Concerning the yield estimation, the methodology demanded adjustment for grain

Table 3. Demographic characteristics

Variable	No.	%
Age group in years	20-29	21
	30-39	29
	40-49	27
	50-59	15
	60+	8
Sex	Male	95
	Female	5
Marital Status	Single	1
	Married	90
	Widowed	4
	Divorced	5
Education level	Illiterate	55
	Elementary	34
	Secondary	11
Years of rice farming	1-5	33
	6-10	29
	11-15	25
	16-20	7
	21-25	3
	26+	3
Major income source	Rice planting	88
	Other crop	10
	Livestock	2

Table 4. Agronomic Practice

Variable	Category	%
Technical support	Receiving	48
	Not receiving	52
Future intension for rice farming	Increasing	83
	The same	14
	Decreasing	3
Ecosystem	Irrigated	2
	Lowland rained	75
	Upland	24
Planting	Transplanting	8
	Row sowing	3
	Broadcast	90
Harvesting	Manual	100
	Mechanical	0
Fertilizer use	Not use	15
	Use chemical	83
	Both	2
Pesticide	Don't use	68
	Use	32
Name of Variety	X-Jigna	76
	Gumera	24

moisture content. This will adjust the possible upward biases on the yield due to moisture content above the recommended level (14%) and the downward biases due to over drying.

Using the actual measurement method the Fogera district total rice cultivated area for 2016/2017 cropping year was estimated to be 29779.9 hectare with 14.2% CV. The overall average household level rice cultivated area was

Table 5. **District level rice cultivated area estimated using interview method**

Parameter	Estimate	CV (%)
Area (ha)	*28424.6*	*14.2*
Yield (ton/ha)	*4.1*	*9.4*
Production (ton)	*117128*	*17*

Table 6. District level rice cultivated area estimated using actual measurement

Parameter	Estimate	CV (%)
Area (ha)	29779.9	14.2
Yield (ton/ha)	3.3	13.4
Production (ton)	98149.7	19.5

Table 7. Comparison for the interview and actual measurement estimates

Variable	Interview method		Actual measurement		Difference
	Estimate	CV (%)	Estimate	CV (%)	%
Area (ha)	28424.6	14.2	29779.9	14.2	-4.6
Yield (ton/ha)	4.1	9.4	3.3	13.4	24.8
Production (ton)	117128.3	17.0	98149.7	19.5	19.3

estimated as 0.59 hectare. Regarding the rice productivity in Fogera, the average yield level was estimated as 3.3 tons per hectare with 13.4 % CV. In similar way the district rice production volume for the 2016/17 cropping year was estimated as 98149.66 tons with 14.2% CV. In general the precision level of the estimated parameters, cultivated area (14.2%), yields (13.4) and production volume (14.25) can be rated as acceptable (Table 6.).

Comparing the estimates from the interview and measurement based methods

As shown in table 7, the estimated CV for all the three parameters from both methods was below 20%. This may infer usefulness of both methods as long as viable data collection procedure is in place. The estimated coefficient of variation via the measurement level is a bit higher than the interview method.

As mentioned earlier, the measurement method tries to get the effective planted area by subtracting size of any uncultivated area from the total plot area. This fact establishes a rational to expect size of the area estimate from the measurement method to be lower than size of the similar estimated to be obtained via the interview method. On the contrary, the cultivated area estimate from the interview method was below what was obtained from the measurement method by 4.6% (1355.3 ha). An independent sample t-test was used to test significance of the observed difference and found to be insignificant at 5% level of significance (Table 8). Here it will be wise to note the importance of land register certificate in improving awareness of the farmers about their land size.

The yield estimate from the interview method was above the measurement method by 0.8 tons per hectare (Table 7)). The estimates from the two methods were compared using independent sample t-test and were found significantly different for $P< 0.001$ (Table-8). Some part of the observed difference could partly be attributed to the grain moisture adjustment made on the data collected via the measurement method. As situation on the ground dictates, largest part of the observed difference could be attributed for biases introduced while converting collected data points from local to standard measurement units. The observed wide difference between the two estimates puts a doubt on the reliability of the data obtained via the interview method.

Crop production estimates are generally portrayed as the product of two components: area harvested and yield obtained per unit area. The accurate estimation of both harvested area and yield are equally important in ensuring the accurate determination of their product (Michael Craig and Dale Atkinson 2013). As shown in table 7, the production estimates obtained from the interview method excel the one obtained from the measurement method by 16.2 % (18979 tons). The observed difference was found significant at $P<0.05$ (Table 8). It is quite logical to label the difference in the yield estimate from the two methods as the major cause for the observed significant difference in the production volume estimates of the methods. Considering quality of the rigors data collection procedures followed the data

Table 8. Independent sample t-test

Variable	Variances	Mean difference	DF	t Value	Pr > |t|
Yield (qt/ha)	Equal	9.2595	178	3.92	0.0001
production (qt/HH)	Equal	5.0749	178	2.06	0.0409
Area	Unequal	0.0001	178	0	0.9979

from the measurement method could be taken for grant. Based on this fact, it can be concluded that the interview method underestimate the yield and hence the production volume estimates.

CONCLUSION

Both interview and measurement based survey methods were tested under similar two stage simple random sampling design and systematic sample selection scheme. The primary stage sampling units were enumeration areas (EAs), which belongs to the district, obtained from population census cartographic work while rice producing households in the sample EAs form the secondary sampling units. The coefficient of variation estimates obtained for all the three parameters from both methods were below 20%. And this may infer usefulness of both methods as long as viable data collection procedure is in place. The cultivated area estimate from the interview method was below what was obtained from the measurement method by 4.6%. But this difference was found insignificant at 5% level of significance. The district land registration certificate awarding system could be seen as a major factor which narrows the gap between the two cultivated area estimates. Both the yield and production volume estimates obtained from the interview method were significantly greater than the one obtained from the actual measurement method. Considering quality of the rigors data collection procedures followed, the data from the measurement method could be taken for grant. Based on this fact, it is quite rational to label both the yield and production volume estimates obtained from the interview method as overestimated.

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