http://dx.doi.org/10.18350/ipaid.2016.25s.211

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일반논문「지역발전연구」제25권 특별호 : 211~242 JRSD

Measuring Poverty in the Dry Highlands of the Northern Ethiopia: Income vs. Calorie*

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In this study, we measure poverty in the four rural villages, Koraro, Selam (MVs), Debrehiwot, and Simret (non-MVs), in the Hwazen district, Tigray of Ethiopia. The sample for the field survey consists of 324 households and 1,865 individuals. The prevalence of extreme poverty are measured in three ways: the fraction of individuals whose per capita daily gross income or net income falls short of $1.25 in 2005 PPP, and the fraction of households whose annual calorie intake falls short of the minimum calorie requirement. We find that the prevalence of extreme poverty is 30% higher than the official statistics; that the poverty measures based on income insufficiency turn out to be more or less the same as that based on calorie deficiency; that though poverty is more severe in non-MVs than in MVs, the difference is insignificant when measured in income deficiency but significant when measured in calorie deficiency; and that there is remarkable inequality of income and calorie in those rural villages and a poorer village has a more concentrated income/calorie distribution.

[Key words: Poverty, Calorie Intake, Ethiopia, Millennium Village, smallholder]

* This work was supported by the National Research Foundation of Korea Grant funded by the Korean Government (NRF-2013S1A5B8A01055336).

Ⅰ. Introduction

The UN defines extreme poverty as "a condition characterized by severe deprivation of basic human needs, including food, safe drinking water, sanitation facilities, health, shelter, education and information." (UN, 1995) Its operational definition was updated by the World Bank as earning below the international poverty line of $1.25 per day in 2005 prices (Ravallion et al., 2013) and equivalently $1.90 per day in 2011 prices (Ferreira et al., 2015). According to the UN Fact Sheet 2010, it was estimated that as of September 2010, 1.2 billion people lived in extreme poverty based on that criterion. Also, the World Bank estimates that 0.9 billion people suffered from poverty based on the $1.90 poverty line in 2012. Finally, the UN announced that the number of people living in extreme poverty has been reduced to 836 million in 2015. (UN, 2015)

The measurement of the prevalence of poverty influences the policies to mitigate poverty. In a subsistence economy where a significant fraction of the agricultural output is auto-consumed, however, it is a daunting challenge to acquire a reliable measure of household income because it is hard to observe their agricultural output, which the poor farmers themselves often do not know accurately. In addition to the quantity of agricultural output, unreliable price indexes in a subsistence economy provide another source of bias for the income of subsistence households and they create the endogeneity problem because the amount of self-consumed crops depends on their value. (Capéau and Dercon, 1998; Deaton, 1987) These difficulties are serious obstacles to measure the prevalence of extreme poverty in a reliable way by counting the number of people with income below $1.25/day in 2005 PPP in the context of a subsistence economy.

Letting alone the difficulty of measuring household income in a subsistence economy, the operational criterion for extreme poverty, $1.25/day in 2005 PPP, set by the World Bank has been under criticism that it is too simplistic to capture the depth of poverty and the relative poverty for diverse countries and regions. (Deaton, 2010) Klasen (2009) and Reddy and Pogge (2010) address that the

operational criterion is a limited measure of the prevalence of poverty because it is relatively arbitrary and uniform. Ackland et al (2009) and Deaton and Dupriez (2011) also criticize that the PPP index as a national account does not reflect the varied nature of poverty. In addition, Székely (2004) notes that the measured poverty ratio is considerably sensitive to the estimation methodology based on poverty indices. Dhonde & Minoiu (2013) show that the measured poverty varies considerably depending on whether it is based on the national accounts or the household survey data. Bevan and Joireman (1997) adopt various sociological indexes to measure the degree of poverty in Ethiopia. They emphasize that measuring poverty based on long term social and human assets is more credible than on short term indexes, such as income.

To remedy this shortcoming, the UNDP, for instance, proposed a multidimensional poverty index (MPI) that reflects basic human needs as well as income. Based on MPI, the UNDP estimated that 1.5 billion people worldwide, as opposed to 1.2 billion people, were in extreme poverty in 2010. (UNDP, 2014) More dramatically, 39% of the population is extremely poor in Ethiopia according the $1.25/day criterion, whereas multidimensional poverty is estimated to be from 70% to 90%. (Morrell, 2011; Alkire and Roche, 2013)

In this study, we share with the readers the sense of how vulnerable the subsistence households' income measure is to biases and omissions by showing the details of the measurement. We then count the number of people whose per capita daily income falls short of $1.25, to measure the prevalence of the extreme poverty. In doing so, we use two different measures of income, gross income and net income, with net income being gross income net of farming cost. In order to cross check the reliability of the poverty measure based on the income estimation, we employ an alternative way of measuring poverty using the notion of calorie deficiency. That is, we measure the prevalence of extreme poverty by comparing the amount of calories contained in the foods consumed by the households and the minimum requirement of calories recommended by the FAO. In this context extreme poverty may be defined as the lack of calorie intake that falls short of the

minimum requirement. (Ravallion, 1992) We also measure inequality in terms of of income and calories, to show that there is considerable inequality even among the extremely poor. We conclude by discussing the implications of our findings.

Ⅱ. Data Collection

1. Study Area

Hawzen, a district of Tigray, Ethiopia, was chosen as the study area because Koraro, one of the two villages where the MVP was launched for the first time in 2005, is located in Hawzen. (The other village where MVP first started is Sauri in Kenya.) In 2006, ten additional villages from Hawzen were included as the MVP target areas. MVP office refers to these eleven Millennium Villages in Hawzen as "the Koraro cluster."

Tigray is a province of Ethiopia, sharing the border with Eritrea in the north and with Sudan in the west. Its capital city is Mekelle. Tigray is divided into five sub regions, Western Tigray, North-western Tigray, Central Tigray, Eastern Tigray, and Southern Tigray. Tigray consists of 47 districts (woredas) and 673 villages (tabias). Ethnic composition is almost mono-ethnic; According to 2007 census, there are 4,316,988 people and 992,635 households in Tigray. Ethnically, 96.55% of the residents are Tigrinya who speaks the local language, Tigrinya. Many residents cannot speak Amharic, which is the official language of Ethiopia. (Central Statistical Agency (CSA) of Ethiopia, 2010)

Hawzen is one of the 47 districts (woredas) of Tigray. According to the 2007 census, in Hawzen there live 117,954 people and 25,067 households. This implies that the average household size is 4.71. Ethnically, 99.68% were Tigrayan, speaking Tigrinya. Religiously, 99.45% are Orthodox Christians. (CSA, 2010) Among the twenty five villages (tabias) of Hawzen, eleven are included in the Koraro cluster (Millennium Villages, MVs), while fourteen villages are not (non-Millennium

Villages, non-MVs). Out of the eleven MVs, we chose Koraro and Selam and out of the fourteen non-MVs we chose Debrehiwot and Simret as our study area. We chose two MVs and two non-MVs to evaluate the impact of the Millennium Village Project in Hawzen district. In this study we compare the prevalence of poverty and the degree of income and calorie inequality between the MVs and non-MVs.

2. Survey Instruments

The basic frame of the survey instruments was adopted from the Townsend Thai Rural Survey (Binford et al., 1997), which was designed to measure various economic activities, social network, and health related behaviors of the households in the underdeveloped villages. We modified the interdisciplinary survey instruments to suit the context of the dry highland of Northern Ethiopia. The major focus of the survey instruments is to measure agricultural productivity and health status. The survey instrument is available at the IPAID website, http://ipaid.yonsei.ac.kr/contents/bbspage/xbd/board.php?bo_table=m5_db9&page=0.[1)]

3. Sample and Interviews

In Feb. 2013, we implemented a field survey on the 324 households sampled from the selected four villages, Koraro, Selam, Debrehiwot, and Simret, in the Hawzen district of Tigray, Ethiopia. The original goal was to interview 100 households for each village and we selected the sample randomly using the village roster. In the rural area of Ethiopia there are no street addresses and the houses are scattered far apart from one another. Without the help of the village head or a village manager it was not possible to find households selected in the sample. Sometimes the enumerator finally found the house only to discover that no one

1) In order to download the survey questionnaire, contact YoungJe Kim, Ph. D. e-mail: kyj9989@yonsei.ac.kr

was home. Given the limits in budget and time, the difficulty in logistics allowed us to finish interviews with only 325 households, 159 households from Millennium villages and 166 households from non-Millennium villages. The sample covers 6.9% of the households of the four villages and 8.4% of the population.

Fifteen graduate students and lecturers of Mekelle University were hired and trained as the enumerators. All of them are bilingual in Tigrinya and English. The enumerators visited the households selected in the sample to interview them; they asked the questions in the questionnaire and wrote down the responses of the interviewee. Most of the time, the head of the household answered the questions. But sometimes the spouse or other member of the household answered the questions. On average, it took fifty minutes or so to complete the interview with one household.

Ⅲ. Extreme Poverty in terms of income

1. Measurement of Income in a subsistence rural economy: The case of villages in Hawzen, Tigray, Ethiopia

In the context of a subsistence rural economy, the cash flows will not reveal the true income of a subsistence household because the major portion of the agricultural output is self-consumed by the household and only a small part is sold or exchanged at the market. In addition, the valuation of home-produced foods is difficult to determine because some of them do not have a clear market equivalent or are non-market goods. (Margaret & Glewwe, 2010) The limited extent of the marketization of these economies makes it difficult to measure the household income. We need to measure carefully the amounts of agricultural outputs, their prices, and the earnings in cash in order to generate a reliable measure of income for a subsistence household in a rural area. Not only academic field surveys but the government's official data collection is exposed to the same sort of difficulty in this respect.

The major portion of household income accrues in kind in rural Ethiopia. Porter (2012) reports that the overall agricultural output takes up from 66% to 79% of the total income in rural Ethiopia. Weldegebriel et al. (2015) observe that the non-farm income or cash earned here is more related to building wealth than for subsistence reasons. Tracking the amounts of agricultural outputs of a subsistence household, however, is not an easy task, because the households typically do not keep a good record of their agricultural activities and would not remember clearly their economic activities a few months ago. (Margaret & Glewwe, 2010) As a result, the agricultural output data collected by survey instruments is notorious for its noisiness. Nevertheless, in a situation where there is no official measurement of agricultural outputs at the household level, a field survey may be one of few viable options for obtaining the information on households' agricultural output.

In the dry highland of Northern Ethiopia, the major cereals produced are teff, wheat, barley, maize, sorghum, and millet, and the major pulses are bean, pea, and lentil. In addition, there are dairy products such as milk, eggs, and meat. Other minor products are vegetables and fruits. <Table A1> and <Table A2> in the Appendix summarize the average output of cereals and pulses of the households in the sample by village. It is notable that the crop portfolio of villages in terms of the number of households cultivating the crop varies significantly across villages.

To convert the agricultural output measured in volume into the economic value, we have to multiply it by the price. There are three different prices available; the national prices in Ethiopia, the local prices surveyed at the Hawzen district market, and the prices that the respondents cited. Among the three different sets of prices, the national prices are highest and the prices cited by the farmers are the lowest on average. We use the local prices surveyed at the Hawzen district market to compute the value of agricultural products.[2] (See <Table A3> in Appendix.)

2) When the national prices are applied, the value of cereals is higher by ten percent compared to that evaluated

Table 1. Household Income, 2012 by Villages in current ETB

		Value of Income in Kind		Income in Cash		Gross Income (Income in Kind and Cash (A+B+D-C)	Net Income (Gross Income – Cost of Farming)
		Cereals (teff, wheat, barley, maize, millet, sorghum) (A)	Self-consumed Dairy products and Vegetables (B)	Cash Income from Selling Cereals (C)	Cash Income from All Sources (D)		
Villages	N	Mean (S.D)	Mean (S.D)	Mean (S.D)	Mean (S.D)	Mean (S.D)	Mean (S.D)
Koraro	78	4,767.3 (3,778.3)	2,558.4 (2,421.5)	533.1 (1,079.8)	4,984.1 (4,344.3)	12,309.8 (7,625.4)	11,030.9 (7,658.1)
Selam	81	3,554.6 (2,833.0)	3,745.0 (4,417.0)	345.9 (1,050.5)	4,444.3 (5,480.0)	11,744.0 (7,746.2)	10,97.1 (7,420.5)
MV Subtotal	159	4,149.5 (3,375.0)	3,162.9 (3,618.1)	437.7 (1,065.7)	4,709.1 (4,947.4)	12,021.5 (7,668.1)	10,708.1 (7,520.8)
Debrehiwot	80	3,581.0 (3,306.1)	3,650.7 (4,031.9)	242.3 (605.6)	3,999.4 (4,133.7)	11,231.2 (6,898.7)	9,986.6 (6,860.6)
Simret	85	2,422.2 (1,876.9)	3,509.6 (5,294.7)	199.2 (953.0)	4,183.4 (3,563.9)	10,115.2 (7,493.3)	8,965.7 (7,446.5)
Non-MV Subtotal	165	2,984.2 (2,721.6)	3,578.0 (4,711.1)	220.1 (801.5)	4,094.2 (3,840.0)	10,656.3 (7,211.0)	9,460.7 (7,164.9)
Total: All	324	3,556.0 (3,110.2)	3,374.3 (4,209.0)	326.9 (954.3)	4,396.0 (4,422.1)	11,326.3 (7,458.6)	10,072.8 (7,356.9)
Testing Null Hypothesis: Mean of MVs=Mean of Non-MVs							
T-stat		**3.428*** **	-0.887	**2.082** **	1.253	**1.652***	1.529
P-value		0.001	0.376	0.038	0.211	0.099	0.127

Source : This table was made by processing our survey data collected in Feb 2013. In the survey we asked the farmers in the previous year (i.e. in 2012) how much of teff, wheat, barley, maize, sorghum, millet, bean, pea, lentil, milk, egg, meat, and vegetables they produced. We multiplied the prices on each item that we observed at the Wednesday market of Hawzen to turn that into the monetary value. The first column (A) is the sum of the monetary value of cereal and pulse outputs, and the second column (B) is the sum of monetary value of self-consumed dairy products and vegetables. The third column (C) is the monetary value of cereal and pulse they sold at the market during the previous year (2012). The fourth column is the total cash income including the sales of agricultural outputs, wage, remittances, subsidies, and etc.

The first column in <Table 1> shows the mean and the standard deviation of the value of cereal outputs of households by village. The value of the cereals produced per household in the MVs is significantly larger than that in the non-MVs. The second column is the mean and the standard deviation of the value of the non-cereal agricultural goods self-consumed by the households. Though the value of other agricultural outputs self-consumed per household in non-MVs is larger than that in the MVs, the difference is not significant. The sum of the first two columns of <Table 1> is the value of the income in kind at the household level.

The third column of <Table 1> shows the cash earning from selling the cereals and the pulses. Comparing the first and the third column, one can see that only a small fraction of the cereal output is sold at the market. In terms of the monetary value, only 9.2 % of the cereal output is sold at the market, and the rest is auto-consumed by the households. The households in the MVs earn more cash by selling cereals than the counterparts in the non-MVs. The fourth column is the total cash income from all sources, including the cash earned from selling the cereals, the cash earned from selling dairy products and vegetables, income from selling livestock, wage earnings, income from a business such as shop and trading, various rental income, interests from various sources, remittances received, and the subsidy from the government. Though the total cash income for households is larger on average in MVs than in non-MVs, the difference is not significant.

The fifth column of <Table 1> shows the gross income for households. The gross income is defined to be the sum of total income in kind plus the sum of total cash income minus the cash income from selling the cereals (A+B+D−C). We subtract the cash income from selling cereals to avoid double counting because it is included in the value of the cereal output. The gross income for households in MVs is significantly larger than that for those in non-MVs. It is also interesting that the gross income for households in MVs is larger than that in non-MVs but the income in cash for the households is not. A similar pattern was observed in the Sauri MVP cluster of Kenya by Wanjala et al. (2013). As Wanjala et al. expressed

their concerns about the future of the Sauri cluster of Kenya, the MVP in the Koraro cluster of Ethiopia may not be able to provide a sustainable momentum for economic development because it does not seem to generate enough cash that can be used for investment in expanding production capacities.

The ratio of the total cash income to the gross income for the households, shown in <Table 2>, may be considered as the extent of the marketization of these village economies. On average, only about 37 % of household income accrues in the form of cash. The cash income ratio for the households in non-MVs is higher than that in MVs. But the difference is not statistically significant.

It should also be noted that the gross income may not be a proper counter part of GRDP, because the value of agricultural outputs includes not only the value added but the value of intermediate inputs. Thus, we deduct from the gross income the cost of farming to make it closer to the concept of GRDP. The cost of intermediate inputs for farming includes the expenditure on seeds, chemical fertilizers, organic fertilizers, and pesticides/herbicides. The net income is defined to be the gross income less the cost of intermediate inputs for farming. The final column of <Table 1> shows the average net income of households by villages. Though the net income for households in MVs is still larger than that in non-MVs, the difference is insignificant. This result is consistent with the finding of Lee et al. (2014) that though the households in the MVs produce more cereals than the counterparts in non-MVS, the most of the difference in output can be attributed to the larger amount of inputs such as land, fertilizer and pesticides. That is, the production of cereals in MVs is less efficient than that in non-MVs. The farming cost for intermediate inputs turns out to be about 11% of the gross income. Therefore, the net income for households is about 89 % of their gross income on average. This implies that the head counting measure of extreme poverty can be quite different depending on which income measure we use.

2. The Head Counting Measure of Extreme Poverty

Table 2. Daily Income per Capita in 2005 International Dollar and Extreme Poverty

		Daily Gross Income per Capita in USD 2005 PPP		Daily Net Income per Capita in USD 2005 PPP	
Villages	Number of people in the Sample	Mean (S.D)	Fraction of the Extremely Poor (%)	Mean (S.D)	Fraction of the Extremely Poor (%)
Koraro	436	1.04 (0.73)	80.0	0.90 (0.84)	83.3
Selam	467	0.89 (0.63)	81.8	0.78 (0.59)	86.7
MV Subtotal	903	0.96 (0.68)	81.0	0.84 (0.61)	85.0
Debrehiwot	497	0.96 (0.98)	86.1	0.87 (0.96)	86.9
Simret	465	0.86 (0.68)	86.9	0.75 (0.65)	88.4
Non-MV Subtotal	962	0.91 (0.84)	86.5	0.81 (0.82)	87.6
Total: All	1,865	0.94 (0.76)	83.8	0.83 (0.72)	86.4
Testing Null Hypothesis: Fraction of People in Extreme Poverty in MV equals that in Non-MV					
T-stat		0.630		0.351	
P-value		0.529		0.726	

Source : The daily income per capita in 2005 international price is computed by converting the household gross income or net income derived from your survey data. The fraction of the extremely poor is the fraction of people whose daily income is below $1.25 in 2005 PPP.

In order to count the number of people whose daily income is less than $1.25 in 2005 PPP, (1) we need to divide the household income by the number of household members to turn it into the per capita income, (2) we convert the per capita income in current ETB into 2005 ETB, (3) we apply the WHO conversion rate to make it denoted in terms of 2005 international dollar, and then (4) we divide it by 365 to turn it into the daily income.

Using that daily income per capita in 2005 international dollar, we can count the number of people whose daily income is less than $1.25 in 2005 PPP. We do this computation using the gross income and the net income described in the previous section.

<Table 2> summarizes the computed daily income per capita in 2005 international prices. The average daily income per capita in 2005 international dollar is the highest in Koraro ($1.04) and the lowest ($0.91) in Simret, when we use the gross income. But the income difference across villages is not significant. When we compute the daily per capita income based on the net income, the village average decreases by $0.09~$0.14 and the order villages in average daily income per capita does not change. The income differences across villages continue to be insignificant.

When we use the gross income of the households, the fraction of the people whose daily earning is less than $1.25 (2005 PPP) is 80.0% for Koraro, 81.8% for Selam, 86.1% for Debrehiwot, and 86.9% for Simret. The extreme poverty for MV is lower by 5.5%. When we use the net income of households, the extreme poverty measure increases slightly. It is 83.3% for Koraro, 86.7% for Selam, 86.9% for Debrehiwot, and 88.4% for Simret. However, the gap between MVs and non-MVs decreased to 2.6%. In either case, the fraction of people in extreme poverty in MVs is not significantly different from that in non-MVs.

Ⅳ. Extreme Poverty in Terms of Calorie Deficiency

In this section we define extreme poverty as the deficiency of calories, which is the difference between the minimum calorie requirements and the calories contained in the foods consumed by the households. And then we measure the prevalence of the extreme poverty by computing the fraction of households whose calorie intake falls short of the minimum requirement.

Because we know the age and gender of each and every member of household and the FAO (2008) provides us with the table for the minimum daily dietary energy requirement by age and gender, we can compute the minimum daily calorie

requirement for the household. When we multiply this number by 356, it becomes the minimum annual calorie requirement for the household. As shown in <Table 3> the households in non-MVs have higher calorie requirements per household. The reason is that the size of households in non-MVs is larger and they consist of more adolescents.

Table 3. Calorie Intake and Calorie Deficiency

Villages	Number of households in the sample	Calorie from cereals (A)	Calorie from other foods (B)	Minimum required calorie (C)	Calorie Deficiency (C)-(A)-(B)	Fraction of the Extremely Poor*
		Mean (S.D)	Mean (S.D)	Mean (S.D)	Mean (S.D)	%
Koraro	78	1691251 (1302301)	528953.1 (888781.3)	3557650 (1580621)	1337446 (1968717)	80.8
Selam	81	1324567 (1071067)	612950.7 (840824.7)	3749325 (1398704)	1811807 (1831472)	87.7
MV Subtotal	159	1504450 (1200498)	571744.3 (862965.3)	3655296 (1489082)	1579102 (1908881)	84.3
Debrehiwot	80	1413069 (1350422)	556444.1 (699600.9)	4044469 (1483157)	2074956 (2183975)	83.8
Simret	85	1074068 (82892.8)	477660.7 (844489.5)	3636667 (1331323)	2068697 (168227)	90.6
Non-MV Subtotal	165	1240449 (1124039)	515858.7 (776276.7)	3834389 (1417481)	2071769 (1938657)	87.3
Total: All	324	1370810 (168112)	543284.1 (819167.1)	3746501 (1453573)	1828496 (1936789)	85.8
Testing Null Hypothesis: Mean of MVs=Mean of non-MVs, or Fraction of EP in MVs=Fraction of EP in non-MVS						
T(Z)-stat		**2.0375****	0.613	-1.109	**-2.297****	0.772
P-value		0.042	0.540	0.268	0.022	0.220

Source : The calorie intake and the minimum calorie requirements are computed using our survey data and the FAO's table for the minimum daily dietary energy requirement by age and gender and food composition table for use in Africa.

Note : *The fraction of the extremely poor is defined as the fraction of households whose calorie intake falls short of the minimum requirement for the household.

We computed the calorie intake using the survey data of the amount of food consumption and the food composition tables for Africa made by FAO and the USDA. We estimated that the annual cereal consumption for the household is the sum of the difference between the cereal output and the cereal sales and the amount of cereals purchased for consumption. That is, in this computation we assumed that the unsold cereal outputs are all consumed by the households. For the consumption of other food items such as milk, meat, egg, and vegetables, we used the responses of the interviewees. (In this computation, we have not included the pulses and the fruits, of which the consumption is very small.)

The Food composition tables for Africa that we used in this study are summarized in <Table A4> of Appendix. To compute the calorie intake for the household we multiply the amount of consumption of each food item by the calorie containment of that food per kilogram and add them up for all food items. The first and the second columns of <Table 3> show that the households in MVs take more calories than those in non-MVs. But only the difference in the calorie intake from cereals is significant statistically.

We define the calorie deficiency as the difference between the minimum calorie requirement and the total calorie intake. The fourth column of <Table 3> shows that the calorie deficiency is prevalent in this region. And it is significantly more so in the non-MVs. A dominant proportion of households in all of the four villages appear to have a serious problem in acquiring enough energy from the foods. For the whole sample, 85.8 % of the households suffer from calorie deficiency. The fraction of households who suffer from calorie deficiency is the lowest in Koraro, a MV, and it is highest in Simret, a non- MV. However, the fraction of households with calorie deficiency in Selam, another MV, is higher than that in Debre Hiwot, another non-MV. Across the four villages, the only meaningful difference is observed between Koraro and Simret. The calorie deficiency is more prevalent in Simret than in Koraro at the 5% significance level. Though a slightly larger fraction of the households in non-MVs seem to suffer from the food shortage, the difference is not significant statistically.

Ⅴ. Comparison: Insufficient Income, Calorie Deficiency, and Official Measure

The measurements of the prevalence of extreme poverty in the four villages of Hawzen, Tigray vary depending on how we define and measure the lack of material resources for sustaining life. In this study we measured the access to the material resources by estimating the daily income per capita in terms of money and the daily calorie intake per capita from the food consumption. And then we measured the prevalence of the extreme poverty by the fraction of people whose daily income falls short of $1.25 in 2005 PPP, or by the fraction of households whose total calorie intake falls shorts of the minimum requirement suggested by WHO.

<Table 4> summarizes how the prevalence of extreme poverty varies depending on the definitions and measurements. The extreme poverty based on gross income insufficiency in the four study villages is less prevalent than that based on net income insufficiency and calorie deficiency. Because net income is less than gross income by the farming expenses, the net income based poverty measure must be is larger than that based on gross income. Nevertheless, the difference is not large: The difference is the largest for Koraro, 3.3% point, is the smallest for Simret, 0.6% point, and the difference for all four villages is 2.6% point. The reason for the slim difference between the two head counting poverty measures reflects the fact that the subsistence farming does not use much agricultural inputs.

Poverty in terms of calorie deficiency is smaller by 0.6% point than that in terms of net income but larger by 2.0% point than that in terms of gross income. Poverty in terms of calorie deficiency is larger than that in terms of insufficient gross income for all four villages. But it is not smaller than that in terms of the insufficient net income for all villages; it is larger for Selam and Simret, but smaller for Koraro and Debrehiwot. Except for Koraro, poverty in terms of calorie deficiency is much closer to that in terms of insufficient net income. In sum, we may well say that the three measurements of poverty we have constructed using our survey data are not much different from one another. Because the measurements

using the income data and the calorie data have adopted different approach and criteria, theses measure cross check the validity of the others. In this sense, it is reassuring that these measurements remain consistent with one another.

Table 4. The Prevalence of Extreme Poverty: Head-counting Index

Villages	Insufficient Daily Income per Capita (Less than 1.25 USD in 2005 PPP)			Calorie Deficiency of Households (Calorie intake < Minimum Calorie Requirement)	
	Number of people in the Sample	Based on Gross Income (%)	Based on Net Income (%)	Number of households in the sample	Based on Calorie Deficiency (%)
Koraro	436	80.0	83.3	78	80.8
Selam	467	81.8	86.7	81	87.7
MV Subtotal	903	81.0	85.0	159	84.3
Debrehiwot	497	86.1	86.9	80	83.8
Simret	465	86.9	88.4	85	90.6
Non-MV Subtotal	962	86.5	87.6	165	87.3
Total: All	1,865	83.8	86.4	324	85.8

Source : This table is reorganized using <Table 2> and <Table 3>.

However, it should be noted that our measurements of poverty are markedly higher than the official statistics. According to the Bureau of Planning and Finance of Tigray, the per capita GDP of the State of Tigray was 926 birr in the 1999-2000 fiscal year. According to a back-of-envelop calculation using that the average inflation rate during the last decade is 14.2 % (Index Mundi, http://www.indexmundi.com/g/g.aspx? c=et&v=71), and that the WHO conversion rate of ETB into 2005 international dollar is 2.81 (WHO, http://www.who.int/choice/costs/ppp/en), we can estimate that the per capita GDP of the State of Tigray was $642.4 in 2005 PPP in the fiscal year of 1999-2000. It means that the daily earning per capita in Tigray in that year was about $1.76 in 2005 PPP. Considering that the income distribution is skewed to the right we may

infer that more than a half of the population of Tigray was below the poverty line in 2000[3]. This implies that our measurements of poverty may be higher than the official statistics by at least by 30 percentage points.

This conjecture is, indeed, corroborated by Afera (2015) who estimated that the prevalence of poverty in Gulomekeda wereda of Tigray using the data collected by the local NGO, the Relief Society of Tigray (REST) as of 2010. According to Afera, the fraction of the households below the poverty line was 51%. The gap is even wider when our measurements are compared to the official measurement of the Ministry of Finance and Economic Development (MOFED, 2012) of Ethiopia. According to MOFED, the fraction of rural households below the poverty line in terms of their daily income was 51% in 2004 and 36.5% in 2010.

However, Alkire and Roche (2013) argue that poverty in Ethiopia had not been improved significantly between the periods from 2000 to 2005 and from 2005 to 2011 when the multidimensional poverty criterion is applied. They estimate that the fraction of households below the multidimensional poverty line was 89.7% during the period between 2000 and 2005, and 84.1% during the period between 2005 and 2011. It turns out that our measurements of poverty based on income insufficiency and calorie deficiency turn out to be similar to Alkire and Roche's multidimensional poverty measurement. A further study is called for to investigate where the discrepancy between our measurements and the official measurements come from.

Ⅵ. Other Features of Subsistence Economy: Marketization and Inequality among the Poor

In a typical subsistence economy, only a small fraction of the agricultural outputs of households are sold at the market. Using our survey data we can take a glimpse

3) According to the official statistics of the World Bank, the fraction of the entire Ethiopian population whose daily income was below the poverty line was 54.6% in 2000, 39.0% in 2005 and 36.8% in 2011. (World Bank, http://databank. worldbank.org/data/views/reports/tableview.aspx)

at how limited marketization is in a subsistence economy. The gross income <Table 1> includes the value of agricultural outputs – sold and self-consumed – as well as the income that accrues in cash such as wage, remittances, subsidies, and etc. The total cash income in the same table include the value of agricultural outputs sold at the market and other income in cash. Because the income in the form of cash has to go through market transactions, the ratio between the two can tell us how well the market system is developed in the subsistence village economy.

<Table 5> summarizes the degree of marketization by villages. Among the four villages, Simret, a non-MV, has the highest marketization ratio, 41.3%, while Selam, a MV, has the lowest ratio, 33.3%. Overall, the degree of marketization for the four villages is 36.9%. The non-MVs have a slightly higher degree of marketization than the MVs. But the difference is not statistically significant.

Table 5. Degree of marketization: The ratio of the cash income to the gross income

Villages	N*	Degree of Marketization	
		Mean	S.D.
Koraro	78	0.382	0.202
Selam	81	0.333	0.261
MV Subtotal	159	0.357	0.234
Debrehiwot	80	0.344	0.226
Simret	85	0.413	0.219
Non-MV Subtotal	165	0.379	0.225
Total: All	324	0.369	0.229
Testing Null Hypothesis: Mean of MV=Mean of Non-MV			
T-stat		-0.864	
P-value		0.388	

Source : Degree of marketization is the ratio of total cash income to the gross income of the households. In this computation we used the cash income and gross income computed in <Table 1>. * N is the number of households.

It is interesting to see that the degree of marketization is not necessarily higher

for a village with higher income. This may be because in a subsistence economy those farmers who cannot produce enough to feed their family may have to resort to the economic activities that involves buying and selling at the market, including labor. Also, as can be seen in <Table 5> the degree of marketization is fairly low. This is one of the features of a subsistence economy that makes it difficult to measure the household income. When the subsistence household is asked how much you have earned last month or year, they are most likely to give us an answer only about the income they earned in cash, which is a minor part of their true income.

Figure 1. Kernel density distribution of gross income of households

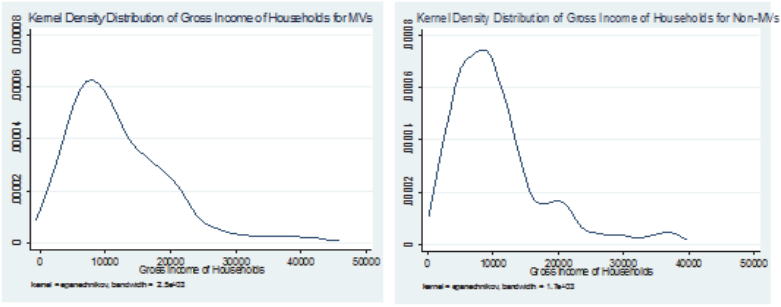


Figure 2. Kernel density distribution of net income of households

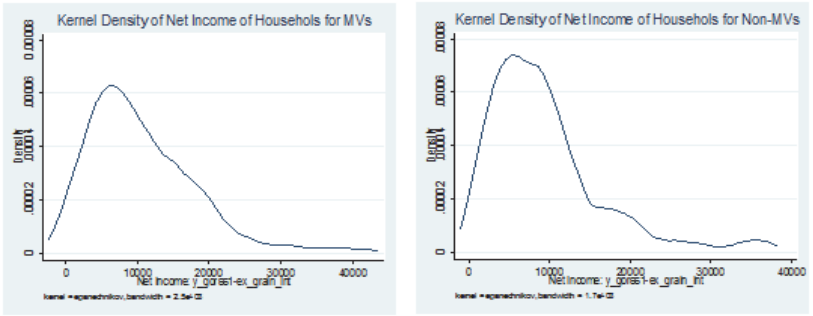
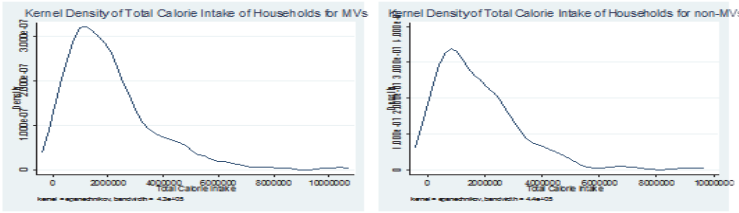


Figure 3. Kernel Density Distribution of Total Calorie Intake of Households



Even in a subsistence economy where many households suffer from extreme poverty, income and food consumption are not equally distributed. Thus, the measure of extreme poverty by head counting is limited in the sense that it does not reflect the entire distribution. The kernel density distributions of the gross income for households are shown in <Figure 1>. The distribution is drawn separately for MVs and non-MVs. The distribution of gross income for MVs is more dispersed and skewed to the right. The kernel density distributions of the net household income are shown in <Figure 2>. Again the distribution net income of households in MVs is more dispersed and skewed to the right. If comparing the Figures 1 and 2, we can see that the distribution of net income has a thicker right tail, which implies that the distribution of net income is more concentrated. <Figure 3> shows the kernel density distribution of total calorie intake of the households for MVs and non-MVs separately. Compared to the distributions of gross income and net income, the distribution of the total calorie intake has much thicker right tail, which means that the distribution of calorie consumption is more concentrated than those of gross and net income.

Table 6. Income and Calorie Inequality: Gini coefficients

Villages	N	Income		Calorie
		Gini Coefficient for Gross Income	Gini Coefficient for Net Income	Gini Coefficients for Total Calorie Intake
Koraro	78	0.316	0.356	0.369
Selam	81	0.353	0.383	0.422
MV Subtotal	159	0.336	0.371	0.400
Debrehiwot	80	0.329	0.367	0.409
Simret	85	0.354	0.399	0.441
Non-MV Subtotal	165	0.345	0.386	0.430
Total: All	324	0.343	0.380	0.416

Source : Gini coefficients were computed using the gross income and net income computed in <Table 1> and the total calorie intake computed in <Table 3>.

In order to assess how concentrated the income distribution is we computed the Gini coefficients. It is surprising to see that the inequality of income and calorie consumption is not small in a subsistence economy where a large number of people suffer from extreme poverty. It implies that even among the extremely poor households, there are many households who are relatively poorer. This observation raises question of whether a development project should target the poorer of the poor or to take a universal approach.

Among the four villages, Simret, a non-MV and the poorest for the four, has the most concentrated distribution of income and calorie intake in terms of Gini coefficient. On the other hand, the Gini coefficients for Koraro, an MV and richest of the four, are the lowest. We cannot conclude that the level of income and inequality has an inverse relationship. However, the observations provide a strong indication that the income inequality is not systematically related to the level of income.

Also, the income and the calorie intake distributions of non-MVs are more concentrated than those of non-MVs. When we compare the Gini coefficients for

gross income and net income, the Gini coefficients for net income is invariably more concentrated than the gross income.

Ⅶ. Implications

In this section we conclude by discussing the implications of our findings.

(1) We found a huge gap between the poverty measurement based on our survey data and the government's official measurement of poverty. The large discrepancy seems to come from the difficulty in measuring subsistence farmers' income in a reliable way. Depending on how one measures the income of a subsistence rural household, the degree of extreme poverty is affected significantly. As shown in section 6, in the four villages that we have surveyed only about 37% of the subsistence farmers' income accrues in cash. Thus, the difficulty in measuring income stems from two sources: the difficulty in observing the agricultural output and finding the relevant prices of theirs. The former is in line with Margaret and Glewwe's (2010) argument that income measure is noisy because of the difficulties of measuring the value of self-consumed food and its seasonality. The latter is the same sort of bias that Gebremedhin and Whelan (2007) reports when they found out that the poverty in several urban areas of Ethiopia is higher than the official figures when the proper prices are used in estimating the cost of living. The researchers, the practitioners, and the policy-makers should be careful in dealing with the income data collected from a subsistence rural area.

It is typically the case that subsistence farmers report their agricultural outputs less than what they actually produced partly because they do not remember accurately and partly because they have various incentives to report less. Our survey data suffers from the same defect and this will lead to overstating poverty. On the other hand, we have evaluated the agricultural products with local prices instead of

national average prices. In the case of the four villages that we studied the local prices are lower than the national average by about 10%. This implies that the government statistics constructed using the national average prices will understate the poverty of this region. Thus, it is fair to say that the true measurement of poverty must lie somewhere between our measurements and the official government measurement. More investigation is called for to pin down the true value of poverty measure.

(2) In this study, we cross-checked the poverty measurement based on the income insufficiency with that based on the calorie deficiency. This cross-checking method that we adopted is consistent with Margaret and Glewwe (2010)'s suggestion that consumption may be a better measure of poverty when income data is not reliable. And the calorie approach can complement the limitation of the World Bank's simplistic definition of extreme poverty. In our case, the poverty measurements based on income and calorie turned out to be coherent. This indicates that a close scrutiny on designing the questionnaire and interview can improve the reliability of the measurement of subsistence farmers' income.

(3) Even in extremely poor economies, there is remarkable income and calorie inequality among the villagers. The poorer the village is, the more concentrated the income and calorie intake is. The consumption of calories is more concentrated than income. These findings tell us that we need to pay attention to the distribution of income along the way when we are trying to start turning the wheel of economic growth. They also seem to justify the strategies of some development NGOs who are targeting the poorer of the poor. For instance, REST hires poorer households in the village when they launch civil construction projects for a village.

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Appendix

Table A1. Yield of major cereals per hectare in 2012 by villages

	teff			wheat			Barley		
	N*	Mean (100kg)	S.D. (100kg)	N*	Mean (100kg)	S.D. (100kg)	N*	Mean (100kg)	S.D. (100kg)
Koraro	60	2.2	1.8	6	1.5	0.8	12	1.4	1.2
Selam	46	1.2	0.9	58	1.8	1.2	34	2.0	1.8
Subtotal: MV	106	1.8	1.5	64	1.8	1.2	46	1.9	1.7
Debrehi wot	39	0.9	0.9	53	1.6	1.2	30	2.4	1.7
Simret	5	0.4	0.4	68	1.4	1.0	60	1.5	1.2
Subtotal: Non-MV	44	0.9	0.8	121	1.5	1.1	90	1.8	1.4
Total: All	150	1.5	1.4	185	1.6	1.2	136	1.9	1.5
Testing Null Hypothesis: MV=Non-MV									
T-stat	3.57***			1.85*			0.14		
P-value	0.001			0.067			0.893		
	maize			sorghum			Millet		
	N*	Mean (100kg)	S.D. (100kg)	N*	Mean (100kg)	S.D. (100kg)	N*	Mean (100kg)	S.D. (100kg)
Koraro	48	2.0	1.7	50	2.1	1.6	21	1.1	0.9
Selam	9	1.8	2.1	8	1.1	0.6	50	13	1.3
Subtotal: MV	57	2.0	1.8	58	2.0	1.5	71	1.2	1.2
Debrehi wot	15	1.1	1.4	29	2.1	1.6	48	1.4	1.0
Simret	17	1.4	1.4	10	0.5	0.3	52	1.0	1.1
Subtotal: Non-MV	32	1.3	1.4	39	1.7	1.6	100	1.2	1.0
Total: All	89	1.7	1.7	97	1.9	1.5	171	1.2	1.1
Testing Null Hypothesis: MV=Non-MV									
T-stat	1.892*			1.04			0.441		
P-value	0.062			0.299			0.660		

Source : This table is constructed using the survey data.
Note : * N is the number of households who cultivated the particular cereal in 2012.

Table A2. Yield of pulses in 2012 by villages

	bean			pea			Lentil		
	N*	Mean (100kg)	S.D. (100kg)	N	Mean (100kg)	S.D. (100kg)	N	Mean (100kg)	S.D. (100kg)
Koraro	1	0.25	-	2	2.3	2.5	3	0.7	0.3
Selam	14	1.2	1.8	4	0.8	0.5	1	0.3	-
Subtotal: MV	15	1.1	1.7	6	1.3	1.4	4	0.6	0.3
Debrehi wot	4	0.7	0.3	9	0.7	03	0	-	-
Simret	12	0.3	0.2	4	0.6	0.3	4	0.6	03
Subtotal: Non-MV	16	0.4	0.3	13	0.7	0.2	4	0.6	0.3
Total: All	31	0.7	1.2	19	0.8	0.8	8	0.6	0.3
Testing Null Hypothesis: MV=Non-MV									
T-stat	1.590			1.532			0.000		
P-value	0.123			0.144			1.000		

Source : This table is constructed using the survey data.
Note : * N is the number of households who cultivated the particular pulse in 2012.

Table A3. Cereal prices at the Hawzen district market in Aug. 2013

Cereal	Price(Birr)
Teff	
White(Qtl)	1693
Sergen(Mixed)(Qtl)	1451
Red(Qtl)	1123
Wheat(Qtl)	
Shehan (white) (Qtl)	742
Improved seed(Qtl)	793
Canada(Qtl)	850
Barley(Qtl)	687
Maize(Qtl)	617
Millet(Dagusa) (Qtl)	945
Sorghum(Qtl)	
White(Qtl)	691
Red(Qtl)	850
Ater	
Abiy Ater(Qtl)	1147
Ayni Ater(Qtl)	1147
Keyih Ater(Qtl)	1147
Birsin(Qtl)	1820
Sebere(Qtl)	725
Entatie(Qtl)	900
Abaeke(Kg)	27

Source : Separately from the survey, the price data was attained from the Wednesday market of Hawzen, at the district center, on August 2013.

Table A4. Food Composition Table for Use in Africa

1. Grains and beans

	Unit	Calorie(FAO)	Reference
Teff	kg	3,380	(white teff:3320, red:3280, mixed:3380)
Wheat	kg	3,310	(Hard wheat: 3310, soft wheat:3300)
Barley	kg	3,370	Whole grain
Maize	kg	3,570	Whole kernel, dried
Sorghum	kg	3,450	Average of all varieties
Millet	kg	3,280	Ragimillet(African millet), whole grain, Red: 3280/ While:3450
Bean	kg	3,340	Phaseolus(Ethiopian bean), white, whole dried
Chick pea	kg	3,570	Whole seeds: 3570, ground seeds: 3760
Lentil	kg	3,450	Whole lentil

2. Meat

	Unit	Calorie		Reference
		FAO	USDA	
Chicken	kg	1,460		
Beef	kg	2,370		Very thin:1220, medium fat:2370, fat:4100
Pork	kg	4,180		Medium fat
Goat	kg	-	1,090	
sheep	kg	2,650		unspecified

3. Dairy product

	Unit	Calorie(FAO)	Reference
Egg	1kg	1,400	Hen egg, whole, raw
Milk	liter	790	Cow, whole

Source : FAO, FOOD COMPOSITION TABLE FOR USE IN AFRICA
(http://www.fao.org/infoods/infoods/tables-and-databases/africa/en/)

USDA, National Nutrient Database for Standard Reference Release 27
(http://www.nal.usda.gov/fnic/foodcomp/search)

국문초록

북부 에티오피아 건조 고원지대의 빈곤측정: 소득기준과 칼로리기준

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본 연구에서는 에티오피아 티그레이주(州) 하우젠군(郡)의 네 개 농촌마을 Koraro, Selam (밀레니엄 빌리지, MVs)과 Debrehiwot, and Simret (非 밀레니엄 빌리지, non-MVs)의 빈곤을 측정한다. 설문조사의 표본은 324개 가구 1,865명으로 구성되어 있다. 절대빈곤의 정도는 세 가지 방식으로 측정하는데, 일인당 일일 소득이 2005 PPP $1.25에 이르지 못하는 사람의 비중, 일인당 일일 순소득이 2005 PPP $1.25에 이르지 못하는 사람의 비중, 그리고 연간 총 칼로리 섭취량이 FAO가 권고한 최소필요열량에 미치지 못하는 가구의 비중으로 측정한다. 본 연구의 분석을 통해 발견한 사실들은 다음과 같다. (1)본 연구에서 계측한 빈곤의 정도는 정부가 공식으로 발표한 수치보다 최소 30% 포인트 이상 높다. (2) 소득미달 기준으로 계측한 빈곤의 정도와 섭취열량부족으로 계측한 빈곤의 정도는 대동소이하다. (3) non-MV의 빈곤의 정도가 MV에 비해 더 심한 것으로 파악되지만, 소득 기준으로 집계한 빈곤의 차이는 통계적으로 비유의적인 반면 칼로리 기준으로 집계한 빈곤의 차이만 통계적으로 유의하다. (4) 절대빈곤이 만연한 경제에서도 소득과 열량섭취의 불평등도가 상당히 높은 수준이며, 소득과 열량섭취의 분배는 소득수준이 상대적으로 낮은 마을에서 더 집중되어 있는 경향이 있다.

[주제어: 빈곤, 칼로리 섭취, 에티오피아, 새천년 마을, 소작농]

논문접수일: 2015년 12월 2일 / 심사일: 2016년 1월 8일 / 게재확정일: 2016년 2월 17일

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