［*Jpn. J. Agric. Econ.* Vol.25, pp.13-16, 2023］

Seasonal Energy Deficiency of Rural Rice Farmers in Madagascar

Sakiko Shiratori,[1*] Davaatseren Narmandakh[2] and Jules Rafalimanantsoa[3]

This study examines the effect of seasonality by utilizing original individual, household level energy intake panel dataset of three rounds of surveys from rural lowland farmers in the Central Highlands in Madagascar. Household's food consumption revealed by 24-hour recall was converted to energy intake per person using adult male equivalent measure. We employed a fixed effects model and found that seasonally significantly affects negatively on energy intake and energy sufficiency rate during lean season. In lean season, farmers tend to substitute roots and tubers for rice, and they are more likely to depend on purchased food.

Key words: seasonality, Madagascar, energy intake

1. Introduction

Smallholder farmers represent half of the world's starving people (Sanchez and Swaminathan, 2005). They mainly live by small-scale agriculture and livestock breeding, selling their surplus and purchasing foodstuff as seasonally required (Barret 2008). Especially these smallholders in rural areas of the developing regions tend to experience seasonal hunger due to not enough self-production, stock shortage, and high consumer prices in lean seasons.

Madagascar is of particular interest when considering malnutrition, with almost half of the children under 5 years of age stunted, with an annual 277 kilocalories of deficit per person per day (UNDP 2017). In lean seasons, over half of rural households often reduce their daily ratios and switch to less preferred food which is likely to be of lower nutritional values to cope with shortages (WFP and UNICEF 2011).

Researchers have found that not only food availability but also various welfare indicators such as consumption, income, and prices moved together with the agricultural seasons (Dercon, and Krishnan 2000, Dostie *et al*. 2002) and thereby energy intake and energy sources change by seasons (Stelmach-Mardas *et al*. 2016, Sibhatu and Qaim 2017). Seasonality could threaten "stability", which is one of the important aspects of food security, thus seasonal effect on hunger is of particular importance in nutritional improvement policy formulation. However, rigorous analysis of rural smallholder diet is still limited.

This study expands the build on those relationships, by profiling seasonal fluctuation of energy intake in rural area in Central Highlands of Madagascar and its determinants. In Madagascar, rice is a dominant staple food and about 85% of farmers grow rice (GRiSP 2013). Taking lowland rice farmers as targets, this study aims to determine the role of seasonality in household diets in terms of energy intake, energy acquisition source, and energy source by food groups, by utilizing originally collected data of three rounds of panels.

2. Data

Data were collected from May 2019 to February 2020 in Vakinakaratra region, Central Highlands of Madagascar. From three districts, 60 villages were selected proportionally to the size of each district, from which 10 lowland rice farming households were randomly selected. We selected 600 households at baseline. After correcting for energy intake outliers,[1)] the dataset became an unbalanced panel of three rounds of 1,638 households, including 7,207 individuals.

The households were asked to recall their twenty-four-hour food intake for each meal at household level. The recipes and ingredients used were all recorded with their quantities. Other socio-economic characteristics of the household and anthropometric data of each household member were also collected.

The first survey was conducted in May-June 2019 (hereafter refer it as "June"), shortly after lowland rice harvest was done. The second survey in October-November 2019 ("Oct") was almost five months after the main harvest

[1] Japan International Research Center for Agricultural Sciences
[2] Asian Development Bank Institute
[3] National Nutrition Office, Madagascar

Corresponding author*: Shiratori.Sakiko@affrc.go.jp

1) Households that have higher than 1.5 times interquartile range above the third quartile energy intake per day were excluded.

season, and the third survey in February-March 2020 ("Feb")[2] was before the main harvest season. The hunger gap extends from January to April, during which few crops are ready for harvest, leading to shortages if the previous year's stock is exhausted.

3. Methods

We converted ingredients of household meals to energy provided by them by compiling a food composition table, using US Department of Agriculture (USDA)'s food composition database (2021) as well as Vincent *et al.* (2019) and Charrondière *et al.* (2017), and then using extractions rates as described in Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan (2015).

We calculated adult male equivalent (AME) for each individual by considering their age, sex, weight, and pregnancy/lactation stage. We then computed the weight of food consumed at household meals by each individual in proportion to AME[3] for each meal. Individual's energy intake was compared with each individual's estimated average requirement (EAR) for energy.[4]

Due to the nature of our dataset, we used individual fixed effects model to capture seasonal effect on the total energy intake and energy sufficiency rate.[5] Table 1 shows descriptive statistics of variables shown in Equation 1.

$$Y_{ihs} = \beta_0 + \beta_1 Season_s + \alpha' X_{is} + \gamma' F_{hs} + u_i + \varepsilon_{ihs} \quad (1)$$

Y_{ihs} is our dependent variable, which is the amount of energy intake (or energy sufficiency rate) from household meals of individual i in household h at season s. β_1 measures our main variable of interest, the seasonality effect on individuals' energy intake. X_{is} are individual time-varying characteristics that include breastfeeding/pregnant status to control for increased energy demands. F_{hs} are household level time-variant variables including several characteristics of household head, household size, household composition, and livestock holdings to control for wealth.[6] F_{hs} also includes diet specific characteristics to control for variation

Table 1. Descriptive statistics

	June		October		February		Pooled	
Panel A : Household level								
Number of households (HH)	549		550		539		1638	
HH head's age	47.0	(14.22)	47.94	(14.21)	47.49	(14.17)	47.49	(14.17)
HH head's sex (=1 if male)	0.89	(0.31)	0.88	(0.32)	0.88	(0.31)	0.88	(0.31)
HH head's education (years)	5.38	(3.67)	5.35	(3.71)	5.36	(3.69)	5.36	(3.69)
HH size	4.68	(1.89)	4.69	(1.93)	4.68	(1.91)	4.68	(1.91)
Percentage of children under 5 in HH	0.12	(0.15)	0.11	(0.15)	0.11	(0.15)	0.11	(0.15)
Percentage of school age children in HH	0.24	(0.19)	0.24	(0.20)	0.24	(0.20)	0.24	(0.20)
Percentage if elderly in HH	0.21	(0.44)	0.16	(0.33)	0.21	(0.49)	0.21	(0.49)
Livestock (tropical livestock unit: TLU)	1.01	(0.85)	1.09	(0.87)	1.05	(0.86)	1.05	(0.86)
Ceremony, celebration (=1 if yes)	0.05	(0.22)	0.00	(0.00)	0.02	(0.13)	0.02	(0.13)
Last market visit:								
Today (=1 if yes)	0.19	(0.39)	0.06	(0.22)	0.12	(0.32)	0.12	(0.32)
1-3 days ago (=1 if yes)	0.41	(0.49)	0.44	(0.49)	0.43	(0.49)	0.43	(0.49)
4-7 days ago (=1 if yes)	0.39	(0.48)	0.49	(0.50)	0.44	(0.49)	0.44	(0.49)
8+ days ago (=1 if yes)	0.01	(0.09)	0.01	(0.11)	0.01	(0.08)	0.01	(0.08)
Total number of guest per day	0.24	(1.28)	0.18	(0.79)	0.20	(1.01)	0.20	(1.01)
Weekend (=1 if yes)	0.18	(0.38)	0.21	(0.40)	0.20	(0.40)	0.20	(0.40)
Panel B : Individual level								
Number of individuals	2417		2412		2378		7207	
Age	26.26	(19.03)	26.96	(19.34)	27.25	(19.58)	26.82	(19.32)
Individual's sex (=1 if male)	0.51	(0.50)	0.51	(0.49)	0.51	(0.50)	0.51	(0.49)
In 2nd trimester of pregnancy (=1 if yes)	0.00	(0.06)	0.00	(0.02)	0.00	(0.04)	0.00	(0.04)
In 3rd trimester of pregnancy (=1 if yes)	0.01	(0.07)	0.00	(0.04)	0.00	(0.04)	0.00	(0.05)
Is currently breastfeeding (=1 if yes)	0.02	(0.13)	0.02	(0.14)	0.02	(0.13)	0.02	(0.13)

Note: Standard deviation in parenthesis

2) While it was after the upland rice harvest for some upland rice farmers, it was considered as lean period by many farmers as it was before the main harvesting season of lowland rice.

3) When the household had a guest, they were counted as one AME, also the computation took account missed meals by household's members. Therefore, the energy intake is of food consumed from household meals.

4) It was challenging to assign actual physical activity level for each individual, thus we assigned 1.85 (moderately active) for everyone above the age of 17.

5) The ratio of energy supplied to the requirement.

6) Since household head could change over time due to death, divorce, or migration, we controlled for household head characteristics.

in diets. u_i is individual specific fixed effects, and the last term is the error term.

4. Results

Table 2 shows the average intake, requirement, and sources of energy per individual per day. Their energy intake does not meet their requirement on average (Panel A). The sample mean of percentage of EAR supplied is around 90 percent. Energy deficiency prevalence, the ratio of individuals who have energy intake lower than each individual's EAR, is about two-thirds. Furthermore, energy intake seems seasonal, decreasing during lean season.

In Panel B of Table 2, we show acquisition sources of energy intake. Right after the main harvest season, 69% of the consumed energy originate from home production, while that from purchases is only 17%. However, as time passes households become increasingly dependent on purchases, and the ratio from purchases surpasses that from home production in lean season.

In Panel C of Table 2, we show mean energy intake by food categories. More than 60 percent of energy intake originates from rice. However, consumption of rice decreases from harvest season to lean season, and households seem to try smooth this gap by increasing their intake of roots and tubers (cassava, taro roots, potatoes). Energy intake from animal source foods is generally low, and intake of vegetables increases during lean seasons.

Farmers consume rice produced by themselves and they also sell rice at a market to get cash. Sometimes they sell rice at a lower price when they need cash and buy it back later when they need rice to eat, even at a higher price. In our data, of all the rice they consumed, while 12% were purchased in June, 59% were purchased in February.

Table 3 shows the results of equation 1. In column 1, the dependent variable is the total consumed energy in kilocalories, while in column 2 the dependent variable is the share of energy supplied by household meals in comparison to the energy requirement of that specific person. As mentioned earlier, differences in person's weight, physical activity, age range and procreation decisions change the person's energy requirement so we thought it might be good to show this result to confirm the robustness of column 1.

Even while holding for dietary characteristics of that day and carrying out an individual fixed effects model regression compared to the sample of June, the lean season in February had significantly lower level of energy intake, around 80 kilocalories. This is confirmed in column 2 as we see a 5% significant decrease in energy sufficiency rate. However,

Table 2. Intake, requirement, and sources of energy

	June		October		February		Pooled	
Panel A : Energy intake and requirement (S.D. in parenthesis)								
Average energy intake (kcal)	2,018.1	(21.2)	1,998.7	(19.4)	1,925.5	(21.7)	1981.0	(12.0)
Average EAR for energy (kcal)	2,200.0	(11.5)	2,215.3	(11.3)	2,199.9	(11.1)	2205.1	(6.5)
Average energy sufficiency rate	92.2	(0.8)	90.4	(0.7)	87.5	(0.8)	90.0	(0.4)
Energy deficiency prevalence	67.4%		68.7%		67.9%		68.1%	
Panel B : Mean energy intake by source of ingredients (kcal, % of energy provided from source in parenthesis)								
Produced at home plots	1,395.6	(69.2%)	1,039.4	(52.0%)	845.6	(43.9%)	1077.3	(54.4%)
Hunted wild animal, plants gathered	4.1	(0.2%)	4.1	(0.2%)	2.9	(0.1%)	3.8	(0.2%)
Purchased	343.3	(17.0%)	826.8	(41.4%)	893.0	(46.4%)	677.9	(34.2%)
Gift from friends and relatives	65.7	(3.3%)	7.4	(0.4%)	20.6	(1.1%)	25.7	(1.3%)
Aid from NGO or other organization	0.9	(0.0%)	0.0	(0.0%)	0.0	(0.0%)	0.3	(0.0%)
Leftovers	199.3	(9.9%)	120.9	(6.1%)	159.1	(8.3%)	148.7	(7.5%)
Other sources	9.2	(0.5%)	0.1	(0.0%)	4.3	(0.2%)	6.8	(0.3%)
Panel C: Mean energy intake by food category (kcal, % of energy provided from food category in parenthesis)								
Rice	1,364.1	(67.6%)	1,290.9	(64.6%)	1,135.1	(58.9%)	1250.3	(63.1%)
Cereals (excluding rice)	57.9	(2.9%)	72.6	(3.6%)	49.5	(2.6%)	56.6	(2.9%)
Roots and tubers	165.5	(8.2%)	307.5	(15.4%)	316.1	(16.4%)	257.5	(13.0%)
Vegetables	17.7	(0.9%)	25.1	(1.3%)	54.1	(2.8%)	31.3	(1.6%)
Fruits	8.6	(0.4%)	0.3	(0.0%)	0.4	(0.0%)	3.0	(0.2%)
Meat, poultry and offal	52.7	(2.6%)	54.1	(2.7%)	70.1	(3.6%)	53.7	(2.7%)
Eggs	0.2	(0.0%)	0.6	(0.0%)	0.2	(0.0%)	0.3	(0.0%)
Fish and seafood	66.2	(3.3%)	60.5	(3.0%)	53.0	(2.8%)	57.6	(2.9%)
Pulses, legumes and nuts	195.6	(9.7%)	93.6	(4.7%)	158.3	(8.2%)	139.9	(7.1%)
Milk and milk products	2.8	(0.1%)	2.6	(0.1%)	1.2	(0.1%)	2.3	(0.1%)
Oil and fats	64.8	(3.2%)	72.8	(3.6%)	72.9	(3.8%)	67.8	(3.4%)
Sugar and honey	21.1	(1.0%)	17.0	(0.8%)	12.7	(0.7%)	18.7	(0.9%)
Miscellaneous	0.8	(0.0%)	1.3	(0.1%)	2.0	(0.1%)	1.3	(0.1%)

Table 3. Seasonality on individuals' energy intake

Variables	Column 1: Total energy intake (kcal)			Column 2: Energy sufficiency rate (%)		
October	-17.1		(23.0)	-1.8	*	(1.0)
February	-79.3	***	(27.2)	-5.1	***	(1.2)
Head's sex	915.0	***	(175.2)	40.1	***	(6.9)
Head's age	3.2		(21.8)	-0.3		(1.0)
Head's age^2	-0.1		(0.21)	-0.0		(0.0)
Head's educ	159.0	***	(52.6)	7.0	***	(2.1)
Head's educ^2	-9.0	***	(2.3)	-0.4	***	(0.1)
HH size	-781.7	***	(105.8)	-34.3	***	(4.4)
HH size^2	44.5	***	(7.2)	1.9	***	(0.3)
% child <5	-16.6		(300.1)	7.1		(13.3)
% school age	-193.1		(233.9)	-6.4		(9.8)
% elderly	25.1		(156.8)	1.1		(6.7)
Livestock	9.1		(60.8)	-0.1		(2.7)
Special day	579.0	***	(152.3)	25.3	***	(6.9)
Market: <3d	167.5	***	(44.7)	7.5	***	(2.0)
3-7d	149.0	***	(45.5)	7.1	***	(2.0)
>7d	-376.2	***	(108.2)	-17.5	***	(4.5)
# of guest	-71.1	***	(14.4)	-3.4	***	(0.6)
Weekend	64.8	**	(26.8)	3.1	***	(1.2)
Preg. 2nd trim.	160.7		(282.1)	-8.1		(10.9)
Preg. 3rd trim.	268.5		(194.0)	-9.4		(6.9)
Breastfeeding	712.9	***	(154.2)	9.7	***	(5.9)
Constant		***	(720.3)	166.3	***	(30.7)
Obs:	7207			7207		

Note: *: 10%, **: 5%, ***: 1% of significance
Robust standard error in parenthesis

these are the results from our assumption that they allocate food according to their AME. Obtaining information on actual intrahousehold food allocation will be needed to appropriately interpret these results.

5. Conclusion

By utilizing our panel dataset, we found that seasonality exists for energy intake in this rural Madagascar. Energy intake significantly decreases in lean period of February. We also see the tendency that the energy source shifts from rice to roots and tubers, and from self-production to purchased food as time approaches to lean season. It implies that we may misunderstand if we take only one point in the year to evaluate rural farmers' nutritional intakes.

This study has several limitations. First, we only saw the quantity aspect without considering quality aspects in nutrition such as micronutrient intakes. Second, the intrahousehold food allocation and individual physical activity level were based on our assumptions. Assumed activity level was rather conservative and may have made the magnitude of seasonal energy gap relatively small. Third, there could be multitude of ways seasonality impacts energy intake, but it was out of scope to explore the channels. How seasonality affects energy and other nutrient intakes is still a question to be explored in future research.

Acknowledgement: Funded by SATREPS, JST/JICA (Grant No. JPMJSA 1608).

References

Barrett, C. B. (2008) Smallholder Market Participation: Concepts and Evidence from Eastern and Southern Africa, *Food Policy* 33(4), August 2008: 299-317.

Charrondière, U. R., D. Rittenschober, F. Grande, V. Nowak, and B. Stadlmayr (2017) FAO/INFOODS Analytical Food Composition Database Version 2.0-AnFooD2.0.

Dercon, S. and P. Krishnan (2000) Vulnerability, Seasonality and Poverty in Ethiopia, *The Journal of Development Studies* 36(6): 25-53.

Dostie, B., S. Haggblade, and J. Randriamamonjy (2002) Seasonal Poverty in Madagascar: Magnitude and Solutions, *Food Policy* 27(5-6): 493-518.

GRiSP (Global Rice Science Partnership) (2013) *Rice Almanac, 4th edition*. Los Baños, Philippines.

MEXT (2015) Standard Tables of Food Composition in Japan. https://www.mext.go.jp/en/policy/science_technology/policy/title01/detail01/1374030.htm (accessed on December 12, 2021).

Sanchez, P. A. and M. S. Swaminathan (2005) Cutting World Hunger in Half, *Science* 307(5708): 357-359.

Sibhatu, K. T. and M. Qaim (2017) Rural Food Security, Subsistence Agriculture, and Seasonality, *PLoS ONE* 12(10): e0186406.

Stelmach-Mardas, M., C. Kleiser, I. Uzhova, J. L. Peñalvo, G. La Torre, W. Palys, D. Lojko, K. Nimptsch, A. Suwalska, J. Linseisen, R. Saulle, V. Colamesta, and H. Boeing on behalf of the DEDIPAC-Consortium (2016) Seasonality of Food Groups and Total Energy Intake: A Systematic Review and Meta-analysis, *European Journal of Clinical Nutrition* 70: 700-708.

UNDP (2017) *Human Development Report 2016: Human Development for Everyone*. New York: UNDP.

USDA (2021) FoodData Central. https://fdc.nal.usda.gov/ (accessed on December 12, 2021).

Vincent, A., F. Grande, E. Compaoré, G. A. Annor, P. S. Addy, L. C. Aburime, D. Ahmed, A. M. Bih Loh, S. Dahdouh Cabia., and N. Deflache (2019) *FAO/INFOODS Food Composition Table for Western Africa*. Rome: FAO.

WFP and UNICEF (2011) Rural Madagascar Comprehensive Food and Nutrition Security and Vulnerability Analysis. https://documents.wfp.org/stellent/groups/public/documents/ena/wfp246796.pdf (accessed on June 1, 2022).