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KEY FINDINGS: DO COMMON YIELD MEASURES MISREPRESENT PRODUCTIVITY AMONG SMALLHOLDER FARMERS? A PLOT-LEVEL ANALYSIS OF RICE YIELDS IN TANZANIA

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Why does accurate yield measurement matter?

Crop yield is one of the most common proxies for agricultural productivity, with yield generally estimated as the harvested weight divided by harvested area. New estimates using data from the 2008 Tanzania National Panel Survey Living Standards Measurement Study – Integrated Surveys on Agriculture (LSMS-ISA) reveal that on almost a quarter of rice plots surveyed, farmers harvested less area than they planted. We find that common measures of yield that omit this "null production area" may significantly overestimate land productivity, particularly for poorer farmers and those with smaller plots.

Drawing on detailed plot-level data on rice planting and harvests from the LSMS-ISA we assess the factors that contribute to variations in smallholder productivity using ***two different measures of yield***:

(1) Kilograms per hectare harvested
(2) Kilograms per hectare planted

Median unhulled rice yield by area harvested was 1186 kg/ha on plots fully harvested. On plots with some area of null production, the median yield by area harvested was 1038 kg/ha. However if the full area planted is used in the denominator, median yield by area planted is only 371kg/ha – suggesting median land productivity is overestimated by a factor of three on these plots. An additional 6% of plots planted with rice were entirely unharvested. If these plots were included in our analysis, average yields on land with null production would drop further.

What causes a loss in area between planting and harvesting?

Farmers harvested less area than they planted on 23% of rice plots in Tanzania. As shown in Figure 1, farmers most commonly attribute lost pre-harvest production area to drought. Six percent of plots with no pre-harvest loss in area are irrigated, compared to 2% of plots that suffer some loss.

KEY FINDINGS

- Median yield is 1186 kg/ha on plots fully harvested. On plots with less area harvested than planted, the median yield is 1038 kg/ha using a common yield measure based on area harvested, but only 371 kg/ha using a yield measure based on area planted.
- Measuring rice yield by area harvested rather than by area planted may:

  Incorrectly measure the magnitude of some factors associated with yield variations:

  - Underestimate the positive association with hired labor days
  - Overestimate the negative association with larger plot sizes, above average temperature, and below average rainfall
  - Overestimate the positive association with soil nutrients, years of education of the household head, household labor days, and access to an ox

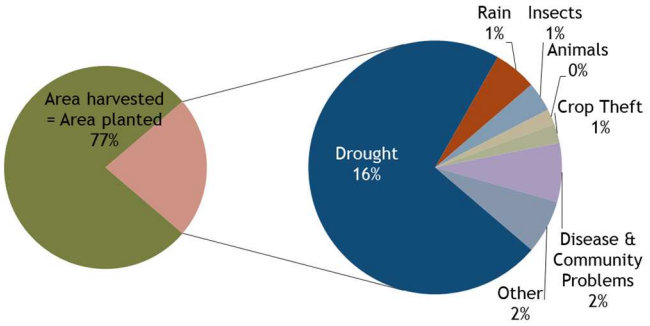
  Miss the significance of other factors associated with yield variations:

  - Miss the negative association with above average rainfall, female headed households, and receiving advice
  - Miss the positive association with selling rice
- Different demographic and management-related drivers of yield gains surface depending on the yield measurement used, leading to different implications for policy and economic development interventions.

The literature suggests other factors that contribute to pre-harvest losses in crop area include harvesting that is spread over a long time period, limited labor for maintaining and harvesting crops, non-planted areas due to natural obstructions, and intercropping. Intercropping in particular, can complicate the calculation of female farmer productivity because women are more likely to intercrop.[1]

NOTE: The findings and conclusions contained within this material are those of the authors and do not necessarily reflect positions or policies of the Bill & Melinda Gates Foundation.

Figure 1: Farmer-reported reasons for loss in area between planting and harvesting on long rainy season rice plots



What factors explain variation in Tanzanian rice yields?

We use multivariate regression to estimate the contribution of abiotic, biotic, management and socio-economic factors to variation in rice yields, comparing a common yield measurement (kg/ha harvested) to a measurement that includes null production on part or all of some plots (kg/ha planted). Overall, the model using yield by area planted explains more of the variation across smallholders than the model using yield by area harvested.

The choice of yield measure also results in different conclusions about the strength and significance of the estimated relationships. Access to an ox (plough, planter or cart) was associated with increased average yields of 1196 kg/ha when using yield by area harvested. The effect was also strong, but just under half as large (643 kg/ha) for yield by area planted. Reported soil fertility was important in explaining variation in yield by area harvested; soil that is not nutrient constrained is associated with yields 726 kg/ha higher. Market involvement and rainfall were more strongly associated with changes in yield by area planted: plots on which some rice was sold had yields by area planted that were higher by 572 kg/ha on average, and above average rainfall was associated with yields that were lower by 652 kg/ha on average. Neither the market activity nor the above average rainfall variable was significant in estimates with yield by area harvested, though below average rainfall was significant in both models. Household labor input is more important in the model with area harvested, whereas hired labor input is more strongly associated with increased yields in the area planted model.[2]

Are we measuring productivity of the poorest?

Comparing the results of the two alternative rice yield models, there is considerable variation in the socio-economic determinants of rice yield – suggesting the possibility of a nonrandom distribution across farmers of null production plots. Common yield measures based on area harvested may overestimate land productivity for poorer farmers in particular. Yield estimates using area planted rather than area harvested are 330 kg/ha lower for plots owned by households with total daily consumption under $1.25/day per adult equivalent yield, compared to 100 kg/ha lower for wealthier farmers. As shown in Table 1, the difference makes up 13% of the total yield for poorer farmers: median yields for these poorer farmers are 1038 kg/ha by area harvested and only 791 kg/ha by area planted.

Table 1: Comparing yield overestimation

ALL SAMPLE PLOTS n=376		p-value
Average yield (kg/ha) difference when using area harvested compared to area planted		
Daily consumption greater than $1.25/day per adult eq	99.7 kg/ha	0.0829
Daily consumption less than $1.25/day per adult eq	329.9 kg/ha	
Average proportion of yield difference when using area harvested instead of area planted		
Daily consumption greater than $1.25/day per adult eq	6%	0.0837
Daily consumption less than $1.25/day per adult eq	13%	

The difference in median yields for rice plots owned by farmers consuming more than $1.25/day per adult equivalent is far less, with only a 6% discrepancy between the two measures (these plots yield medians of 1236 kg/ha by area harvested and 1137 kg/ha by area planted).

Land productivity on smaller plots also appears to be disproportionately overestimated using common yield measures. For plots with null production, measuring yield by area harvested on smaller plots (those under one acre (0.40 ha) estimates yield to be 1928 kg/ha higher than yield by area planted. Yields for larger plots are also higher using area harvested versus area planted, but only by 633 kg/ha.[3]

Why measure yield by area planted?

Tanzanian rice farmers reported pre-harvest losses on over half of their plots, and they abandoned some crop area before harvest on nearly a quarter of plots. Hence, yield as measured by area planted, rather than harvested, may offer a fuller indication of the most important investments to improve smallholder productivity. In addition to pre-harvest losses, smallholder rice farmers also frequently report large post-harvest losses,[4] which are not accounted for when tracking productivity by simple yield measures. Productivity measures that fail to account for losses may be missing opportunities to increase the agricultural productivity of the poorest farmers, and instead be focusing efforts towards increasing the productivity of the relatively productive.

Please direct comments or questions to Leigh Anderson and Mary Kay Gugerty, at eparx@u.washington.edu. EPAR's innovative student-faculty team model is the first University of Washington partnership to provide rigorous, applied research and analysis to the Bill and Melinda Gates Foundation. Established in 2008, the EPAR model has since been emulated by other UW Schools and programs to further support the foundation and enhance student learning.

1 Golenko, A., Kpaka, C., McKee, C., Anderson, C.L., & Gugerty, M.K.(2013). EPAR Brief No. 216: TzNPS LSMS-ISA Intercropping.
2 Anderson, C.L., Reynolds, T., Slakie, E. Derksen-Schrock, K., Paulsen, J., & Cauthen, J. (forthcoming). EPAR Report No. 193: Do Common Yield Estimates Misrepresent Smallholder Land Productivity?
3 P= 0.0920
4 Bergh, K., Paulsen, J., Derksen-Schrock, K., Gugerty, M.K., & Anderson, C.L.(2012). EPAR Brief No. 188: TzNPS LSMS-ISA Rice In Tanzania.