Natural Disaster, Agricultural Extension, and Farmer’s Productivity: Evidence from Papua New Guinea

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Natural Disaster and Farmer’s Life

- Natural disasters including earthquakes, landslides, floods, fires, droughts, and hailstorms can threaten the livelihoods of smallholder farmers and their access to food at any time and everywhere
- Johnson (2003) found that the events most frequently reported by the 57 countries that replied were drought (91 percent) local severe storms (83 percent), floods (79 percent) frost (74 percent), and high winds (72 percent).

Natural Disasters, Productivity, and Extensions (1)

- Natural disasters make farmers need funds and technical assistance to rearrange agricultural land, damaged crops, and dead livestock, as well as infrastructure and supply their daily needs.
- Restoring agricultural productivity due to natural disasters requires a long process, especially if agricultural commodities take a long time to be harvested
- Natural disasters reduce the technical efficiency of farmers because they force farmers to allocate some of their resources to repair damaged land, crops, equipment, and infrastructure. Therefore, program interventions for farmers are important to be dedicated to, besides increasing productivity, it is also necessary to protect the environment from damage so that it has sustainability in production

Natural Disasters, Productivity, and Extensions (2)

- The role of intervention in dealing with the ravages of climate change which results in weather irregularities and natural disasters that are increasingly occurring is urgently needed on two sides.
- The first is prevention by increasing the productivity of farmers before a disaster occurs and environmental-oriented policies and the second is reducing the burden of agricultural recovery costs due to natural disasters.

Empirical Facts of Papua New Guinea

- From 1962 to 1979 growth of agricultural sector, on average is 3.34 percent with a standard deviation 1.32 (the lowest period of agricultural growth fluctuation), 1980-2019 grew only 2.78 percent with 5.32 standard deviation (4 times higher fluctuation) (WDI, World Bank)
- In 2009, the direct economic loss attributed to disaster relative to GDP is more than 50 percent, 68 percent in 2020 (UNDRR).
- Papua New Guinea employment has still dominated by the agricultural sector in which 56 percent (73.8 percent in 1991), based on ILO estimation, of workers live depend on this sector’s performance

Research Objectives

1. Identifying the impact of natural disasters (drought or irregular rains, floods, earthquakes, landslides, crops damaged by insects, disease, and animals) on agricultural sector production
2. Measuring productivity/technical efficiency of farmer’s production
3. Investigating the impact of agricultural extension support on farmers’ productivity/efficiency

Literature Review (1)

The literature review related to this study is divided into two parts, namely the impact of natural disasters on agricultural performance and the role of extension in increasing agricultural production.

Studies from Sivakumar (2005), Israeli and Briones (2012), Trinh, Feeny, and Posso (2021), Anh (2016) Weerasekara et al (2021), Boustan et al (2017), Barua and Banerjee (2020), Bui et al (2014), and Weerasekara et al (2021). All these studies prove that natural disasters and climate change are detrimental to well being of farmers

On the other hand, agricultural extension is important in terms of increasing productivity to restore conditions after natural disasters and if the extension program is environmentally oriented, it will not only increase productivity but will also reduce the potential for local natural disasters to occur. Indeed, environmental problems can not only be solved locally but global problems, but the deteriorating local environment and the possibility of local natural disasters can be reduced

Literature Review (2)

- Most studies find that agricultural extension has a positive impact on farmers' productivity and income, especially in the short term after an extension program as found by Owens et al (2003), Egziabher et al (2013), Zafar and Haq (2016), Ragasa et al. (2016), Emmanuel et al (2016), Abbeam et al (2018), Lampach et al (2018), Sebaggala and Matovu (2020), and Meta-analysis by Ogundari (2022). Fishman et al (2017) show that farmer behavior persists over a long period of time and there is no evidence of behavioral decline suggested in extension programs.

- FAO (2019) provides cost benefit analysis at farm level in the multi-county study and shows that Disaster Risk Reduction (DRR) has positive impact on both increasing farmer’s productivity and the resilience of farmers resilience to natural disasters.

Data

- This study uses Papua New Guinea Household Survey on Food Systems in 2018 provided by International Food Policy Research Institute (IFPRI).
- The survey provides comprehensive information on household characteristics, agricultural production, Household assets, Income apart from own agricultural activities, consumption, and expenditures, economic shocks, and household well-being as well as food insecurity covering 1026 respondents across the country.

Modeling Strategy

- I employ the stochastic frontier production approach (SFA) which is firstly proposed by Aigner, Lovell, and Schmidt (1977) and Meeusen and van den Broeck (1979)
- However, Karakaplan (2017) and Chen, Hsu, and Wang show the problem of endogeneity problem using the standard SFA estimation
- To come up with the endogeneity problem in applying SFA, this study treats SFA with two-stage least squares (2SLS) using an instrument variable that is agricultural extension variable. Assuming that agricultural extensions are randomly selected program that has a direct impact on production
- The last step is estimating the natural disaster impact on agricultural efficiency following a strategy proposed by Weerasekara et al (2021) and Boustan et al (2017)

Empirical Model (1)

- Firstly, I estimate the following equation:

$$LnQ_{pi} = \alpha_0 + \sum_{i=1}^{9} \alpha_i \, AGEX_i + \mu_i$$

Where Q_{pi} is the crop production for commodity i, and AGEX is the agricultural extension support received and applied by the farmers, which is the multiplication of dummy variable when household member received the assistance/advice (1 if received and 0 otherwise) and dummy variable of whether the advice or assistance is implemented (1 if applied and 0 otherwise) which are assumed to be exogenous. There will be 8 indicators for AGEX variable

Empirical Model (2)

- On the second step estimate the following equation:

$$\widehat{LnQ_{pi}} = \beta_0 + \beta_1 Ln(Land_i) + \beta_2 LnLabor_i + \frac{1}{2}\beta_3 Ln(Land)_i^2 + \frac{1}{2}\beta_4 \left(LnLabor\right)_i^2 + \beta_5 Ln(Land).Ln(Labor) + v_i - \mu_i$$

$\widehat{LnQ_{pi}}$ is the predicted value of crop production from equation 1, Land is the land owned for planting the crops (in M^2), labor (in person) is the number of working farmers and from the equation 2 we measure the efficiency score

Technical Efficiency

$$Eff_i = \frac{LnQ_i}{exp(X_i\beta)} = \frac{exp(X_i\beta - \mu_i)}{exp(X_i\beta)} = exp(-\mu_i)$$

The i-th farmer's technical efficiency is determined by the ratio of the observed output to the potential output, as determined by the frontier function, given the input vector Xi (input variables)

Empirical Model (3)

- The third step, is estimating the determinants of farmer's production efficiency (Eff) the model as follows:

$$Eff_i = \gamma_0 + \sum_{j=1}^{5} \gamma_{ij}\, NATDIS_i + \sum_{k=1}^{6} \delta_{ik} HHcha_i + \theta_6 LAI_i + \theta_7 HCAI_i + \theta_8 Assoc_i + \sum_{l=1}^{3} \rho_{il}\, DP_i + \varepsilon_i$$

Where NATDIS is the natural disaster score (drought or irregular rain, floods, earthquake, landslides, damage by insects) experienced by the farmers (total value of dummy variable score of each type of natural disaster, 1 if experience and 0 otherwise), Hhcha is the household characteristics consist of education level, Age and Age^2, Child is the number of kids, Mar denotes marital status, gender, LAI is the lack of agricultural inputs such as seeds and fertilizer, etc, HCAI represents for the high cost of agricultural inputs experience by the farmers, Assoc denotes association and it is 1 if farmer joins with any agricultural, industry, and tourism association that connects them to other farmers, industry or business, and tourism, DP is a dummy for provinces (3 dummies variable from 4 provinces surveyed)

Results: Step 1 (Regression Adjustment)

Variable: lntotalprod		
ATE	Kina	Kg
totalagex		
(1 vs 0)	-0.1147	-0.0941
	(-0.1597)	(0.1754)
(2 vs 0)	0.6725***	0.6524***
	(0.2138)	(0.2253)
(3 vs 0)	-0.0709	0.0570
	(0.4360)	(0.4481)
(4 vs 0)	1.9827***	2.1041***
	(0.1559)	(0.2333)
(5 vs 0)	0.3462	0.2658
	(0.6218)	(0.6738)
(6 vs 0)	0.6251***	1.3562***
	(0.0807)	(0.0783)
(7 vs 0)	-0.0085	0.2687
(8 vs 0)	2.2103***	2.4392***
	(0.1260)	(0.1385)
POmean	5.3840	4.4639
totalagex	(0.0583)	(0.0621)
Obs	633	633

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

There are many methods used, but in conditions where there are several levels of intervention with more than two choices or binary, the options that can be practically used are regression adjustment (RA) and inverse probability weighting (IPW), and combination between RA and IPW.

The effect of the extension program significantly affects production and if these impacts are accumulated in total, the potential outcome averages 5.3 percent of the total value of production and 4.6 percent of the weight of production.

Results: Step 2

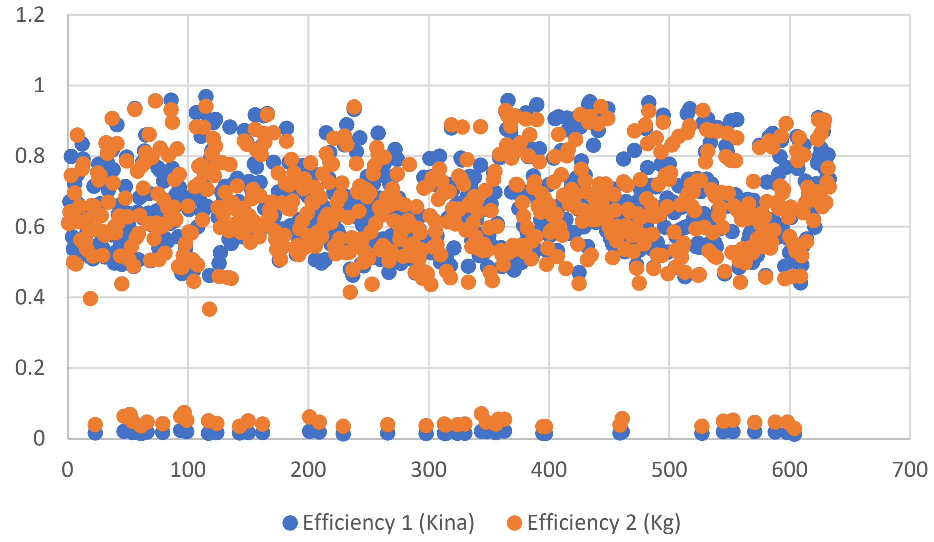
	Lntotalprod	
Variables	Kina	Kg
lnlabor	0.1646***	0.2088***
	(0.0586)	(0.0662)
lnlabor2	-0.0295**	-0.0323**
	(0.0137)	(0.0144)
lntotalland	0.1504***	0.1402***
	(0.0181)	(0.0194)
lntotalland2	-0.0098***	-0.0092***
	(0.0016)	(0.0017)
lnlaborland1	0.0709***	0.1084***
	(0.0180)	(0.0211)
lnsig2v	-4.8618***	-3.7781***
	(0.3843)	(0.1975)
lnsig2u	0.2268***	-0.1672***
	(0.0608)	(0.0656)
sigma_v	0.0879	0.1512
	(0.0169)	(0.0149)
sigma_u	1.1200	0.9197
	(0.0340)	(0.0301)
sigma2	1.2623	0.8688
	(0.0756)	(0.0546)
lambda	1.2734	6.0826
	(0.0412)	(0.0365)
Obs	633	633
LR test Sigma u	5.3	3.8
Wald Test (Chi)	825	702

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

The estimation results of the production function of labor input and land area show a quadratic pattern with the coefficient values of the two quadratic variables being statistically significant (Inlabor2 and lntotaland2). In addition, from the estimation results it is also known that the total coefficient of the estimation of the two models is 0.4 for Kina and 0.62 for Kg. This means that farmers' production shows decreasing returns to scale.

Technical Efficiency Distribution

Variable	Obs	Mean	Std. dev.	Min	Max
Efficiency 1 (Kina)	633	0.6205	0.1948	0.0126	0.9682
efteffect 2 (Kg)	633	0.6208	0.1902	0.0290	0.9565



The efficiency values range from 0.01 to 0.96 for the production value in Kina and 0.02 to 0.02 to 0.95 in Kg. if you look at the average value of the two is almost the same, namely 0.62. The Efficiency score of most of the observations is at a value of 0.62 for both models. The maximum score is 1 so closer to 1 is more efficient/productive

Results: Step 3 (Natural Disaster Effect on Technical Efficiency

	Efficiency	
Variable	Kina	Kg
marstat	0.6414***	0.6011***
	(0.0091)	(0.0102)
sex	0.0078	0.0135
	(0.0079)	(0.0089)
ag_assoc	-0.0021	0.0012
	(0.0051)	(0.0058)
childer	0.0003	-0.0009
	(0.0011)	(0.0012)
age	0.0075***	0.0079***
	(0.0011)	(0.0013)
age2	0.0000	-0.0000
	(0.0001)	(0.0000)
Prov		
East Sepik Province	0.0522***	0.0521***
	(0.0055)	(0.0063)
Madang Province	0.1323***	0.1434***
	(0.0058)	(0.0066)
Sepik (Sandaun) Province	0.2027***	0.2195***
	(0.0062)	(0.0070)
lai	-0.0004	-0.0008
	(0.0052)	(0.0059)
hcai	-0.0066	-0.0097
	(0.0054)	(0.0061)
nadits1	-0.0144***	-0.0098***
	(0.0038)	(0.0044)
nadits2	0.0047	0.0048
	(0.0045)	(0.0051)
nadits3	0.0087	0.0059
	(0.0063)	(0.0071)
nadits4	0.0028	0.0013
	(0.0046)	(0.0052)
nadits5	0.0090	0.0095
	(0.0043)	(0.0049)
educ	-0.0008	0.0168
	(0.0006)	(0.0007)
_cons	-0.3936	-0.4746
	(0.0268)	(0.0302)

Standard errors in parentheses, *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Natdis has a negative effect on the productivity or efficiency of farmers. The decomposition of natdis variable shows that drought and irregular rains are a consistently negative effect on productivity

The effect of natural disasters in the last five years that affected farmers' overall wellbeing

Conclusion

- Agricultural extension (AGEX) programs have a positive contribution to the farmer’s total production.
- On the other side, natural disasters, especially droughts and irregular rains that have been experienced in the last 5 years negatively affect the production efficiency of the farmers.
- Policies or interventions in the form of agricultural extension down to the farmer level need to be designed in such a way as not only to increase production but also to maintain farmers' resilience to disasters and to minimize worsening risks due to wrong management of nature for agriculture such as Disaster Risk Reduction (DRR).