sustainability

MDPI

Article

Are Development Projects Pursuing Short-Term Benefits at the Expense of Sustainability?

Yigezu A. Yigezu *, Tamer El-Shater and Aden Aw-Hassan

International Center for Agricultural Research in the Dry Areas (ICARDA), Amman, Jordan; tamer_149@hotmail.com (T.E.-S.); a.aw-hassan@cgiar.org (A.A.-H.)

* Correspondence: y.yigezu@cgiar.org; Tel.: +962-79-854-9674

Received: 5 September 2017; Accepted: 2 October 2017; Published: 5 October 2017

Abstract: When evaluated purely on financial grounds, most developmental interventions targeting the livestock sector exhibit a positive impact. This study also provides empirical evidence that a project which provided loans to livestock producers in Syria succeeded in increasing the annual farm income and reducing the income risk. However, these annual benefits were accompanied by a reduction in technical efficiency which, unabated, may compound over the years and compromise the livestock enterprise's sustainability. The development lesson from these findings is that misguided interventions with well-known short-term livelihoods benefits could, in the long run, hurt the very sector which they aim to support.

Keywords: small ruminants; loans; sustainability; income; risk; technical efficiency

1. Introduction

While the objectives of development projects' interventions are often specific and narrowly defined in space, time, and theme, they generally have complex social, economic, and environmental impacts that transcend the anticipated temporal, spatial, and thematic boundaries. Throughout the past several decades, the improvement of human livelihoods has served as a key objective in guiding the planning and implementation of a broad range of bilateral, multilateral, local, and global development efforts [1]. However, many national and international agencies, including FAO and the World Bank, have expressed their concern that little progress has been made so far, with only a few developing countries such as Nicaragua, El Salvador, Mauritania, Morocco, Philippines, Sierra Leone, Turkmenistan, Ghana, and Uganda on track to meet the Sustainable Development Goals (SDGs).

When evaluated purely on financial grounds, most development interventions targeting the livestock sector exhibit positive impacts. For instance, in an ex-post evaluation of 104 agricultural development projects which were wholly or partially devoted to the development of the livestock sector, roughly 60% of the economic rates of return (EER) exceeded 10%, while 34% were below 5%. The average return on livestock investments, weighted by the amount invested per project, exceeded 12%. Although these are only moderate returns relative to those estimated for other World Bank investments, livestock projects have offered an acceptable return [2]. Such narrow evaluations, however, omit many important social, economic, and environmental considerations which have far-reaching consequences.

The World Bank Independent Evaluation Group (IEG) has conducted 59 Global and Regional Partnership Program (GRPP) evaluations. In roughly half (49%) of these cases, efficiency was not evaluated, and in a further 36%, efficiency was mentioned but not analyzed in any meaningful way. A modest or substantial assessment of efficiency was found in only 15% of all cases [1]. While goals such as improving short term income, employment, and food security are very important, the pursuit of these objectives without due regard to their long term implications could prove to be detrimental.

Empirical evidence indicates that farmers in developing countries are generally risk-averse [3,4]. Poor farmers are more likely to be reluctant to adopt technologies that increase risk [5]. In addition to this direct effect, risk aversion indirectly affects technology adoption through its impact on the credit market [6]. Risk-averse farmers are less likely to demand credit. Since credit is essential for the adoption of technologies that require a high initial investment and purchased inputs, risk aversion discourages technology adoption. This indirect effect of risk is often considered to be more important than its direct effect [6].

By taking a case study of 511 smallholder sheep producers in the Jabal Alhoss area of the Aleppo province in Syria and employing a variant of the stochastic frontier production function approach (which explicitly and simultaneously accounts for technical inefficiency and production risk), this study provides empirical evidence that development projects may be inadvertently pursuing short term gains in household income and a reduction of income risk at the expense of reduced productive efficiency. In turn, this will hurt the enterprise and ultimately lead to a long term reduction in income itself. This study, in particular, pursues an assessment of factors affecting smallholder income and productive efficiency, as well as the long term implications of the provision of agricultural loans to smallholder sheep producers. The findings of this study will be useful to guide future interventions by governmental and non-governmental development agencies and provide much needed precautionary information to extension workers and policy makers in Syria, as well as other countries with similar agro-ecological and socio-economic conditions. They can also help to better target and avoid, or at least minimize, undesirable long term impacts.

2. Description of the Study Area

The Jabal Alhoss area is located 15 km southeast of Aleppo city in the Aleppo province. The area falls in zones 3 and 4 of Syria, which are characterized as drylands (Figure 1). Jabal Alhoss covers a total area of about 157,000 hectares, out of which about 85% is cultivable. The estimated total population of Jabal Alhoss is two hundred and fifty thousand with an average household size of 8.6 distributed across 157 villages. The main source of livelihood in the area is livestock production, particularly sheep rearing. Barley, which is mainly used as feed for livestock, is the main crop cultivated in the area. Income from the sale of live animals and livestock products has long been an essential component of income generation in the rural area. Livestock production is predominantly carried out by poor smallholder farmers with a very low income and limited access to new technologies, improved animal feed, and other productive resources. Barley-based livestock production systems such as those in Jabal Alhoss sustain some of the poorest segments of the rural population in the North Africa and West Asia region. The livelihoods of these poor rural households largely depend on agricultural production and animal-keeping activities. Over the years, these practices have proven to be highly resilient under arid conditions brought about by recurrent droughts and a developing pattern of erratic and declining rainfall. These systems, therefore, play an important role in the food security status of poor rural households in West Asia and North Africa that often have little diversification in their livelihoods or skills base to mitigate shocks.

However, over the years, the growing urban population and per capita income in these regions in general, and in Syria in particular, has increased the demand for animal products, which has provided adequate incentives for small ruminant producers in the country, including those in Jabal Alhoss, to increase their flock sizes. This trend is believed to have huge implications for the availability of animal feed and productive efficiency of resources.

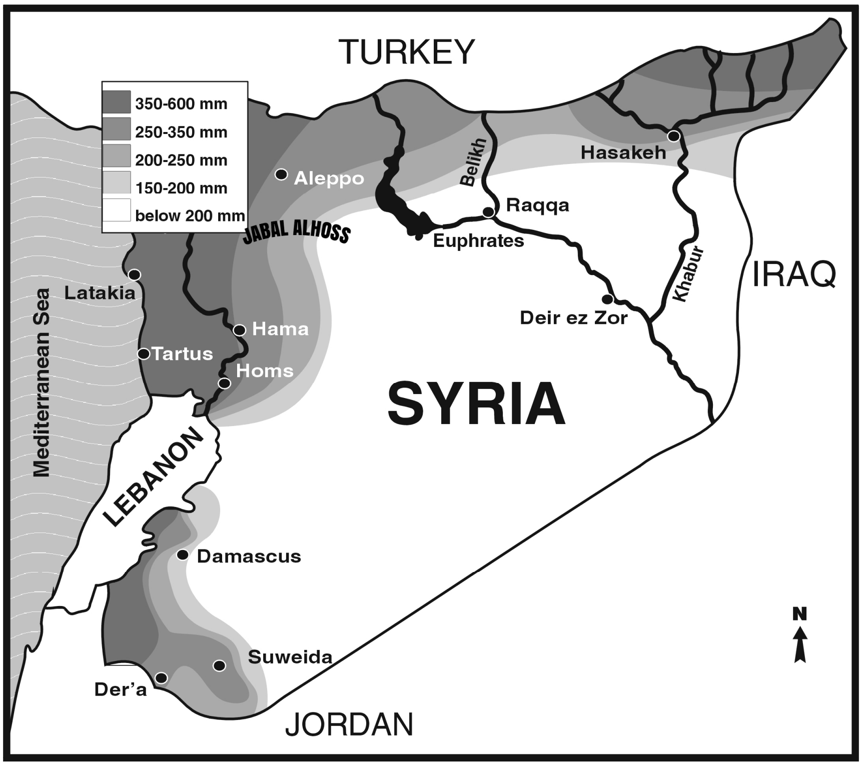

Figure 1. Agricultural stability zones in Syria.

Technological progress is key to increasing the competitiveness of the livestock sector in this region. Local and international research centers have been generating new technology options, such as animal health and nutrition methods, genetic enhancement, and better postharvest handling and processing, which can improve small ruminant productivity. For instance, the use of new breeds of ram can play an important role in improving flock performance [7]. Without productivity improvements, domestic producers may not only lose traditional export markets (mainly the gulf countries), but also local markets, to more competitive producers from abroad. Value additions such as fattening, dairy processing into high-value commodities, and the targeting of niche markets with specific products are also other ways of increasing the performance of small ruminant enterprises. As a result, interventions by government and non-government development organizations are deemed necessary to help improve resource-poor farmers' access to new technologies. Among many other such efforts, the Jabal Alhoss Agricultural Development (JAAD) Project is established to respond to these needs in the Jabal Alhoss area of the Aleppo province in Syria.

In 1998, the Ministry of Agriculture and Agrarian Reform (MAAR) established the Directorate of Agricultural Development in Jabal Alhoss to implement and manage the JAAD project. The project is supported and financed by MAAR and the International Fund for Agricultural development (IFAD) and the Arab Fund for Social and Economic Development (AFSED). The main objectives of the JAAD project are to improve the livelihoods of smallholder farmers and rural women by improving the management of natural resources, such as land and water, and the development of the mixed crop-livestock production system. Another Rural Development project supported and financed by MAAR, the Ministry of Planning and International Cooperation (MPIC), the United Nations Development Program (UNDP), and the Government of Japan was also launched in 1999 to operate under the auspices of the JAAD project. This particular project aimed at improving the livelihood of smallholder livestock producers through the provision of loans for the development of the livestock sector.

3. Material and Methods

3.1. Data

Syria is divided into five agro-ecological zones, mainly based on the amount of precipitation received. The study area is situated in two of the relatively drier zones (zones 3 and 4), where Zone 3 represents areas with an average annual rainfall value of about 250 mm with more than a 50% chance of falling below the average, while Zone 4 represents areas with an average annual rainfall value of 200 mm with more than a 50% chance of falling below the averages. Zones 3 and 4 comprise the areas where most of the animal production takes place in the country. In this study, two variables (agro-ecological zone in which the farmer is operating and the farmer's access to loans) are used for stratification. Accordingly, four strata of farmers are formed, namely:

1. Zone 3 and loans (3WL)
2. Zone 3 without Loans (3WOL)
3. Zone 4 with loans (4WL)
4. Zone 4 without loans (4WOL).

A stratified random sample of 511 flock owners was selected for this study using an approach outlined in previous literature [8]. The sample was then proportionally distributed across the four strata as shown in Table 1.

Table 1. Distribution of Samples across the Four Strata.

Zone	With Loans	Without Loans	Total	
	Sample Size	Sample Size	Population	Sample Size
Zone 3	197	218	162,427	415
Zone 4	48	48	37,573	96
Total	245	266	200,000	511

A one-time survey was conducted during April–June 2010 in order to gather required data from the sample flock owners. A structured questionnaire was used to collect the data on production systems, feed type and quantities, sheep and animal product marketing, labor, loans, and income sources. The data collection was conducted by a multi-disciplinary team comprised of personnel from the International Center for Agricultural Research in the Dry Areas (ICARDA), MAAR, and JHADP.

3.2. Methods

The stochastic frontier production approach has been widely applied to analyze technical efficiency in production [9–12]. By extending the application of stochastic production, other studies have proposed a new measure of input-specific technical efficiency (TE) in production [13]. They have also applied the new method to study the technical inefficiency of irrigation water among out-of-season vegetable growers in Crete, Greece. Another study also applied the method to study the technical inefficiency of irrigation water in citrus producing farms in Nabeul, Tunisia [14]. Both studies identified a low (47.2% and 53%) mean irrigation water use technical efficiency with very high variability, ranging between 23.9%–98.63% and 1.6%–98.87%, respectively. The low estimated mean irrigation water efficiency results show that using the observed values of other inputs, as well as 53% and 47% less irrigation water, respectively, the observed quantities of outputs can be produced.

We formulate the stochastic frontier production function with flexible risk properties for a cross-section of N sample firms as follows [15]:

$$y_i = f(x_i, a) + g(x_i, \beta) + (v_i - u_i), \quad i = 1, 2, \ldots, N \tag{1}$$

where y_i is the production for the i-th firm during the period involved; x_i is a vector of K explanatory variables of the i-th firm, such that the first element is the base of the natural logarithms, e; $f(x_i, a) \equiv \Pi_{\kappa=0}^{K} x_{ik}^{\alpha k}$ and $g(x_i, \beta) \equiv \Pi_{\kappa=0}^{K} x_{ik}^{\beta k}$ are Cobb-Douglas forms; v_i is assumed to represent independent and identically distributed standard normal random variables; and u_i represents non-negative random variables, associated with the technical inefficiency of the firms in the industry, which are assumed to be independent and identically distributed truncations of the $N(\mu, \sigma_{vi}^2)$ distribution, independently distributed from the v_i-random errors.

The production function in Equation (1) required that all explanatory variables are parametric functions of inputs and other variables, such that they have positive values. Other functional forms can be used for $f(.)$ and $g(.)$, provided that they are positive.

The mean and variance of production for the i-th firm, given the values of its inputs and the technical inefficiency effect, are:

$$E(y_i|x_i, U_i) = \left(\Pi_{\kappa=0}^{K} x_{ik}^{\alpha k}\right) - \left(\Pi_{\kappa=0}^{K} x_{ik}^{\beta k}\right) U_i \tag{2}$$

and

$$\mathrm{v}(y_i|x_i, u) = \left(\Pi_{\kappa=0}^{K} x_{ik}^{\beta k}\right)^2 \tag{3}$$

The marginal production risk with respect to the j-th explanatory variable, defined as the partial derivative of the variance of production (3) with respect to the j-th explanatory variable, is thus:

$$\frac{\partial \mathrm{V}\ (y_i \mid x_i,\ U_i)}{\partial x_{IJ}} = \frac{2\ \beta_j \mathrm{v}(y_i \mid x_i,\ U_i)}{\partial x_{IJ}} \tag{4}$$

where:

$$y_i = \left(\Pi_{\kappa=0}^{K}\ x_{ik}^{\alpha k}\right) e^{v_i - u_i} \tag{5}$$

where v_i is distributed as $N(0, \sigma_v^2)$ and u_i exhibits a truncated normal distribution.

The stochastic frontier (5) has a marginal production risk given by:

$$\frac{\partial \mathrm{V}\ (y_i \mid x_i\ ,\ U_i)}{\partial x_{IJ}} = \frac{2a_j}{x_{ij}} \left[E(y_i \mid x_i\ ,\ U_i)^2\right](e^{av^2} - 1) \tag{6}$$

where a_j is the elasticity of the mean output for the i-th firm, given its level of inputs and its technical inefficiency effect.

Given the stochastic frontier model (1), it follows from Equation (2) that the technical efficiency of the i-th firm is given by:

$$TE_i = 1 - U_i \left[\Pi_{\kappa=0}^{K}\ x_{ik}^{\beta_{k-\alpha k}}\right] \tag{7}$$

The best predictor for the technical efficiency (7) is the conditional expectation of TE_i, given the realized values of the random variable $E_i \equiv v_i - u_i$ [16,17].

$$E(TE_i \mid E_i\ ) = 1 -\ (U_i\ \mid E_i)\ \left[\Pi_{\kappa=0}^{K}\ x_{ik}^{\beta_{k-\alpha k}}\right] \tag{8}$$

It can be shown that, given the assumptions of the model (1), the conditional distribution of u_i, given that the random variable, E_i, has a value of e^i, is defined by the positive truncation of the $N(\mu_i^*, \sigma_*^2)$ distribution, where μ_i^* and σ_*^2 are defined by:

$$\mu_i^* = \frac{\mu - e_i \sigma^2}{\sigma^2 + 1} \tag{9}$$

$$\sigma_*^2 = \frac{\sigma^2}{\sigma^2 + 1} \tag{10}$$

The conditional expectation of u_i, given that E_i has a value of e_i, can be shown to be:

$$E(u_i \mid E_i = e_i) = \mu_i^* + \sigma_* [\Phi(u_i^*/\sigma_*)/\phi(\mu_i^*/\sigma_*)] \tag{11}$$

where $\Phi(.)$ and $\phi(.)$ represent the density and distribution functions for the standard normal random variable, respectively.

An operational predictor for the technical efficiency, TE_i, is obtained by substituting estimators for the parameters involved in the expressions of Equations (8)–(10). The predictor for the random variable e_i, involved in the conditional mean μ_i^* defined by Equation (9), is:

$$\hat{e}_i = \left[y_i - \Pi_{\kappa=0}^{K} x_{ik}^{\alpha k}\right] / \Pi_{\kappa=0}^{K} x_{ik}^{\beta k} \quad (12)$$

where y_i represents the observed value of production for the i-th firm and the carets above the parameters denote the appropriate maximum-likelihood estimators of the parameters involved.

Thus, the log likelihood ratio (LR), which has a chi-square distribution, is used to test the significance of the parameter estimates.

Smallholder sheep producers in Jabal Alhoss rear their livestock to produce multiple outputs (milk, meat, wool, and hide). In this study, the dependent variable (Y_{it}) in Equation (1) is formulated as the gross income from all activities under the livestock enterprise measured in Syrian Lira (SL). Hence, Y_{it} is calculated as the sum, across all activities, of the product of the quantities of outputs and their respective prices. The set of independent variables (x_{it}) in the stochastic frontier production function include: the number of productive ewes (*flock*); number of household members working in the livestock enterprise (*labor*); amounts of compound feed (*compd*), straw (*straw*), and barley grain (*bgrain*) used as feed; and total size of irrigated (*irrig*) and rainfed (*rfed*) land cultivated by the household. The selection of most of the explanatory variables included in this model has been based on existing literature that deals with the estimation of agricultural production frontiers for developing countries [18–26].

The vector of explanatory variables associated with technical inefficiency and risk in production over time representing the farm and farmer characteristics used in this study to explain inefficiency include: mortality (*mortality*); abortion (*abortion*) and fertility (*fertility*) rates in the flock; farming experience (*hhexp*); and the education level measured in years (*hheduc*) of the household head. In addition, the following dummy variables were used in the inefficiency and risk models: whether or not the farmer received loans from the project (*loan*); and the agro-ecological zone where the farm is located (*Zn*), where *Zn* takes a value of 1 if the farm is in Zone 3 (relatively wetter zone) and a value of 0 of the farm is located in Zone 4; (please see Table 2 for the list of variables included in the model, measurement units used, and codes when applicable).

Table 2. Mean and Collinearity Statistics of Variables in the Production Frontier and Inefficiency Model.

Variables and Units of Measurement/Codes	Variable Name	Sample Mean	Collinearity Diagnostics	
			VIF	1/VIF
Number of productive ewes (head)	*flock*	13	2.95	0.338
Labor (persons)	*labor*	4	1.16	0.864
Compound used as feed (kg)	*compd*	2079	2.21	0.311
Straw used as feed (kg)	*straw*	1260.4	1.230	0.812
Barley grain used as feed (kg)	*bgrain*	803.5	1.36	0.732
Stubble grazing land (ha)	*grazing*	3.02	1.36	0.733
Irrigated land (ha)	*irrig*	1.74	1.76	0.568
Rain fed land (ha)	*rainfed*	1.1	1.46	0.687
Farming experience (years)	*exp*	27.84	2.03	0.491
Education (years)	*educ*	3.91	1.06	0.944
Mortality rate (%)	*mortality*	5	1.06	0.944
Abortion rate (%)	*abortion*	4.38	1.05	0.954
Fertility rate (%)	*fertility*	85.81	1.16	0.864
Zone (Parentage of farmers in Zone 3: Zone 4 = 0, Zone 3 = 1)	*Z*	81.2	1.31	0.762
Loans (Percentage of farmers who received loans: No = 0, Yes = 1)	*loan*	47.95	1.54	0.649

4. Results and Discussion

Before proceeding to an estimation of the stochastic frontier production function, the Variance Inflation Factor (VIF) was computed to test the data for multicollinearity. Using an VIF threshold of 10, the data proves to be free from multicollinearity with a mean VIF value of 1.51 [27]. Moreover, the values are smaller than 2 for most of the variables, providing further confidence for the absence of multicollinearity (Table 2).

Theoretically, one can expect a higher output in response to an increase in the number of productive ewes. This is the logical basis for the Jabal Alhoss Agricultural Development Project (JHADP) to provide credit facilities (loans) for livestock producers in the study area. Particularly, by reducing the liquidity constraints of the livestock producers, loans are expected to encourage farmers to increase their flock size and purchase adequate and quality feed, which would ultimately lead to higher efficiency production and a greater income from their livestock enterprise.

The model results show that the current stocking rate (flock size) of productive ewes and the amount of compound feed used among typical farmers are less than the levels which lead to zero or negative marginal revenues. As a result, the number of productive ewes and the quantity of compound feed used indeed have positive and significant effects on the total value of the output from the farm households' livestock enterprises (Table 3). However, the amount of barley grain and straw fed to the animals does not have significant effects on the total value of production. Given its resistance to moisture stress, barley is a major crop in these zones, which are characterized by harsh environments. Barley grain and straw are also relatively inexpensive. This causes the farmers to use excessive amounts of barley and straw over and above the optimal levels, which justify this result. The size of irrigated farm land is also found to have a positive and significant effect on the total value of the output from the livestock enterprise. All these results are consistent with the theoretical expectations because the more nutritious feed the animals are provided, the more weight they gain and the more milk they produce. The size of irrigated farm land is also expected to lead to a higher biomass yield and hence more feed for the animals.

Table 3. ML Estimates of Parameters of the Stochastic Frontier Production Function and Inefficiency Models.

Inputs/Attributes	**Deterministic Frontier**	
	Coefficient	**Std. Err.**
Inputs/Attributes	Coefficient	Coefficient
Productive ewes (head)	0.052	(0.012) **
Family labor	0.002	0.014
Compound Feeds (kg)	0.669	(0.031) ***
Straw (kg)	0.001	0.004
Barley grain (kg)	0.012	(0.003) ***
Irrigated (ha)	0.028	0.021
Rain fed (ha)	−0.015	0.013
Constant	5.387	(0.187) ***
	Risk function	
Productive ewes (head)	1.039	(0.187) ***
Family labor	0.008	0.140
Compound Feeds (kg)	−0.681	(0.229) **
Loans x Productive ewes	1.689	(0.957) *
Loan x compound feeds	0.055	0.043
Loan x barley grain	0.010	0.070

Table 3. *Cont.*

Inputs/Attributes	Deterministic Frontier	
	Coefficient	Std. Err.
Loans x Productive ewes x compound feeds	−0.012	0.084
Loans x Productive ewes x barley grain	−0.127	(0.046) ***
Straw (kg)	−0.008	0.036
Barley grain (kg)	0.005	0.039
Irrigated (ha)	0.079	0.152
Rain fed (ha)	0.126	0.122
Loans (1 = loans, 0 = no loans)	0.608	1.009
Zone (1 = Zone3, 0 = Zone4)	−0.890	0.261
Constant	−1.366	1.349
	Mean function of inefficiency	
Productive ewes (head)	−1.781	(0.578) ***
Experience	−0.052	(0.013) ***
Education	−0.078	(0.035) **
Compound Feeds (kg)	3.704	(0.829) ***
Loans (1 = loans, 0 = no loans)	−3.414	(1.801) *
Loans x Productive ewes	5.266	(2.270) **
Loan x compound feeds	−0.042	0.064
Loan x barley grain	0.134	0.101
Loans x Productive ewes x compound feeds	−0.572	(0.226) **
Loans x Productive ewes x barley grain	−0.0191	0.094
Duration	−0.092	0.120
Fattening	−0.393	0.271
Zone (1 = Zone3, 0 = Zone4)	−0.336	0.394
Mortality (Sheep)	−0.002	0.008
Abortion	0.012	0.016
Fertility (Lamb) 2010	−0.004	(0.002) **
Irrigated (ha)	0.052	0.463
Rain fed (ha)	−0.294	0.273
Family labor	−0.021	0.261
Constant	−25.882	(5.273) ***
log likelihood function	237	

Notes: Dependent variable is total value of output from the livestock enterprise measured in Syrian Lira (SL). *, ** and *** represent significance at α levels of 0.1, 0.05 and 0.01 respectively.

In the inefficiency model, the coefficients of the loan, farmer experience, education, and the fertility rate in the flock are all negative and significant. This shows that the provision of loans to the livestock farmers, more farmer experience and education, and high fertility rates in the flock reduce inefficiency, which are all consistent with the theoretical expectations.

The provision of loans significantly reduces inefficiency among farmers in both zones 3 and 4 (Table 4). However, the effect of loans is more pronounced among low efficiency farmers in zone 4 than in zone 3, which is exhibited by the relatively larger rightward shift of the lower portion of the cumulative percentage efficiency curve (Figure 2) for the farmers with loans in zone 4 than those in zone 3. This indicates that loans have higher returns in zone 4 than in zone 3. These results also suggest that under a limited loanable resources scenario and in purely economic terms, the project should target zone 4 with loans and target zone 3 with other more effective interventions. Moreover, loans lead to a more equitable distribution of income, regardless of the respective agro-ecological zone.

A closer look at the efficiency figures shows that in zone 3, the farmers who had received loans had a much higher efficiency (0.86) than that of those who did not receive loans (0.80). Likewise, in zone 4, the farmers who received loans have efficiency 0.85 against 0.78 for who did not receive loans—a clear indication that the provision of loans helps in the improvement of productive efficiency.

Table 4. Average Technical Efficiency by Zone and Loan Categories.

		Mean Values by Zone		
		Zone 4	**Zone 3**	***t*-statistic**
Got loan?	No	0.78	0.80	4.82 **
	Yes	0.85	0.86	1.067
	t-statistic	111 ***	215.4 ***	

Note: ***, ** and represent significance at 99%, 95% and 90% respectively.

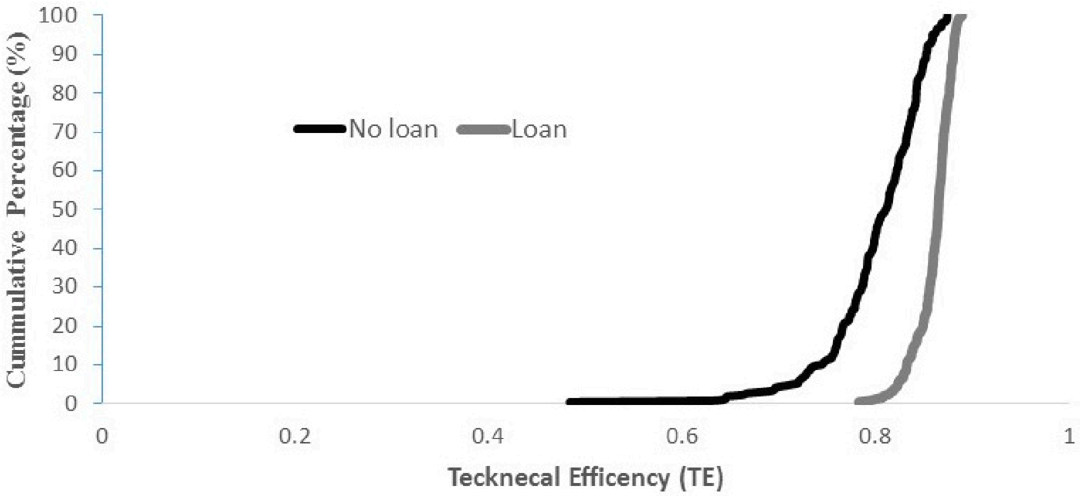

Figure 2. Cumulative Distribution of the Estimated Efficiency by Loan Categories.

With regard to production risk, the model results show that farmers who had received loans exhibited a 30% and 22% reduction in the risk of obtaining output levels below 47,210 Syrian Lira (SL) and 30,000 SL, respectively. Productive ewes (head) had a positive and significant effect on production risk, meaning that purchasing productive ewes is a risk-increasing factor. The negative and significant effects of Compound Feed (kg) on risk is evident for farmers, which indicates that the investment in Compound Feed (kg) will decrease the production risk in overall livestock production.

It should be noted here that these findings do not completely discredit the sustainability of the barley-livestock production systems found in Syria, Iraq, Jordan, and Lebanon (in West Asia), as well as in Morocco, Tunisia, and Algeria (in North Africa), but instead, they highlight the potential damages that can be inflicted by well-meant interventions (such as the project providing credit in Syria), which lead to the exploitation of natural resources by creating unsustainably ambitious smallholders who increase their flock sizes to the extent of overstocking, thereby compromising the carrying capacity of the system. To mitigate this problem, we argue that loans should be focused on the purchase of concentrate feed (which the model results showed to be effective in increasing both income and efficiency) to complement the forage obtained from the production of barley in the system. By limiting the use of the loan to the purchase of concentrates, we believe that it will cause farmers to refrain from overstocking (as they don't have the financial means to buy more sheep) and also from producing barley in marginal and fragile environments in order to produce more forage to support larger flock sizes. This will help further enhance the resilience and sustainability of the system.

One result which seems counterintuitive is the positive coefficient on the *loans* variable that can be justified on the grounds that it is consistent with current practice where many farmers are using the loan for purchasing productive ewes, which is a risky investment. This is even more so as the estimates are generated as the mean values and the current mean values are already high.

5. Conclusions and Recommendations

A common misconception among many development practitioners is that interventions that increase household income and/or reduce short term production or income risk are to be hailed. However, while increasing the income of smallholder farm households is an important development goal, it could possibly come at the expense of reducing the productive efficiency of available resources. Such reductions in the productive efficiency of resources would ultimately lead to a long term reduction in household income and compromise the sustainability of the enterprise. For instance, in this Syrian case, the provision of loans is generally found to increase the short term income and reduce the long term income risk. Particularly, by increasing the liquidity among poor livestock producers, the provision of loans for increasing the stocking rate of productive ewes and the amount of compound feed used among typical farmers would lead to an increased value of the total output from the livestock enterprise. This would provide a greater income, while at the same time reducing income risk. These results suggest that loans can be instrumental in increasing household income by reducing the constraints in financial capital among poor farm households that limit their ability to increase their flock size and the amount of compound feed they can make available for their animals. However, even though increasing the number of productive ewes leads to a higher value of the total output, the use of loans to increase the number of productive ewes among Syrian farmers would lead to an increase in the overall productive inefficiency of the enterprise (i.e., productive efficiency would decline, which is a negative outcome).

A main challenge in the provision of loans for livestock keepers is that, given the freedom of choice, they may choose to use them for increasing their flock sizes and/or the amounts of barley grain and straw feed, all of which lead to increased productive inefficiency. Additionally, if the objective of the project is to develop the livestock sector and farmers are left to choose, they could use the loans for establishing or developing other enterprises which compete for labor and divert other resources from the livestock enterprise, thereby defeating the very purpose of the provision of the loans. Therefore, if loans are to be effective in improving the short and long term livelihoods of the smallholder livestock producers, they need to be accompanied with expert advice. For example, the use of loans to increase the amount of compound feed leads to an increase in both income and productive efficiency—serving both the short and long-term development goals. Systematically tying loans to the purchase of compound feed, or better yet, the provision of in-kind loans of compound feed, could possibly prove to be more effective in this Syrian case.

More years of farmer experience and education, as well as higher fertility rates, led to the reduction of productive inefficiency among smallholder livestock producers in Syria. Therefore, organizing different farmer education schemes, including demonstration trials and field days, tailored training programs and the provision of extension support to help farmers acquire certain skills, and increasing their knowledge levels, especially in the areas of flock fertility management, would lead to productive efficiency. These interventions are also likely to have cost reduction effects and hence gains in short term net returns. The developmental lesson that can be drawn from these results is that while they could have favorable short term income and/or cost effects, misguided interventions such as the unconditional provision of loans might have detrimental effects, thus reducing the efficiency (or increasing inefficiency). Such effects could compromise the long term sustainability of the enterprise, thereby hurting the very sector they are supposed to support.

Pilot-testing such interventions and analyzing their effects on the immediate development and long term productivity effects could help in directing the limited development funds towards the interventions which maximize both the short and long term benefits. While the instability in the country in general, and the countryside in particular, makes it impossible to revisit the study area and perform validity checks, we argue that the results would still hold true even under the current conditions because the barley-livestock production system has always been characterized by rudimentary technologies with a low dependence on the market for inputs. The only aspect that might have changed substantially as a result of the conflict is the output market, where the demand for meat is expected to have decreased due to a reduction in the purchasing power of the people. In turn, this creates a disincentive effect for the smallholder sheep producers to increase their flock sizes. Even then, we expect that there is illegal cross-border trade for which the demand for live animals may not have been significantly affected. If this is the case, then access to credit might still have a detrimental impact on the sustainability of natural resources as smallholders may want to take advantage of the system by increasing their flock sizes. The uncertainty about the future may also have eroded the society's sense of stewardship of natural resources. All these, however, are speculations that we can't be sure about. The lack of clarity on the current situation of the barley-livestock production system also makes it difficult for us to make recommendations for how to revitalize the barley-livestock production system in post-war Syria. The introduction of technologies that increase the resilience of the system include the introduction of short maturing and high yielding barley varieties, the introduction of zero tillage for the reduction of soil erosion to increase soil organic carbon and soil moisture retention, the introduction of dairy technologies to increase the efficiency of milking, butter, and cheese extraction, and increasing hygiene and developing the value chain in such a way that the benefits to the smallholders are maximized in some of the ways that will help to increase the sustainability of the system.

By making use of marginal lands, turning co-products into edible goods, contributing to crop productivity, and turning edible crops into highly nutritious, protein-rich food, animal production plays a vital role in the food system [28]. Therefore, improved and more efficient feed conversion will reduce livestock's environmental footprints. In the rehabilitation efforts that will be required for rebuilding Syria, continued progress will be needed to make the system more sustainable with the development of alternative and more efficient uses of barley for both human consumption and animal feed. In addition, it is essential to improve the recycling of food waste and by-products into livestock feed, as well as to increase feed crops yields [28]. Even though no analysis is made in this paper on the economic and environmental tradeoffs between milk and meat production, the use of barley and concentrates for fattening lambs may be a better option for the Syrian smallholders to increase their profits, enhance productive efficiency, improve their environment, and ensure the sustainability of the system. Further in-depth study on this topic will therefore be warranted.

Acknowledgments: All costs of this study as well as the costs for publishing it on open access were obtained from the International Center for Agricultural Research in the Dry Areas (ICARDA).

Author Contributions: Yigezu A. Yigezu, Tamer El-Shater and Aden Aw-Hassan conceived the research questions; Tamer El-Shater led the data collection and Yigezu A. Yigezu and Tamer El-Shater analyzed the data; The paper was written by Yigezu A. Yigezu, Tamer El-Shater and Aden Aw-Hassan.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Maredia, K. *Evolution of and Emerging Trends in Impact Assessment Methods and Approaches in Agricultural Development*; IFPRI Discussion Paper 00929; International Food Policy Research Institute: Washington, DC, USA, 2009.
2. The World Bank. *The Smallholder Dimension of Livestock Development. Operations Evaluations Department*; The World Bank: Washington, DC, USA, 1985.
3. Binswanger, H.P. Attitudes toward Risk: Experimental Measurement in Rural India. *Am. J. Agric. Econ.* **1980**, *62*, 395–407. [CrossRef]
4. Walker, T.S.; Ryan, J.G. *Village and Household Economics in India's Semi-Arid Tropics*; Johns Hopkins University Press: Baltimore, MD, USA, 1990; ISBN 080183886X.
5. Pandey, P. *Illness, Income and Poverty in Developing Countries*; Pennsylvania State University: University Park, PA, USA, 2000; pp. 1–23.
6. Binswanger, H.P.; Sillers, D.A. Risk Aversion and Credit Constraints in Farmers' Decision Making: A Reinterpretation. *J. Dev. Stud.* **1983**, *20*, 5–21. [CrossRef]

7. Thomson, E.; Martini, M.A.; Tutwiler, R.N. *Sheep Management Practices in Iraq, Jordan and Syria: The Case of Reproduction and Fertility*; Integrated Natural Resources Management Research Report No. 2; ICARDA: Aleppo, Syria, 2003. Available online: www.indigofoundation.org/pdfs/Auction_handout.pdf (accessed on 3 October 2017).
8. Israel, G.D. *Determining Sample Size*; Institute of Food and Agricultural Sciences (IFAS), University of Florida: Gainesvill, FL, USA, 2000.
9. Shomo, F.; Ahmed, M.; Shideed, K.; Aw-Hassan, A.; Ekran, O. Sources of Technical Efficiency of sheep production systems in dry areas. *Small Rumin. Res.* **2010**, *91*, 160–169. [CrossRef]
10. Zhang, T.; Xue, B.D. Environmental efficiency analysis of China's vegetable production. *Biomed. Environ. Sci.* **2005**, *18*, 21–30. [PubMed]
11. Kebede, T.A. Farm Household Technical efficiency: A Stochastic Frontier Analysis, A Study of Rice Producers in Mardi Watershed in the Western Development Region of Nepal. Masters' Thesis, Department of Economics and Social Sciences, Agricultural University of Norway, As, Norway, 2001.
12. Battese, G.E.; Coelli, T.J. Frontier production functions, technical efficiency and panel data with application to paddy fanners in India. *J. Product. Anal.* **1992**, *3*, 153–169. [CrossRef]
13. Karagiannis, G.; Tzouvelekas, V.; Xepapadeas, A. Measuring irrigation water efficiency with a stochastic production frontier: An application to Greek out- of season vegetable cultivation. *Environ. Resour. Econ.* **2003**, *26*, 57–72. [CrossRef]
14. Dhehibi, B.; Lachaal, L.; Elloumi, M.; Messaoud, E.B. Measuring irrigation water use efficiency using stochastic production frontier: An application on citrus producing farms in Tunisia. *Afr. J. Agric. Resour. Econ.* **2007**, *2*, 1–15.
15. Battese, G.E.; Rambaldi, A.N.; Wan, G.H. A Stochastic Frontier Production Function with Flexible Risk Properties. *J. Product. Anal.* **1997**, *8*, 269. [CrossRef]
16. Jondrow, J.; Lovell, C.A.K.; Materov, I.S.; Schmidt, P. On the estimation of technical inefficiency in the stochastic frontier production function model. *J. Econom.* **1982**, *19*, 233–238. [CrossRef]
17. Battese, G.E.; Coelli, T.J. Prediction of Grm-level technical efficiencies: With a generalized frontier production function and panel data. *J. Econom.* **1988**, *38*, 387–399. [CrossRef]
18. Belbase, K.; Grabowski, R. Technical Efficiency in Nepalese Agriculture. *J. Dev. Areas* **1985**, *19*, 515–525.
19. Kalirajan, K. An econometric analysis of yield variability in paddy production. *Can. J. Agric. Econ.* **1981**, *29*, 283–294. [CrossRef]
20. Kalirajan, K. Farm-specific technical efficiencies and development policies. *J. Econ. Stud.* **1984**, *11*, 3–13. [CrossRef]
21. Kalirajan, K.; Flinn, J.C. The measurement of farm-specific technical efficiency. *Pak. J. Appl. Econ.* **1983**, *2*, 167–180.
22. Kalirajan, K.P.; Shand, R.T. Frontier Production Functions and Technical Efficiency Measures. *J. Econ. Surv.* **1999**, *13*, 149–172. [CrossRef]
23. Phillips, M.J.; Marble, R.P. Farmer Education and Efficiency: A Frontier Production Function Approach. *Econ. Educ. Rev.* **1986**, *5*, 257–264. [CrossRef]
24. Rawlins, G. Measuring the impact of IRDP II upon the technical efficiency level of Jamaican peasant farmers. *Soc. Econ. Stud.* **1985**, *34*, 71–96.
25. Taylor, T.G.; Drummond, H.E.; Gomes, A.T. Agricultural credit programs and production efficiency: An analysis of traditional farming in southeastern Minas Gerais. *Braz. Am. J. Agric. Econ.* **1986**, *68*, 110–119. [CrossRef]
26. Taylor, T.G.; Shonkwiler, J.S. Alternative stochastic specifications of the frontier production function in the analysis of agricultural credit programs and technical efficiency. *J. Dev. Econ.* **1986**, *21*, 149–160. [CrossRef]
27. Leahly, K. Multicollinearity: When the solution is the problem. In *Data Mining Cookbook*; Rud, O.P., Ed.; John Wiley & Sons, Inc.: New York, NY, USA, 2001; pp. 106–108.
28. FAO- Food and Agriculture Organization of the United Nations. More Fuel for the Food/Feed Debate. FAO-AGA NEWS, Animal Production and Health Division. e-newsletter 167. Available online: http://www.fao.org/WaICENT/FAOINFO/AGRICULT/AGAInfo//resources/newsletter/2017_newsletter_167.html (accessed on 30 September 2017).