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Sustainability of Sheep and Goat Production Systems under United Arab Emirates’ Aridland Constraints

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Abstract

Sheep and goat production systems in the UAE within scarce natural resource constraints represent an ideal setting for studying input-use economic efficiency (production and allocative). Despite the importance of this subsector in the UAE, no reliable cross-sectional data was ever disseminated. The research objectives are to: obtain the baseline information on the existing small-ruminant farms in UAE; identify the responsiveness of output to percentage changes in inputs, rank the prominent inputs with the greatest impact on output level; and determine the corresponding allocative efficiency for the most significant inputs. A cross-section field survey that covered 661 mixed farms, with major sheep and goat production activities, was conducted in three areas of Al-Ain, the Western Region, and Abu Dhabi during 2012. Cobb-Douglas double-logarithmic production function approach was applied to estimate the important economic derivatives. A multidisciplinary approach was implemented to better understand the integration of biological and economic perspectives of the issue. Results indicated inefficiency of the inputs utilized for sheep and goats separately; where all of the inputs used in sheep production were overutilized, whereas those used in goat production were two underutilized, one over-utilized, with only one input close to economic-use optimality. Study beneficiaries include strategic-decision makers and individual sheep and goats producers.

Keywords: UAE Sheep and Goats Production, Production Functions, Input-Use Economic Efficiency

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1. Introduction and Objectives

United Arab Emirates (UAE) imports more than 95% of its overall food needs. Red-meat production in the UAE is currently one hot issue on the agenda of the UAE government. Reasons have to do with a number of factors such as: the heavy importation of red meat from four main countries, Australia, New Zealand, India, and Pakistan to supplement local meat production; an escalating real per-capita national income that led to increasing demand for red meat; and the ever-increasing global and domestic emphasis on some important meat attributes such as quality and safety; among other factors. UAE possesses a poor agricultural resource base due to being in a typical aridland region. With limited agricultural resources, agricultural policies need to address all of the issues related to resource conservation. The current use of such scarce resources may lead to either economic overutilization or underutilization. As a result, consequences may become irreversible. This requires working towards initiating and acquiring an accurate and comprehensive information system and building of a solid database for the red-meat subsector. The UAE’s Ministry of Environment and Water (MOEW) and the Abu Dhabi Food Control Authority (ADFCA), the two main bodies concerned with all of the related food aspects in the country, built a database for inputs use in the country’s livestock sector. The database information was used for this study along with one previous study made by the first author of this paper.

In sum, the current status of the Emirati’s meat production subsector revealed that the meat-group deficiency has increased from $86 million in 1990 to $374 million in 2008, with an average of $90 (already reached $1.173 billion in 2011 [1]. For red meat alone, the deficit has increased from $61 million in 1990 to $221 million in 2008 (annual growth rate of 4.5%). In other words, the average annual self-sufficiency ratio for red meat has been estimated at 30%. In addition, the monetary value of deficit for animal products has been found to grow by an annual rate of 6.5% [2]. This has led the UAE government to seek achieving economic efficiency of input use as a primary agricultural production policy. Accordingly, the objectives of this project are mainly: (1) to obtain the baseline information on the existing mixed-animal farms; and (2) to determine the production efficiency of input use and the corresponding price efficiency.

2. Data and Methods

The implementation and execution of the study depended heavily on the thorough in-field examination of the red-meat subsector. The conducting of a major and comprehensive cross-sectional survey of the different small-ruminants’ farms scattered around the UAE, and particularly in the main producing areas, was believed to be the best way to discover the problems inherent in this subsector. A computer programmer executed the survey via modifications to an Excel sheet to facilitate data entry and to minimize mistakes in information dissemination and processing.

The main methodology used in this paper to assess economic efficiency of input-use; namely, technical (production) and price (allocative) efficiency was the implementation of production functions. The production function exhibits an engineering (physical) relationship between variable inputs, on the one hand, and output which these inputs affect, on the other. Technical (production) efficiency is inherent in the definition of the production function. This function indicates the maximum amount of output obtainable from the utilization of a specific quantity of inputs given the existing technology level governing the input-output relationship. Alternatively, a specified set of inputs cannot be recombined to produce a larger output, or that a specific level of output cannot be produced with fewer inputs. The said input-output relationship is assumed to be known with certainty; i.e. the producers know the eventual outcome of the production process at the beginning of the production period. Since these relationships are neither fully known nor controllable, a distribution of yields would be associated with each input-use level. This range of expected yields depends on
the estimated variability of the predicted yield corresponding to the specified input-use level. Moreover, inputs included in the production function are assumed to be homogeneous and that prices of both inputs and outputs are presumably known with certainty [3] and [4].

Economic efficiency, on the other hand, refers to the combinations of inputs that maximize individual or social objectives. It is defined in terms of two conditions: necessary and sufficient. The first is met in the production process when estimating the production function. The second varies with the objectives of the individual producer. Like most of the economic literature under perfect knowledge, the individual producer’s objective is assumed to be profit maximization, i.e., allocative efficiency. It is defined as profit maximization through equating the value of marginal product of the variable input to its unit price. The log-log Cobb Douglas production function used in this paper takes the following mathematical form:

\[
Y = \alpha X_1^{\beta_1} X_2^{\beta_2}
\]

(1)

Where \(Y\) is the level of output, the \(X's\) are the inputs, and \(\alpha\) and \(\beta\) are the functions’ coefficients. The assumptions embodied in the function’s estimation are: \(x_i \geq 0\) and finite (nonnegative, real inputs); and the function is finite, nonnegative, real and single valued for all possible combinations of \(X_1\) and \(X_2\); and is everywhere continuous and everywhere twice continuously differentiable and is subject to the law of diminishing returns.

3. Analysis and Results

A quick summary of the descriptive statistics of the 661 mixed farms revealed the following: The sheep/goats farms were found to be 86% and 14% in Al-Ain Region and Western Region, respectively. The majority of sheep/goats farms (428 farms) were in operation for 10 years or less. The typical sheep flock structure was dominated by ewes; whereas does dominated the goats flocks. The average value products (market price) for sheep and goats were AED 116 and AED 93 per head for sheep and goats, respectively. Almost all farmers (99%) claimed that the farm is carrying the right capacity. Fifty seven percent of the farmers claimed they supply adult animals with concentrates. Fifty one percent of the water needs for both of sheep and goats were supplied through tanks, followed by Al-Ain Distribution Company (29%), and groundwater (20%). Meanwhile, 70% of the sheep and goat farmers reported that they seek veterinary services when animals get sick. The main three health control measures adopted in sheep/goat farms are those of vaccination (76%), dipping (68%), and dew arming (68%). Whereas, 94% of farmers reported they don’t do animal identification. The 6% who reported doing it claimed using the ear-tagging method. Fifty six percent of sheep/goat farmers reported culling of sheep and goats from flock for health reasons. Seventy nine percent of farmers reported having shades for each group of animals, with more emphasis on the newly born (61%). Sources of price information were 9%, 8%, and 9% from other farms, the government agent, and negotiations with buyers, respectively. The reported annual total production of sheep and goats by number were 7,661 and 5,845 animals, respectively, with coefficients of variation of 135% for sheep and 120% for goats. Ten percent of sheep/goat farmers reported meeting market demands, whereas 38% claimed they do not, whereas 52% did not respond to that question.

3.1. The Sheep Empirical Model

\[
Y = -0.060 + 0.053 \text{Rhodes} + 0.289 \text{Alfalfa} + 0.122 \text{Wheat Bran} + 0.039 \text{Barley} - 0.086 \text{Corn} + 0.066 \text{Wheat} + 0.121 \text{Wheat Concentrate} + 0.056 \text{Minerals} + 0.075 \text{Vitamins} + 0.388 \text{Labor} + 0.128 \text{Water} + 0.6616829
\]

Equation (2) displays the estimated log-log production function for sheep, where \(Y\) is the number of sheep
heads produced/day, Rhodes and Alfalfa are measured in tons/day, Wheat Bran, Barley, Corn, Wheat, Wheat Concentrate, Minerals, and Vitamins are all measured in kilograms/day; whereas Labor is measured in thousand hours/year, and Water is measured as cost in AED/year (USD 1 = AED 3.675). The model’s F-ratio was 287.55 (model statistically significant), adjusted R-square = 0.827 (all of the estimated variables explain 82.7% of the variations in the level of output); and the significant variables in the above estimated equation at less than the 1% level are those of Rhodes, Alfalfa, Wheat Bran, Wheat, Protein Concentrate, Labor, and Water. The Standardized Beta Coefficients showed that the most prominent variables in affecting the level of output are respectively those of: Labor, Alfalfa, Protein Concentrate, Wheat Bran, Water, Wheat, and Rhodes.

3.1.1. Sheep Allocative (Price) Efficiency of Inputs

The ratio of MVPx and Px was calculated for each significant input to test the null hypothesis that it is equal to one. Table 1 shows the results obtained for all of the significant inputs in the estimated log-log function where: MVPx = Marginal Value Product of the variable input X, Px is the average unit price of the variable input X, MVPx is equal to [EX* PY * (Y/X)]; where: EX is Elasticity of Production of the variable input X, PY is the average output price in AED, Y is the average level of output, X is average level of the variable input X. According to the marginal economic production theory; if MVPx/Px<1 input is underutilized; if MVPx/Px= 1 input is optimally utilized; and If MVPx/Px>1 input is over-utilized.

Table 1 summarizes the allocative efficiency results of the variable inputs used in the production of sheep. Water was not included in table 1 as it was calculated as a monetary value per year and not as a physical amount due to lack of data on the physical amounts used of water in the farms. The table shows that all of the prominent variable inputs are over-utilized as their MVPx to their corresponding prices Px are less than one. Moreover, an elasticity of production of Rhodes, for instance, of 0.053 means that if input level increases by 100% output would increase by 5.3%, and so on for the remainder of the regression coefficients.

Table 1. Allocative efficiency of inputs used in the production of sheep

<table>
<thead>
<tr>
<th>Input</th>
<th>Unit</th>
<th>Coefficient</th>
<th>Output Price (PY)</th>
<th>Average (Y)</th>
<th>Average (X)</th>
<th>Marginal Value Product (MVP)</th>
<th>Market Price (Px) (AED)</th>
<th>MVPx/Px</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhodes</td>
<td>Ton</td>
<td>0.053</td>
<td>116</td>
<td>122</td>
<td>8</td>
<td>93.8</td>
<td>400.9</td>
<td>0.23</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>Ton</td>
<td>0.289</td>
<td>116</td>
<td>122</td>
<td>47</td>
<td>87.0</td>
<td>322.6</td>
<td>0.27</td>
</tr>
<tr>
<td>Wheat Bran</td>
<td>Kg</td>
<td>0.122</td>
<td>116</td>
<td>122</td>
<td>4,380</td>
<td>0.4</td>
<td>1.0</td>
<td>0.53</td>
</tr>
<tr>
<td>Wheat</td>
<td>Kg</td>
<td>0.066</td>
<td>116</td>
<td>122</td>
<td>1,825</td>
<td>0.5</td>
<td>1.0</td>
<td>0.51</td>
</tr>
<tr>
<td>Protein Concentrate</td>
<td>Kg</td>
<td>0.121</td>
<td>116</td>
<td>122</td>
<td>2,920</td>
<td>0.6</td>
<td>0.8</td>
<td>0.78</td>
</tr>
<tr>
<td>Labor</td>
<td>1000 hours</td>
<td>0.388</td>
<td>116</td>
<td>122</td>
<td>2.86</td>
<td>1,919.9</td>
<td>3,400.0</td>
<td>0.56</td>
</tr>
</tbody>
</table>

3.2. The Goats Empirical Model

\[ Y = 4.702 + 0.052 \text{ Rhodes} + 0.395 \text{ Alfalfa} + 0.280 \text{ Wheat Bran} - 0.012 \text{ Barley} - 0.223 \text{ Corn} + 0.196 \text{ Wheat} + 0.296 \text{ Protein Concentrate} + 0.021 \text{ Minerals} + 0.007 \text{ Vitamins} - 0.366 \text{ Labor} - 0.193 \text{ Water} + 1.3333559 \]

Equation (3) displays the estimated log-log production function for goats, where Y is the number of goat heads produced/day, and all of the variable inputs are defined and measured in the same units used in the
estimation of the sheep production function. The model’s F-ratio is 26.346, adjusted R-square = 0.297; and the significant variables in the above estimated equation at less than the 1% level are those of Alfalfa, Wheat Bran, Wheat, and Protein Concentrate. Labor and Water, however, were highly significant at less than the 1% level but with illogic negative signs. This could be due to overutilization of these two inputs due to recruiting cheap expatriate labor for the first and having subsidized water for the second. The Standardized Beta Coefficients showed that the most prominent variables in affecting the level of goats’ output are respectively those of Alfalfa, Wheat Bran, Protein Concentrate, and Wheat.

3.2.1. Goats Allocative (Price) Efficiency of Inputs

Table 2 summarizes the allocative efficiency results of the variable inputs used in the production of goats.

Table 2. Allocative efficiency of inputs for goats

<table>
<thead>
<tr>
<th>Input</th>
<th>Unit</th>
<th>Coefficient</th>
<th>PY</th>
<th>Y</th>
<th>X</th>
<th>MVP</th>
<th>Input Market Price (AED)</th>
<th>MVPx/Px</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>Ton</td>
<td>0.395</td>
<td>93</td>
<td>106</td>
<td>45</td>
<td>86.5</td>
<td>322.6</td>
<td>0.27</td>
</tr>
<tr>
<td>Wheat Bran</td>
<td>Kg</td>
<td>0.28</td>
<td>93</td>
<td>106</td>
<td>3,285</td>
<td>0.8</td>
<td>0.8</td>
<td>1.12</td>
</tr>
<tr>
<td>Wheat</td>
<td>Kg</td>
<td>0.196</td>
<td>93</td>
<td>106</td>
<td>1,095</td>
<td>1.8</td>
<td>1.0</td>
<td>1.76</td>
</tr>
<tr>
<td>Protein Concentrate</td>
<td>Kg</td>
<td>0.296</td>
<td>93</td>
<td>106</td>
<td>2,190</td>
<td>1.3</td>
<td>0.8</td>
<td>1.78</td>
</tr>
</tbody>
</table>

Only Alfalfa was over-utilized, with Wheat Bran, Wheat, and Protein Concentrates under-utilized in varying degrees. The closest input to being optimally utilized was Wheat Bran.

4. Conclusions and Policy Implications

The current status of the Emirati’s meat production subsector revealed that the deficiency in the meat group is on the rise. For red meat alone, the deficit is increasing annually, which in turn led to deterioration in annual self-sufficiency ratios, with the deficit value growing annually by rates higher than those of the growth in the country’s real GDP. With the poor agricultural resource base the country historically possesses because of its geographical location, combined with the government’s objective of achieving a minimum level of food security, the UAE government decided on adopting resource-conservation type of policies. The major attention given to water preservation and optimal use is an example of these policies. This study is focused on how to provide guidance to decision makers through identifying the current and ongoing use of scarce resources in the production of two important red-meat sources; namely, sheep and goats. The venue to that was addressing the issue of input-use economic efficiency. This was a major objective of this proposed study, among others.

What increases the severity of the problem is the continuous rise in real per-capita incomes of the Emirati citizens and a great number of expatriates which imposes an ever-rising demand for red meat. Since the domestic production is insufficient, more importation is anticipated, implying a persistent and chronic decline in red-meat self-sufficiency ratios.

In this study, marginal economic production theory was implemented to address input-use efficiency through the estimation of log-log production functions for sheep and goats separately. The study concluded that the production of sheep and goats in the UAE, considered to be part of the Emirati heritage, suffers from
economic inefficiency of input use. Only one input, Wheat Bran, was found to be close to optimality in goats’ production. Other inputs were found to be either overutilized, the case of sheep; or half underutilized, like the case of goats. Moreover, the Labor and Water inputs, which were found to be positive and highly significant in impacting sheep production, were found to be significant and negatively impacting the level of goat production. The explanation of that is overutilization of these two inputs as Labor is commonly expatriate-low-wage type, and Water is mostly subsidized by the government. Both of which encourage Emirati farm owners to over-utilize. The estimated functions’ coefficients represented the elasticities of production of the said inputs. Through these coefficients, the responsiveness of output to percentage changes in input levels was assessed. The highest impact of an input on output level was labor in case of sheep and alfalfa in case of goats. Both of which were found to be over-utilized. With the ongoing trend of Emiratization and reduction in input subsidization, sheep and goat producers should watch for how much is used of all of the needed inputs because the worst is yet to come. On the other hand, policy makers should consider revising the input-subsidy policies adopted for years as these policies will never lead to optimal input utilization; something the country needs to seriously consider should it acquires sustainability of red-meat production.

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References