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Sustainability and Optimal Allocation of Human Resource of Agricultural Practices in Sistan and Baluchestan Province Based on Network DEA

A. Kord
Kerman Branch, Islamic Azad University

A. Payan *
Zahedan Branch, Islamic Azad University

S. Saati
North Tehran Branch, Islamic Azad University

Abstract. The agricultural sector ensures food security in every country. Optimal agricultural practices presuppose the optimal allocation of resources, including water, soil, etc., by official authorities in every country because excessive use of natural resources would have harmful consequences for posterity despite meeting ad hoc needs. Therefore, sustainable agricultural practices in different regions should be based on environmental, social, and economic criteria in the decision-making process for the future. This study investigated the agricultural practices in two stages: environmental stage (planting and maintaining) and economic stage (harvesting), which use shared resources. A network DEA model was proposed for developing sustainable agricultural practices based on the proposed process. The development of sustainable agricultural practices in different regions presupposes the optimal

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*Correspondingm author

allocation of water and human resources, which is realized by the improvement of irrigation methods and the quality of life of farmers. In network DEA models, weight restrictions are used to determine sustainable development. The proposed model was analyzed with and without weight restrictions to determine the sustainable development of agriculture in Sistan and Baluchestan Province, Iran, between 2013 and 2017. On the other hand, given the important role human resources play in the development of sustainable agricultural practices, some models were suggested for determining the maximum required human resources for each stage according to the obtained performance levels.

AMS Subject Classification: C61; O13 ; O49 ; Q52 ; Q57
Keywords and Phrases: Sustainability, resource allocation, Agricultural Practices, Network DEA.

1 Introduction

After the industrial revolution, economic development has been seen as the most important factor contributing to the growth and prosperity of a country. From its very beginning, however, economic development has been tantamount to the inhumane exploitation of the humans who have been involved in its creation. Long working hours, unfair wages, harsh working conditions, unsafe workplace environments were part of such inhumane treatment of workers. Therefore, it can be said ‘social’ and ‘human’ aspects have been neglected in economic development.

On the other hand, economic growth as a result of an increase in production and consumption has demanded the excessive use of natural resources, creating a vicious cycle. Therefore, the depletion of natural resources would lead to the environmental pollution, an increase in population, and so on, which in turn would lead to a decrease in the quality of life and endanger life on Earth. Therefore, a materialistic attitude and the one which is solely based on economic gains would produce adverse social and environmental impacts.

Such adverse impacts have called for attention to the backstage of economic growth during the recent decades. As a result, international organizations have incorporated a new attitude into their agendas, called sustainable development. Sustainable development is a form of development which strikes a balance between all the aspects, which can be generally divided into social, environmental, and economic aspects. In other words, sustainable development not only focuses on the economic aspect but also ensures that there would be no adverse environmental and social consequences.

Many Iranian rural households depend on agriculture for their survival, and water is both vital to life and agriculture. Water has been one of the main factors involved in the development of the agricultural sector in Iran. And today the agricultural sector consumes more than 90% of the water. Therefore, water shortage has widespread social and economic impacts as well as immediate environmental impacts such as the sinking of the ground, desertification, etc. Water crisis leads to soil salinization and aridification, and in turn to a decrease in production, and subsequently a decrease in farmers' revenues, and an increase in poverty. Moreover, this forces farmers to migrate to cities and engage in 'pseudo-jobs.' In the agricultural sector, sustainable development goals include social welfare, daily sustenance, and proper use of water and soil resources. Therefore, sustainable agriculture plays an important role in improving the environment, the optimal use of the existing water and soil resources, meeting the subsistence needs of the society, and improving the quality of life of farmers. Generally, sustainable development plays an important role in modern societies, in that it enables them "to meet the present needs without threatening the ability of posterity to meet their needs" [27]. Sustainable development presupposes initiatives, projects, plans, and policies for the achievement of economic, environmental, and social goals. Therefore, to determine sustainable development, all economic, environmental, and social goals need to be achieved simultaneously. Definition and complete assessment of such a multi-dimensional system involves the determination of a wide range of economic, environmental, and social indicators, hence demanding complex multi-variable decision-makings. A simple assessment method is to define an aggregated sustainability size through identifying preferences and assigning different importance weights to economic, environmental, and socialindicators [12, 22]. Despite the easy implementation of this method, this method involves personal judgements, which underlie preferences, therefore the system may not be properly assessed, and some options may be neglected.

Two approaches are used for assessing sustainability: The first approach is a ‘toward-target’ one [23], that is, a proposed assessment represents a positive, negative, or neutral judgment about sustainability goals. This is a very limited approach, providing no quantitative guidelines for how to improve the level of sustainability. The second approach is ‘distance-to-target’ approach, which is more effective in practice because it can assess the progress toward (or away from) sustainability goals, which makes it possible to define quantitative goals, and ensures sustainable development [16]. Moreover, quantitative assessment methods can be accompanied by mathematical planning techniques to enable automatic search for options with improved environmental performance [13]. One of such techniquesis the Data Envelopment Analysis (DEA), which is used to determine the sustainability level of systems or organizations. DEA is a non-parametric linear programming based technique for estimating the relative performance of decision-making units (DMUs) with multiple inputs and outputs without the costs of inputs and prices of outputs [4]. In addition to the estimation of performance, DEA provides specific guidelines, which are expressed as quantitative goals, for improving the performance level. Therefore, DEA can be used to determine the sustainability level of a DMU, given the unavailability of weights of inputs and outputs, which are economic, environmental, and social indicators of sustainable development, and the lack of need for personal judgements. DEA was initially developed for measuring the performance level of a DMU as a whole without considering its internal structure. In other words, a DMU is considered a black box, into which inputs are received to create outputs, between which there is usually a positive correlation. However, there are many experimental studies, which show this to be wrong at times. For example, it was revealed that IT had little effect on the performance of a business [9]. Another study revealed two processes for banking and other similar industries: fund-raising and investment [24]. This indicates that it is necessary to study the component processes of a DMU to determine the causes of its inefficiency.

Charnes et al. [8] for the first time found that recruitment by the army has two processes: the first process provides awareness through advertising, and the second one leads to the conclusion of employment contracts. Division of major operations into minor processes helps to identify the real effects of input variables. The simplest method of doing this is to divide a major operation into two processes, as indicated by Charnes et al. [8] and Wang et al. [24]. There are many more complex cases in which operations are divided into more than two processes, which may be of serial or parallel structures or of both. Such structures are often called network structures, and the DEA which is used for measuring the performance of network structure systems is called network DEA [11]. Recently, many studies have been conducted on the performance of network DMUs with shared data for the stages, and desirable and undesirable inputs and outputs, and also on measuring the sustainability level of such units. For example, Lewis et al. [19], Lin Li et al. [20], Halkos et al. [15], and Haibo Zhou and Hanhui Hu [14] are to be mentioned among others. Moreover, many studies have been conducted on determining the sustainability of agricultural practices. Angulo-Meza et al. [1] studied the importance of environmental effects on improving the development of agricultural practices which is an aspect of sustainable development. But, in order to determine the sustainability level of agricultural practices, the internal structure of agricultural practices should be taken into account with respect to simultaneous consideration of economic, environmental, and social dimensions and then they can be developed. Ren and Liu. [6] investigated the effect of cultivated area on sustainable agricultural practices and revealed that the size of cultivated area plays an important role in sustainable improvement of agricultural practices. However, they failed to take into account the role of the optimal use of human resources and water in cultivated area which is a key factor in environmental sustainability for developing agricultural practices. Guofeng Wang et al. [26]showed that optimal use of soil and water resources plays an important role in sustainable development. But, they were not aware that, in sustainable development of agricultural practices, optimal use of water, soil and human resources, as well as increased production area should be considered which would increase the revenues of farmers. Therefore, to determine the sustainability of agricultural practices in different regions, the optimal use of natural resources (i.e. water, soil, etc.) and adequate revenues of farmers should be taken into account. Because the excessive use of natural resources would lead to environmental degradation and would have harmful consequences for posterity, and inadequate revenues of farmers would lead to their discouragement and their consequent migrations to city and engagement in pseudo-jobs. On the other hand, since farmers in different regions produce different products, therefore, sustainable agricultural practices should be based on the local characteristics of different products in different regions. This has been neglected by many studies. Therefore, the sustainability of agricultural practices can be based on the following two stages. In the first stage, the optimal use of water and human resources ensures maximum crop production per area. The second stage ensures an increase in the revenues of farmers and consequently the improvement of the quality of their lives, given maximum crop production per cultivated area. The first stage is related to planting and maintaining, and the second stage is related to harvesting. Furthermore, because human resources is the most effective factor in sustainability of agricultural practices, optimal use of human resources in the first and second stages of agricultural practices is critical regarding the sustainability levels of the regions. Therefore, the first stage aims to increase cultivated area, and the second stage aims to optimally use cultivated area or increase crop production per cultivated area.

This study for the first time divided the process of agricultural practices, including planting, maintaining, and harvesting, into two stages – environmental stage (planting and maintaining) and economic stage (harvesting) – and finally developed a collective network DEA model, using shared resources. A model was then proposed for optimal allocation of human resources required by all stages in order to accomplish agricultural practices. Taking network DEA model and resource allocation model into account, we would respectively assess the sustainability level and maximum human resources required in each stage of agricultural practices in counties of Sistan and Baluchestan Province based on the three components of sustainability.Through this study, we can assess the sustainability level of the agricultural practices in Sistan and Baluchestan Province, and identify major causes of inefficiency in terms of each of sustainability indices. Moreover, this study would help the government and the Ministry of Agriculture Jihad to improve sustainable agricultural practices regarding soil, water resources and population of each county for cultivating and producing better crops.

The rest of this paper is organized in this way. Section (2) presents the network structure of agricultural practices in Sistan and Baluchestan Province with shared resources. Section (3) discusses the DEA methodology for assessing the overall and stagewise sustainable performance, and also presents some models for allocating maximum required human resources to each stage, given constant overall efficiency. Section (4) gives numerical examples of the sustainable agricultural practices in Sistan and Baluchestan Province based on the modes presented in section (3). This section also estimates maximum required human resources for each stage, given constant overall efficiency of the whole province. The final section (5) presents the results and suggestions.

2 Network Structure of Agricultural Practices in Sistan and Baluchestan Province

In an agricultural practice, skilled human resources become engaged in tillage activity and use water and agricultural inputs such as fertilizers and pesticides to cultivate an area of land. Then, the given human resources produce crops based on cultivated area and supply them to the market to generate revenues for themselves. Therefore, the process of agricultural practices is of a network structure, in which some outputs are considered inputs for the next stage. Therefore, this process can be divided into two stages. In the first stage, human resources and water are used to create cultivated area as an output, which is also called middle product. In the second stage, human resources as the shared input with stage 1 and cultivated area as the output of stage 1 create produced crops and also revenues for human resourcesas the final outputs of the system. Shared inputs refer to those inputs which are shared by two or more stages in a network process. In agricultural practices, water is one of the most important indicators. Today the agricultural sector consumes most of the available water. Excessive use of water and the consequent depletion of water resources would lead to water shortage in the future, environmental degradation, and mass migration of villagers to cities. Therefore, to preserve water resources, irrigation methods should be improved and cultivated area should be increased. So, in the first stage, water is considered an input environmental and social indicator, and human resources are considered an input social indicator. Moreover, since the first stage aims to increase cultivated area, then cultivated area is considered an output environmental indicator in this stage. The second stage aims to increase production and hence revenues per cultivated area. So, in the second stage, cultivated area is considered an input economic indicator, and production volume and revenues are viewed as output economic indicators. The first stage is related to planting and maintaining of agricultural products. Since the output of this stage is cultivated area, it is called environmental stage. The second stage is related to harvesting of agricultural products. Since one of the outputs is revenues, it is called an economic stage. Figure (1) illustrates the network structure of the process of agricultural practices.

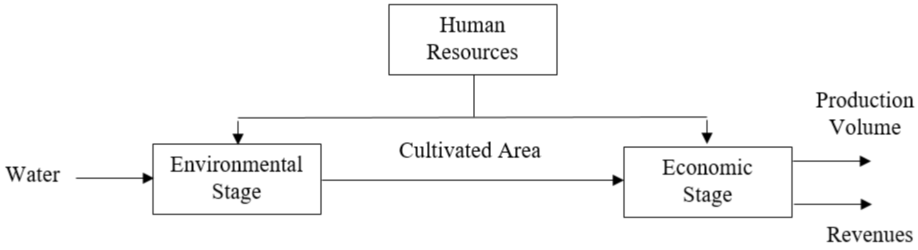

Figure 1: Network structure of agricultural practices

The above structure can be expressed as a DMU as follows:
Suppose there are a set of n DMUs with a two-stage serial structure and shared inputs between the two stages in an agricultural practice system. Suppose each $(j = 1, \cdots, n)$ DMU_j has m inputs, which the i^{th} input is expressed as $(i = 1, \cdots, m)$ x_{ij}. Some of the m inputs are only the inputs from the first stage, which are expressed as $(i_1 = 1, \cdots, t)x_{i_1 j}$, and the rest of them are the shared inputs between the two stages, which are expressed as $(i_2 = t + 1, \cdots, m)x_{i_2 j}$, so that $I_1 \cup I_2 = \{1, \cdots, m\}$. Also suppose that each $(j = 1, \cdots, n)DMU_j$ has D outputs from the first stage, and the D^{th} output is expressed as $(d = 1, \cdots, D)z_{dj}$, which are the inputs of the second stage, and the r^{th} output, which is expressed as $(r = 1, \cdots, s)y_{rj}$, is createdin the second stage. Figure (2) illustrates the structure of such a DMU.

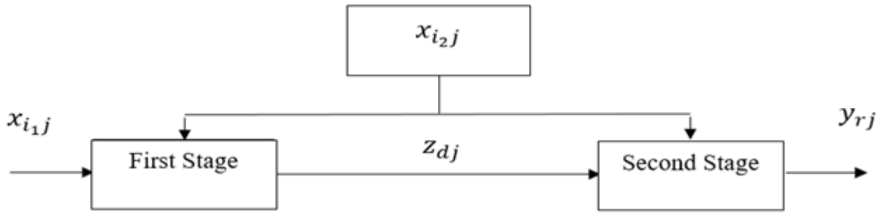

Figure 2: A two-stage Network structure with shared inputs

3 Method

3.1 Network Structure of Agricultural Practices with Shared Resources

Based on the variable returns to scale (VRS) proposed by Banker et al. [2], the efficiency of DMU_o in the first and second stages, given if all the shared inputs are consumed first in the first stage and then in the second stage, is determined as follows:

$$\begin{aligned} e_o^1 &= \max \frac{[\sum_{d=1}^{D} \varphi_d^1 Z_{do} + v^1]}{[\sum_{i_1=1}^{t} \gamma_{i_1} x_{i_1 o} + \sum_{i_2=t+1}^{m} \gamma_{i_2}^1 x_{i_2 o}]} \\ s.t: & \frac{\sum_{d=1}^{D} \varphi_d^1 Z_{dj} + v^1}{\sum_{i_1=1}^{t} \gamma_{i_1} x_{i_1 j} + \sum_{i_2=t+1}^{m} \gamma_{i_2}^1 x_{i_2 j}} \leq 1 \qquad \forall j \qquad (1) \\ & \\ & \varphi_d^1, \gamma_{i_1}, \gamma_{i_2}^1 \geq \varepsilon \forall d, \forall i_1, \forall i_2 \end{aligned}$$

And,

$$\begin{aligned} e_o^2 &= \max \frac{[\sum_{r=1}^{s} u_r y_{ro} + v^2]}{[\sum_{d=1}^{D} \varphi_d^2 Z_{do} + \sum_{i_2=t+1}^{m} \gamma_{i_2}^2 x_{i_2 o}]} \\ s.t: & \frac{\sum_{r=1}^{s} u_r y_{rj} + v^2}{\sum_{d=1}^{D} \varphi_d^2 Z_{dj} + \sum_{t_2=t+1}^{m} \gamma_{i_2}^2 x_{i_2 j}} \leq 1 \qquad \forall j \qquad (2) \\ & \\ & \varphi_d^2, u_r, \gamma_{i_2}^2 \geq \varepsilon \forall d, \forall i_2, \forall r \end{aligned}$$

Where φ_d^1 , γ_{i_1} , $\gamma_{i_2}^1$, φ_d^2 , u_r , $\gamma_{i_2}^2$ are non-negative unknown weights related to the inputs, outputs, and middle data. v^1 representsthe status of returns to scale for the first stage. That is, if $v^1 > 0$, then there would be an increasing returns to scale, if $v^1 < 0$, then there would be a decreasing returns to scale, and if $v^1 = 0$, then there would be a constant returns to scale. v^2 representsthe status of returns to scale for the second stage. ε represents in infinitely small positive number, which is used for the effects of all the input and output indicators on the assessment results.
Since, for every DMU, the outputs of the first stage are the inputs of the second stage, and since there is a need to increase the outputs in the first stage and decrease the inputs in the second stage for improving efficiency, so it is not possible to separately assess the efficiency of each stage by using normal DEA models and then make comparisons. Therefore, consistent with Liang et al. [21] and Chen et al. [7], let's suppose that the middle criteria have the same weights because if this assumption is not true, the overall efficiency of a DMU would be equal to the efficiency of each stage as separately determined by normal DEA models. Therefore, suppose that:

$$\varphi_d^1 = \varphi_d^2 = \varphi_d, (d = 1, \cdots, D)$$

And since $\gamma_{i_2}^1$ and $\gamma_{i_2}^2$ are the weights related to one type of inputs, then suppose that:

$$\forall \ i_2 \ \ \gamma_{i_2}^2 = \gamma_{i_2}^1 = \gamma_{i_2}$$

To determine the overall efficiency of DMU_o, the total weight method can be used to determine the efficiency of each stage, which is the efficiencies of models (1) and (2), as Kao et al. [17] and Wang et al. [25] did, as follows:

$$e_o = \omega_1 e_o^1 + \omega_2 e_o^2 \ , \ \ \omega_1 + \omega_2 = 1$$

Thus:

$$
\begin{aligned}
e_o = \max \omega_1 & \frac{[\sum_{d=1}^{D} \varphi_d Z_{do} + v^1]}{[\sum_{i_1=1}^{t} \gamma_{i_1} x_{i_1 o} + \sum_{i_2=t+1}^{m} \gamma_{i_2} x_{i_2 o}]} \\
& + \omega_2 \frac{[\sum_{r=1}^{s} u_r y_{ro} + v^2]}{[\sum_{d=1}^{D} \varphi_d Z_{do} + \sum_{i_2=t+1}^{m} \gamma_{i_2} x_{i_2 o}]}
\end{aligned}
$$

$$
\begin{aligned}
& s.t: \ \omega_1 + \omega_2 = 1 \\
& \frac{\sum_{d=1}^{D} \varphi_d Z_{dj} + v^1}{\sum_{i_1=1}^{t} \gamma_{i_1} x_{i_1 j} + \sum_{i_2=t+1}^{m} \gamma_{i_2} x_{i_2 j}} \leq 1 \qquad \forall j \\
& \frac{\sum_{r=1}^{s} u_r y_{rj} + v^2}{\sum_{d=1}^{D} \varphi_d Z_{dj} + \sum_{i_2=t+1}^{m} \gamma_{i_2} x_{i_2 j}} \leq 1 \qquad \forall j \\
& \varphi_d, \gamma_{i_1}, \gamma_{i_2} \geq \varepsilon \forall d, \forall i_1, \forall i_2, \forall r
\end{aligned}
\tag{3}
$$

Model (3) can be expressed as follows [25]

$$
e_o = \max \frac{\omega_1[\sum_{d=1}^{D} \varphi_d Z_{do} + v^1] + \omega_2[\sum_{r=1}^{s} u_r y_{ro} + v^2]}{\omega_1[\sum_{i_1=1}^{t} \gamma_{i_1} x_{i_1 o} + \sum_{i_2=t+1}^{m} \gamma_{i_2} x_{i_2 o}] + \omega_2[\sum_{d=1}^{D} \varphi_d Z_{do} + \sum_{i_2=t+1}^{m} \gamma_{i_2} x_{i_2 o}]}
$$

$$
\begin{aligned}
s.t: & \frac{\sum_{d=1}^{D} \varphi_d Z_{dj} + v^1}{\sum_{i_1=1}^{t} \gamma_{i_1} x_{i_1 j} + \sum_{i_2=t+1}^{m} \gamma_{i_2} x_{i_2 j}} \leq 1 \qquad \forall j \\
& \frac{\sum_{r=1}^{s} u_r y_{rj} + v^2}{\sum_{d=1}^{D} \varphi_d Z_{dj} + \sum_{i_2=t+1}^{m} \gamma_{i_2} x_{i_2 j}} \leq 1 \qquad \forall j \\
& \varphi_d, \gamma_{i_1}, \gamma_{i_2}, u_r \geq \varepsilon \forall d, \forall i_1, \forall i_2, \forall r
\end{aligned}
\tag{4}
$$

Model (4) is a fractional planning model, and the equations proposed by Charnes and Cooper [3] are used to make it linear, given that:

$$
\omega_1 \left[\sum_{i_1=1}^{t} \gamma_{i_1} x_{i_1 o} + \sum_{i_2=t+1}^{m} \gamma_{i_2} x_{i_2 o} \right] + \omega_2 \left[\sum_{d=1}^{D} \varphi_d Z_{do} + \sum_{i_2=t+1}^{m} \gamma_{i_2} x_{i_2 o} \right] = \frac{1}{t}
$$

Then, we have:

$$
\begin{aligned}
&e_o = max\ \omega_1\left[\sum_{d=1}^{D}\varphi_d Z_{do} + v^1\right] + \omega_2\left[\sum_{r=1}^{s}u_r y_{ro} + v^2\right] \\
&s.t: \omega_1\left[\sum_{i_1=1}^{t}\gamma_{i_1}x_{i_1o} + \sum_{i_2=t+1}^{m}\gamma_{i_2}x_{i_2o}\right] + \omega_2\left[\sum_{d=1}^{D}\varphi_d Z_{do} + \sum_{i_2=t+1}^{m}\gamma_{i_2}x_{i_2o}\right] = 1 \ \ (5-1) \\
&\sum_{d=1}^{D}\varphi_d Z_{dj} + v^1 - \sum_{i_1=1}^{t}\gamma_{i_1}x_{i_1j} - \sum_{i_2=t+1}^{m}\gamma_{i_2}x_{i_2j} \le 0 \ \ \forall j \ \ (5-2) \qquad\qquad (5) \\
&\sum_{r=1}^{s}u_r y_{rj} + v^2 - \sum_{d=1}^{D}\varphi_d Z_{dj} - \sum_{i_2=t+1}^{m}\gamma_{i_2}x_{i_2j} \le 0 \ \ \forall j \ \ (5-3) \\
&\varphi_d, \gamma_{i_1}, \gamma_{i_2}, u_r \ge \varepsilon \forall d, \forall i_1, \forall i_2, \forall r
\end{aligned}
$$

Theorem 3.1. *Model (5) is always feasible and optimal value of the objective function is bounded.*

Proof. Since $\omega_1 = \omega_2 = \frac{1}{2}, \forall d : \varphi_d = 0, \forall i_1 : \gamma_{i_1} = 0,$
for all $i_2 \neq t+1 : \gamma_{i_2} = 0, \forall r : u_r = 0, v^1 = v^2 = 0$ and $\gamma_{t+1} = \frac{1}{x_{t+1o}}$ is a feasible solution for the model, so it is always feasible.
To prove that the objective function is bounded, we proceed as follows: By multiplying constraint (5-2) by $\omega_1 > 0$ and constraint (5-3) by $\omega_2 > 0$, we have:

$$
\begin{aligned}
\omega_1\left[\sum_{d=1}^{D}\varphi_d Z_{dj} + v^1\right] &\le \omega_1\left[\sum_{i_1=1}^{t}\gamma_{i_1}x_{i_1j} + \sum_{i_2=t+1}^{m}\gamma_{i_2}x_{i_2j}\right] \ \forall j \\
\omega_2\left[\sum_{r=1}^{s}u_r y_{rj} + v^2\right] &\le \omega_2\left[\sum_{d=1}^{D}\varphi_d Z_{dj} + \sum_{i_2=t+1}^{m}\gamma_{i_2}x_{i_2j}\right] \ \forall j
\end{aligned}
$$

Then, we add these two constraints:

$$\omega_1\left[\sum_{d=1}^{D}\varphi_d Z_{dj}+v^1\right]+\omega_2\left[\sum_{r=1}^{s}u_r y_{rj}+v^2\right]\leq$$
$$\omega_1\left[\sum_{i_1=1}^{t}\gamma_{i_1}x_{i_1j}+\sum_{i_2=t+1}^{m}\gamma_{i_2}x_{i_2j}\right]+\omega_2\left[\sum_{d=1}^{D}\varphi_d Z_{dj}+\sum_{i_2=t+1}^{m}\gamma_{i_2}x_{i_2j}\right]\ \forall j$$

Therefore,

$$\frac{\omega_1[\sum_{d=1}^{D}\varphi_d Z_{dj}+v^1]+\omega_2[\sum_{r=1}^{s}u_r y_{rj}+v^2]}{\omega_1[\sum_{i_1=1}^{t}\gamma_{i_1}x_{i_1j}+\sum_{i_2=t+1}^{m}\gamma_{i_2}x_{i_2j}]+\omega_2[\sum_{d=1}^{D}\varphi_d Z_{dj}+\sum_{i_2=t+1}^{m}\gamma_{i_2}x_{i_2j}]}\leq 1\ \forall j$$

This relation holds true for each j in the constraints, so if j=o, then we have:

$$\frac{\omega_1\left[\sum_{d=1}^{D}\varphi_d Z_{do}+v^1\right]+\omega_2\left[\sum_{r=1}^{s}u_r y_{ro}+v^2\right]}{\omega_1\left[\sum_{i_1=1}^{t}\gamma_{i_1}x_{i_1o}+\sum_{i_2=t+1}^{m}\gamma_{i_2}x_{i_2o}\right]+\omega_2\left[\sum_{d=1}^{D}\varphi_d Z_{do}+\sum_{i_2=t+1}^{m}\gamma_{i_2}x_{i_2}\right]}\leq 1$$

According to constraint (5-1),

$$\omega_1\left[\sum_{i_1=1}^{t}\gamma_{i_1}x_{i_1o}+\sum_{i_2=t+1}^{m}\gamma_{i_2}x_{i_2o}\right]+\omega_2\left[\sum_{d=1}^{D}\varphi_d Z_{do}+\sum_{i_2=t+1}^{m}\gamma_{i_2}x_{i_2}\right]=1$$

So,

$$\omega_1\left[\sum_{d=1}^{D}\varphi_d Z_{do}+v^1\right]+\omega_2\left[\sum_{r=1}^{s}u_r y_{ro}+v^2\right]\leq 1$$

Therefore, the optimal value of objective function is always greater than or equal to 1. □

To calculate the efficiency of the first and second stages, the following models can be used, provided that the overall efficiency is known.

$$\begin{aligned}
&e_o^1 = max \ \sum_{d=1}^{D} \varphi_d Z_{do} + v^1 \\
&s.t: \ \sum_{i_1=1}^{t} \gamma_{i_1} x_{i_1 o} + \sum_{i_2=t+1}^{m} \gamma_{i_2} x_{i_2 o} = 1 \\
&\omega_1 \left[\sum_{d=1}^{D} \varphi_d Z_{do} + v^1 \right] + \omega_2 \left[\sum_{r=1}^{s} u_r y_{ro} + v^2 \right] = e_o^* \\
&\omega_1 + \omega_2 \left[\sum_{d=1}^{D} \varphi_d Z_{do} + \sum_{i_2=t+1}^{m} \gamma_{i_2} x_{i_2 o} \right] = 1 \\
&\sum_{d=1}^{D} \varphi_d Z_{dj} + v^1 - \sum_{i_1=1}^{t} \gamma_{i_1} x_{i_1 j} - \sum_{i_2=t+1}^{m} \gamma_{i_2} x_{i_2 j} \leq 0 \ \forall j \\
&\sum_{r=1}^{s} u_r y_{rj} + v^2 - \sum_{d=1}^{D} \varphi_d Z_{dj} - \sum_{i_2=t+1}^{m} \gamma_{i_2} x_{i_2 j} \leq 0 \ \forall j \\
&\varphi_d, \gamma_{i_1}, \gamma_{i_2}, u_r \geq \varepsilon \forall d, \forall i_1, \forall i_2, \forall r
\end{aligned} \tag{6}$$

The above model can be expressed as follows:

$$\begin{aligned}
&e_o^1 = max \sum_{d=1}^{D} \varphi_d Z_{do} + v^1 \\
&s.t: \sum_{i_1=1}^{t} \gamma_{i_1} x_{i_1 o} + \sum_{i_2=t+1}^{m} \gamma_{i_2} x_{i_2 o} = 1 \ \ (7-1) \\
&(\omega_1 - \omega_2 e_o^*)(\sum_{d=1}^{D} \varphi_d Z_{do}) + \omega_2(\sum_{r=1}^{s} u_r y_{ro} - e_o^* \sum_{i_2=t+1}^{m} \gamma_{i_2} x_{i_2 o}) \\
&+ \omega_1 v^1 + \omega_2 v^2 = \omega_1 e_o^* \ \ (7-2) \\
&\sum_{d=1}^{D} \varphi_d Z_{dj} + v^1 - \sum_{i_1=1}^{t} \gamma_{i_1} x_{i_1 j} - \sum_{i_2=t+1}^{m} \gamma_{i_2} x_{i_2 j} \leq 0 \ \forall j \ \ (7-3) \qquad (7) \\
&\sum_{r=1}^{s} u_r y_{rj} + v^2 - \sum_{d=1}^{D} \varphi_d Z_{dj} - \sum_{i_2=t+1}^{m} \gamma_{i_2} x_{i_2 j} \leq 0 \ \forall j \ \ (7-4) \\
&\\
&\varphi_d, \gamma_{i_1}, \gamma_{i_2}, u_r \geq \varepsilon \forall d, \forall i_1, \forall i_2, \forall r
\end{aligned}$$

Theorem 3.2. *Model (7) is always feasible and optimal value of the objective function is bounded.*

Proof. Since $\omega_1 = 0, \omega_2 = 1, \forall d : \varphi_d = 0, \forall i_1 : \gamma_{i_1} = 0,$
$\forall i_2 \neq t+1 : \gamma_{i_2} = 0, \forall r \neq 1 : u_r = 0, v^1 = v^2 = 0$
$, u_1 = \frac{e_o^*}{y_{1o}} \leq 1$ and $\gamma_{t+1} = \frac{1}{x_{t+1o}}$ is a feasible solution for the model, so it is always feasible.
To prove that the objective function is bounded, we proceed as follows:
Constraint (7-3)can be rewritten as follows:

$$\frac{\sum_{d=1}^{D} \varphi_d Z_{dj} + v^1}{\sum_{i_1=1}^{t} \gamma_{i_1} x_{i_1 j} + \sum_{i_2=t+1}^{m} \gamma_{i_2} x_{i_2 j}} \leq 1 \qquad \forall j$$

Since this relation holds true for each j in the constraints, if j=o, then we have:

$$\frac{\sum_{d=1}^{D} \varphi_d Z_{do} + v^1}{\sum_{i_1=1}^{t} \gamma_{i_1} x_{i_1 o} + \sum_{i_2=t+1}^{m} \gamma_{i_2} x_{i_2 o}} \leq 1$$

According to constraint (7-1)

$$\sum_{i_1=1}^{t} \gamma_{i_1} x_{i_1 o} + \sum_{i_2=t+1}^{m} \gamma_{i_2} x_{i_2 o} = 1$$

Therefore,

$$\sum_{d=1}^{D} \varphi_d Z_{do} + v^1 \leq 1$$

So, the optimal value of objective function is always less than or equal to 1. □

The efficiency of the second stage can be calculated by the following model:

$$\begin{aligned}
& e_o^2 = max \ \sum_{r=1}^{s} u_r y_{ro} + v^2 \\
& s.t: \ \sum_{d=1}^{D} \varphi_d Z_{do} + \sum_{i_2=t+1}^{m} \gamma_{i_2} x_{i_2 o} = 1 \\
& \omega_1 \left[\sum_{d=1}^{D} \varphi_d Z_{do} + v^1 \right] + \omega_2 \left[\sum_{r=1}^{s} u_r y_{ro} + v^2 \right] = e_o^* \\
& \omega_1 \left[\sum_{i_1=1}^{t} \gamma_{i_1} x_{i_1 o} + \sum_{i_2=t+1}^{m} \gamma_{i_2} x_{i_2 o} \right] + \omega_2 = 1 \\
& \sum_{d=1}^{D} \varphi_d Z_{dj} + v^1 - \sum_{i_1=1}^{t} \gamma_{i_1} x_{i_1 j} - \sum_{i_2=t+1}^{m} \gamma_{i_2} x_{i_2 j} \leq 0 \ \forall j \\
& \sum_{r=1}^{s} u_r y_{rj} + v^2 - \sum_{d=1}^{D} \varphi_d Z_{dj} - \sum_{i_2=t+1}^{m} \gamma_{i_2} x_{i_2 j} \leq 0 \ \forall j \\
& \varphi_d, \gamma_{i_1}, \gamma_{i_2}, u_r \geq \varepsilon \forall d, \forall i_1, \forall i_2, \forall r
\end{aligned} \tag{8}$$

The above model can be expressed as follows:

$$\begin{aligned}
&e_o^2 = max \ \sum_{r=1}^{s} u_r y_{ro} + v^2 \\
&s.t: \ \sum_{d=1}^{D} \varphi_d Z_{do} + \sum_{i_2=t+1}^{m} \gamma_{i_2} x_{i_2 o} = 1 \ \ (9-1) \\
&\omega_1 \Bigg(\sum_{d=1}^{D} \varphi_d Z_{do} - e_o^* \sum_{i_1=1}^{t} \gamma_{i_1} x_{i_1 o} - e_o^* \sum_{i_2=t+1}^{m} \gamma_{i_2} x_{i_2 o} \Bigg) \\
&\ + \omega_2 \Bigg(\sum_{r=1}^{s} u_r y_{ro} \Bigg) + \omega_1 v^1 + \omega_2 v^2 = \omega_2 e_o^* \ \ (9-2)
\end{aligned}$$

$$\begin{aligned}
&\sum_{d=1}^{D} \varphi_d Z_{dj} + v^1 - \sum_{i_1=1}^{t} \gamma_{i_1} x_{i_1 j} - \sum_{i_2=t+1}^{m} \gamma_{i_2} x_{i_2 j} \leq 0 \ \forall j \ \ (9-3) \\
&\sum_{r=1}^{s} u_r y_{rj} + v^2 - \sum_{d=1}^{D} \varphi_d Z_{dj} - \sum_{i_2=t+1}^{m} \gamma_{i_2} x_{i_2 j} \leq 0 \ \forall j \ \ (9-4)
\end{aligned} \tag{9}$$

$$\varphi_d, \gamma_{i_1}, \gamma_{i_2}, u_r \geq \varepsilon \forall d, \forall i_1, \forall i_2, \forall r$$

Theorem 3.3. *Model (9) is always feasible and optimal value of the objective function is bounded.*

Proof. Since $\omega_1 = 0, \omega_2 = 1, \forall d : \varphi_d = 0, \forall i_1 : \gamma_{i_1} = 0,$
$\forall i_2 \neq t+1 : \gamma_{i_2} = 0, \forall r \neq 1 : u_r = 0, v^1 = v^2 = 0$
$, u_1 = \frac{e_o^*}{y_{1o}} \leq 1$ and $\gamma_{t+1} = \frac{1}{x_{t+1o}}$ is a feasible solution for the model, so it is always feasible.

To prove that the objective function is bounded, we proceed as follows:
Constraint (9-4)can be reformulated as follows:

$$\frac{\sum_{r=1}^{s} u_r y_{rj} + v^2}{\sum_{d=1}^{D} \varphi_d Z_{dj} + \sum_{t_2=t+1}^{m} \gamma_{i_2} x_{i_2 j}} \leq 1 \qquad \forall j$$

Since this relation holds true for each j in the constraints, if j=o, then we have:

$$\frac{\sum_{r=1}^{s} u_r y_{ro} + v^2}{\sum_{d=1}^{D} \varphi_d Z_{do} + \sum_{t_2=t+1}^{m} \gamma_{i_2} x_{i_2 o}} \leq 1$$

According to constraint (9-1),

$$\sum_{d=1}^{D} \varphi_d Z_{do} + \sum_{t_2=t+1}^{m} \gamma_{i_2} x_{i_2 o} = 1$$

Therefore,

$$\sum_{r=1}^{s} u_r y_{ro} + v^2 \leq 1$$

So, the optimal value of objective function is always less than or equal to 1. $\square$

The best method is to suppose that the relative importance of the first and second stage for all the DMUs is the same. Therefore, we should insert the following in Model (5) $\omega_1 = \omega_2 = \omega$, given that: $\omega_1 + \omega_2 = 1$, then:

$$2\omega = 1 \longrightarrow \omega = \frac{1}{2}$$

Therefore, if we insert $\omega_1 = \omega_2 = \frac{1}{2}$ in Model (5), the overall efficiency of the DMU under question will be determined. Finally, based on Model (6) and Model (8), the efficiency of the first and second stages were determined.

In j^{th} county, water and human resources inputs of the environmental stage, and cultivated area output which is the economic stage input, and revenues and production volume outputs of the economic stage are denoted by $x_{1j}, x_{2j}, z_{1j}, y_{1o}$, and y_{2o}, respectively. Model (5) determines the overall efficiency, and Models (6) and (8) determine the efficiency of the first and second stages of sustainable agricultural development in Sistan and Baluchestan Province, respectively, for the given structure of the o^{th} county. They are expressed as follows:

$$\begin{aligned}
&e_o = max\ \omega_1[\varphi Z_{1o} + v^1] + \omega_2\left[\sum_{r=1}^{2} u_r y_{ro} + v^2\right]\\
&s.t: \omega_1[\gamma_1 x_{1o} + \gamma_2 x_{2o}] + \omega_2[\varphi Z_{1o} + \gamma_2 x_{2o}] = 1\\
&\varphi Z_{1j} + v^1 - \gamma_1 x_{1j} - \gamma_2 x_{2j} \leq 0\ \forall j = 1, \cdots, 19\\
&\sum_{r=1}^{2} u_r y_{rj} + v^2 - \varphi Z_{1j} - \gamma_2 x_{2j} \leq 0\ \ \forall j = 1, \cdots, 19\\
&\varphi, u_1, u_2, \gamma_1, \gamma_2 \geq \varepsilon
\end{aligned} \tag{10}$$

and,

$$\begin{aligned}
&e_o^1 = max\, \varphi Z_{1o} + v^1\\
&s.t:\ [\gamma_1 x_{1o} + \gamma_2 x_{2o}] = 1\\
&\omega_1[\varphi Z_{1o} + v^1] + \omega_2\left[\sum_{r=1}^{2} u_r y_{ro} + v^2\right] = e_o^*\\
&\omega_1 + \omega_2[\varphi Z_{1o} + \gamma_2 x_{2o}] = 1\\
&\varphi Z_{1j} + v^1 - \gamma_1 x_{1j} - \gamma_2 x_{2j} \leq 0\ \forall j = 1, \cdots, 19\\
&\sum_{r=1}^{2} u_r y_{rj} + v^2 - \varphi Z_{1j} - \gamma_2 x_{2j} \leq 0\ \forall j = 1, \cdots, 19\\
&\varphi, u_1, u_2, \gamma_1, \gamma_2 \geq \varepsilon
\end{aligned} \tag{11}$$

and,

$$
\begin{aligned}
& e_o^2 = max\left[\sum_{r=1}^{2} u_r y_{ro} + v^2\right] \\
& s.t:\ [\varphi Z_{1o} + \gamma_2 x_{2o}] = 1 \\
& \omega_1[\varphi Z_{1o} + v^1] + \omega_2\left[\sum_{r=1}^{2} u_r y_{ro} + v^2\right] = e_o^* \\
& \omega_1[\gamma_1 x_{1o} + \gamma_2 x_{2o}] + \omega_2 = 1 \\
& \varphi Z_{1j} + v^1 - \gamma_1 x_{1j} - \gamma_2 x_{2j} \leq 0\ \forall j = 1, \cdots, 19 \\
& \sum_{r=1}^{2} u_r y_{rj} + v^2 - \varphi Z_{1j} - \gamma_2 x_{2j} \leq 0\ \forall j = 1, \cdots, 19 \\
& \varphi, u_1, u_2, \gamma_1, \gamma_2 \geq \varepsilon
\end{aligned}
\tag{12}
$$

3.2 Efficiency of Agricultural Practices Based on the Weight Restrictions

One important step in the process of determination of the overall sustainability efficiency based on the proposed models here is to determine the weights of inputs and outputs in such a way that the efficiency of every DMU is maximized. Therefore, if a DMU fails to take weight restrictions into account and is inefficient, then its efficiency may not be assessed by any other model. This implies that free weights of inputs and outputs is one of the strengths of DEA. On the other hand, the efficiency degree of every DMU is determined by the previous models in the best assessment conditions. Thus, in this respect, free weights of inputs and outputs is one of the weaknesses of DEA. To solve this problem, weight restrictions are taken into account to calculate the overall efficiency and the efficiency of each stage, given water and human resources as the shared inputs and revenues and production volume as outputs.

Water is viewed as an input of the environmental stage and is one of the most influential factors in the agricultural sector and its sustainable development. Recently, the Water Resources Management Company and the Ministry of Agriculture Jihad have supplied water at a low price in some regions to encourage the optimal use of water resources, the improvement of irrigation methods, and the substitution of valuable agricultural products needing less water for those needing more water. For example, the minimum and maximum price of water per every square meter was 150 and 300 Rials in 2016 and 2017, respectively. Therefore, water price can be considered a weight restriction for determining the sustainability level of agricultural practices in Sistan and Baluchestan Province.

Human resources is the shared input between the two environmental and economic stages. One of the most important goals of sustainable agricultural practices is to use less human resources for more production, creating an economic efficiency. Since the human and social dimensions are considered by authorities in sustainable development, thus minimum wages are determined for every 8 working hours of human resources every year, given the current economic situation and inflation rates. For example, according to the literature, the minimum wage for 8 working hours in agricultural practices in Sistan and Baluchestan Province in 2017 was $350,000$ Rials, which was used as a weight restriction to determine the overall efficiency of agricultural practices in Sistan and Baluchestan Province in 2017.

Revenues and production volume are the outputs of the economic stage. Since, the outputs of the second stage directly influence the quality of life of farmers, they play an important role in sustainable agricultural development. Then, if u_1 represents the revenue weight of a county and u_2 represents the production volume weight of that county, since the revenues of each county are calculated based on the production volume of that county and its value, therefore, we have:

$$\frac{Revenues of a County}{Production Volume of a County} = \frac{u_1}{u_2} \tag{13}$$

Equation (13) can be expressed as follows:

$$(Revenues of a County)(u_2) - (Production Volume of a County)(u_1) = 0 \tag{14}$$

The linear equation (14) can be used as weight restrictions for revenues and production volume, given the overall efficiency and stage wise

sustainability efficiency of agricultural practices of any of the counties in Sistan and Baluchestan Province.
The proposed model for calculating the overall sustainability efficiency of agricultural practices in the o^{th} county, given weight restrictions, is expressed below. It should be noted that weight restrictions are only for 2017.

$$
\begin{aligned}
& e_o = max\ \omega_1[\varphi Z_{1o} + v^1] + \omega_2\left[\sum_{r=1}^{2} u_r y_{ro} + v^2\right] \\
& s.t:\ \omega_1[\gamma_1 x_{1o} + \gamma_2 x_{2o}] + \omega_2[\varphi Z_{1o} + \gamma_2 x_{2o}] = 1 \\
& \varphi Z_j + v^1 - \gamma_1 x_{1j} - \gamma_2 x_{2j} \leq 0\ \forall j = 1, \cdots, 19 \\
& \sum_{r=1}^{2} u_r y_{rj} + v^2 - \varphi Z_{1j} - \gamma_2 x_{2j} \leq 0\ \forall j = 1, \cdots, 19 \\
& u_2 y_{1o} - u_1 y_{2o} = 0 \\
& 150 \leq \gamma_1 \leq 300\ \ \gamma_2 \geq 350000 \\
& \varphi, u_1, u_2, \gamma_1, \gamma_2 \geq \varepsilon
\end{aligned}
\tag{15}
$$

Accordingly, Models (11) and (12) are expressed below for calculating the sustainability efficiency of the first and second stage.

$$
\begin{aligned}
& e_o^1 = max\ [\varphi Z_{1o} + v^1] \\
& s.t:\ [\gamma_1 x_{1o} + \gamma_2 x_{2o}] = 1 \\
& \omega_1[\varphi Z_{1o} + v^1] + \omega_2\left[\sum_{r=1}^{2} u_r y_{ro} + v^2\right] = e_o^* \\
& \omega_1 + \omega_2[\varphi Z_{1o} + \gamma_2 x_{2o}] = 1 \\
& \varphi Z_{1j} + v^1 - \gamma_1 x_{1j} - \gamma_2 x_{2j} \leq 0\ \forall j = 1, \cdots, 19 \\
& \sum_{r=1}^{2} u_r y_{rj} + v^2 - \varphi Z_{1j} - \gamma_2 x_{2j} \leq 0\ \forall j = 1, \cdots, 19 \\
& u_2 y_{1o} - u_1 y_{2o} = 0 \\
& 150 \leq \gamma_1 \leq 300\ \ \gamma_2 \geq 350000 \\
& \varphi, u_1, u_2, \gamma_1, \gamma_2 \geq \varepsilon
\end{aligned}
\tag{16}
$$

and,

$$
\begin{aligned}
& e_o^2 = max\left[\sum_{r=1}^{2} u_r y_{ro} + v^2\right] \\
& s.t:\ [\varphi Z_{1o} + \gamma_2 x_{2o}] = 1 \\
& \omega_1[\varphi Z_{1o} + v^1] + \omega_2\left[\sum_{r=1}^{2} u_r y_{ro} + v^2\right] = e_o^* \\
& \omega_1[\gamma_1 x_{1o} + \gamma_2 x_{2o}] + \omega_2 = 1 \\
& \varphi Z_{1j} + v^1 - \gamma_1 x_{1j} - \gamma_2 x_{2j} \le 0\ \forall j = 1, \cdots, 19 \\
& \sum_{r=1}^{2} u_r y_{rj} + v^2 - \varphi Z_{1j} - \gamma_2 x_{2j} \le 0\ \forall j = 1, \cdots, 19 \\
& u_2 y_{1o} - u_1 y_{2o} = 0 \\
& 150 \le \gamma_1 \le 300\ \ \gamma_2 \ge 350000 \\
& \varphi, u_1, u_2, \gamma_1, \gamma_2 \ge \varepsilon
\end{aligned}
\tag{17}
$$

3.3 Sensitivity Analysis of Human resources

One of the important factors influencing the sustainability level of agricultural practices is the optimal use of human resources. As it was mentioned earlier, sustainable agriculture presupposes the social welfare and high quality of life of human resources, that is, farmers, as well as the optimal use of natural resources, including water and soil, and food security. Human resources should be maximized in sustainable agricultural practices. According to Model (15), first the overall efficiency is determined, then the following model is used to determine the maximum required human resources for each stage, given that the overall efficiency of the o^{th} DMU is known. Suppose that α is the value of the shared resources allocated to stage 1, and $(1-\alpha)$ is the value of the shared resources allocated to stage 2. Then, the number of human resources allocated to the first and second stages are represented by ah_o

and $(1-\alpha)h_o$. Therefore, Model (15) is reformulated as follows:

$$
\begin{aligned}
& max\ \alpha \\
& s.t:\ \omega_1[\varphi Z_{1o}+v^1]+\omega_2\left[\sum_{r=1}^{2}u_r y_{ro}+v^2\right]=e_o^* \\
& \omega_1[\gamma_1 x_{1o}+\gamma_2\alpha x_{2o}]+\omega_2[\varphi Z_{1o}+\gamma_2(1-\alpha)x_{2o}]=1 \\
& \varphi Z_{1j}+v^1-\gamma_1 x_{1j}-\gamma_2\alpha x_{2j}\leq 0\ \forall j=1,\cdots,19 \\
& \sum_{r=1}^{2}u_r y_{rj}+v^2-\varphi Z_{1j}-\gamma_2(1-\alpha)x_{2j}\leq 0\ \forall j=1,\cdots,19 \\
& u_2 y_{1o}-u_1 y_{2o}=0 \\
& 150\leq\gamma_1\leq 300\ \ \gamma_2\geq 350000 \\
& \varphi,u_1,u_2,\gamma_1,\gamma_2\geq\varepsilon, 0\leq\alpha\leq 1
\end{aligned}
\tag{18}
$$

By using model (18), therefore, maximum allocated human resiurces of every county ineach of environmental and economic stages can be determined provided that overall efficiency of that county is known.

3.4 Algorithm

Based on the above discussion, the following algorithm is used to determine the sustainability level of agricultural practices:

First step: Using models (10) and (15), the overall sustainable efficiency with and without weight restrictions are respectively calculated for each county, and hence two situation happen.

1) If the overall sustainable efficiency of a county equals 1, it can be concluded that the county has reached the sustainability threshold in both environmental and economical stages, and therefore, the algorithm terminates.

2) If the overall sustainable efficiency of a county is less than 1, it can be concluded that the county has not reached the sustainability threshold in one of the environmental and economical stages or in both stages, and we then take the second step.

Second step: Regarding models (11) and (16), the environmental efficiency with and without weight restrictions are respectively determined for the county, and hence two situation happen.

1) If the environmental efficiency equals 1, it can be said that the county has reached the sustainability threshold in the environmental stage. Since its overall efficiency is less than 1, hence, the county has not reached the sustainability threshold in the economical stage, and so, we proceed to the third step.

2) If the environmental efficiency is less than 1, it can be concluded that the county has not reached the sustainability threshold in the environmental stage, and hence, we take the third step.

Third step: Using models (12) and (17), the economical efficiency with and without weight restrictions are respectively calculated for the county, and hence two situation happen.

1) If the economical efficiency equals 1, it can be said that the county has reached the sustainability threshold in economical stage, and consequently, the algorithm terminates.

2) If the economical efficiency is less than 1, it can be concluded that the county has not reached the sustainability threshold in economic stage, and the algorithm terminates.

4 Data Analysis

Sustainable development by definition presupposes that agricultural development does not lead to the environmental degradation, while meeting the subsistence needs of the society, and improving the quality of life of farmers (WCDE, 1978). Sustainable development, according to its three constituent parts (TBL), involves the coordinated economic, environmental, and social development [10]. This study aimed to determine the sustainability level of agricultural practices of Sistan and Baluchestan Province, focusing on the three economic, environmental, and social dimensions at the same time.

Figure 3: Map of Sistan and Baluchestan Province

The area of Sistan and Baluchestan Province is around 187, 502 square kilometers, and Zahedan is its capital with a population of around 2.8 million people. This province has 19 counties, and around 49% and 51% of its population live in urban and rural areas, respectively. Desirable natural conditions have made agricultural and horticultural practices possible during all the four seasons in a year, hence enabling the development of the agricultural sector.

With a higher sustainability efficiency of agricultural practices in Sistan and Baluchestan Province, there would be higher economic returns and social welfare for villagers, and there would also be less negative effects on the environment, and finally the migration of villagers to the cities and their engagement in pseudo-jobs would be precluded. The data used in this study was collected from the websites of the Water Resources Management Company andthe Ministry of Agriculture Jihad (see Table (1)).

Table 1: Data Related to Agricultural Practices in Sistan and Baluchestan Province

Year	County	Water	HUMAN RESOURCES	Cultivated Area	Production Volume(Ton)	Revenues
2013	Iranshahr	280112	112851	21539.33	280562.1	58158885.71
	Chabahar	143819	170778	17359.74	272975.7	74480750
	Khash	172191	110739	32006	223384.6	74832041.07
	Dalgan	482782	57565	24121.11	181423.3	62251714.29
	Zabol	11468.8	26924	14483	75729.2	14007235.71
	Zahedan	142734	79611	10757.65	94456.66	173300083.9
	Zehak	11468.8	61539	19520.67	141060.3	28577191.43
	Saravan	98698	100353	14682.4	87521.15	33910233.93
	Sarbaz	88020	158015	14683.11	174259.6	54581190.36
	SibandSuran	54502	69838	9112.3	78956.4	25550157.14
	Fanuj	6327	36091	3401.38	49897.8	16895767.86
	Qasr − eQand	22889	49471	3964	69856.2	20408982.14
	Konarak	38098	50951	9038.36	210170.6	41912821.43
	Mehrestan	49102	58334	9998.6	83641.2	25695846.43
	Mirjaveh	235991	35998	10540.35	114005	243867266.1
	NikShahr	33680	113591	7721	102745	38464142.86
	Nimruz	11468.8	44712	15288.94	71988.24	14230594.64
	Hamun	11468.8	32613	18942	87971.15	17770021.43
	Hirmand	11468.8	57358	21589.3	256071.9	43887551.07
2014	Iranshahr	280112	112851	28464.02	345370.7	79381104.2
	Chabahar	143819	170778	31873.5	390553.3	86032828.33
	Khash	172191	110739	34083.3	219366.4	77609609.23
	Dalgan	482782	57565	24113.91	170970.4	66638518.33
	Zabol	11468.8	26924	13903.06	120802.3	55060598
	Zahedan	142734	79611	10561.32	79963.62	51790300.7
	Zehak	11468.8	61539	20955.41	233970.2	49882221.23
	Saravan	98698	100353	15120.63	86870.4	34578437.03
	Sarbaz	88020	158015	14769.73	186185.6	58244833
	SibandSuran	54502	69838	9485.98	77484.86	26378260.6
	Fanuj	6327	36091	4043.87	45593.03	15694342.33
	Qasr − eQand	22889	49471	6052.92	57148.09	19045040.33
	Konarak	38098	50951	13955.06	329088.1	70580126.67
	Mehrestan	49102	58334	9258.41	77711.83	22321322.5
	Mirjaveh	235991	35998	10260.31	101942.7	70072994
	NikShahr	33680	113591	6862.15	81698.31	27216401.33
	Nimruz	11468.8	44712	14290.8	117866.4	42840233
	Hamun	11468.8	32613	14955.75	99609.36	21588892
	Hirmand	11468.8	57358	22306.01	320401.5	57059436.8
2015	Iranshahr	280112	112851	23274.52	281759.1	61943348.48
	Chabahar	143819	170778	26972.93	368788.4	98163754.24
	Khash	172191	110739	32575.43	253326.5	87720794.85
	Dalgan	482782	57565	22119.45	158629.5	107778322.6
	Zabol	11468.8	26924	10293.37	50615.34	10830664.55
	Zahedan	142734	79611	9735.57	68154.3	27611923.33
	Zehak	11468.8	61539	19666.96	131787.7	33262970.61
	Saravan	98698	100353	12360.5	75307.3	29096061.82
	Sarbaz	88020	158015	13080.6	176242.2	52713058.33
	SibandSuran	54502	69838	7744.35	65548.7	21158031.21
	Fanuj	6327	36091	2856.84	27581.57	10540898.18
	Qasr − eQand	22889	49471	5019.73	43834.31	14943125.45
	Konarak	38098	50951	10890.62	260577.4	61871835.15
	Mehrestan	49102	58334	6760	62796.73	17664334.85
	Mirjaveh	235991	35998	9464.81	100722.9	23396532.12
	NikShahr	33680	113591	6781.45	86511.71	31424436.06
	Nimruz	11468.8	44712	12095.42	60587.01	13360632.12
	Hamun	11468.8	32613	16145.49	44987.72	12270124.85
	Hirmand	11468.8	57358	21297.57	249467.5	34061801.82

Continuation of the table 1

Year	County	Water	HUMAN RESOURCES	Cultivated Area	Production Volume(Ton)	Revenues
2016	Iranshahr	280112	112851	23704.23	311680.7	80040824.22
	Chabahar	143819	170778	25923.06	468026.9	123068594.3
	Khash	172191	110739	33179.39	312392.5	103667999.7
	Dalgan	482782	57565	23308.71	174937.1	70621543.06
	Zabol	11468.8	26924	14149.47	212652.1	31619218.99
	Zahedan	142734	79611	12200.92	151544.2	47770192.11
	Zehak	11468.8	61539	18268.61	223109.4	47282026.23
	Saravan	98698	100353	13866	104158.9	35842294.1
	Sarbaz	88020	158015	14966.43	13803.58	181306428.1
	SibandSuran	54502	69838	8368.83	98568.42	29331881.1
	Fanuj	6327	36091	3223.18	29941.58	13453539.65
	Qasr − eQand	22889	49471	5286.53	45305	20892724.6
	Konarak	38098	50951	11382.56	335387.6	81154629.16
	Mehrestan	49102	58334	9251.78	118592.9	29289228.88
	Mirjaveh	235991	35998	8353.11	99604.57	24887277.22
	NikShahr	33680	113591	9476.08	855048.7	44131256.89
	Nimruz	11468.8	44712	10439.98	99196.76	23264877.91
	Hamun	11468.8	32613	12737.17	84045.52	20106776.05
	Hirmand	11468.8	57358	16515.45	381997.4	55984084.23
2017	Iranshahr	280112	112851	24823.91	304838.1	66263371.2
	Chabahar	143819	170778	17276.32	397616	89541279.1
	Khash	172191	110739	34314.05	297769.1	101075397
	Dalgan	482782	57565	28503.94	311523.6	87803653.5
	Zabol	11468.8	26924	10537.01	127032.2	21653951.6
	Zahedan	142734	79611	10835.53	90937.83	39463959.5
	Zehak	11468.8	61539	16112.04	142833.8	29627215.9
	Saravan	98698	100353	16222.49	117383.8	38650467.7
	Sarbaz	88020	158015	14714.14	196290.7	73828849.8
	SibandSuran	54502	69838	7522.09	79110.04	23065113
	Fanuj	6327	36091	4667.18	42395.79	16399212.8
	Qasr − eQand	22889	49471	3983.5	45017.1	21131181.4
	Konarak	38098	50951	11165.7	152130.3	39310672.1
	Mehrestan	49102	58334	10233.97	128915.3	25355986.5
	Mirjaveh	235991	35998	10255.8	113009.5	24217800.5
	NikShahr	33680	113591	6951.68	72898.97	27989114.9
	Nimruz	11468.8	44712	14508.09	102342.2	21369456.3
	Hamun	11468.8	32613	14473.85	100223.9	20246557.7
	Hirmand	11468.8	57358	18125.86	346689.8	59712312

Table 2: Results of Sustainability Assessment of Agricultural Practices in Sistan and Baluchestan Province without Weight Restrictions

Year	*County*	*OverallSustainability Efficiency model(10)*	*Efficiencyof EnvironmentalStage model(11)*	*Efficiencyof EconomicStage model(12)*
2013	*Iranshahr*	0.4779	0.3286	0.5934
	Chabahar	0.3174	0.1750	0.4387
	Khash	0.4638	0.4976	0.4412
	Dalgan	0.6701	0.6813	0.6628
	Zabol	1	1	1
	Zahedan	0.3982	0.2785	0.5003
	Zehak	0.7502	0.9480	0.3526
	Saravan	0.3317	0.2708	0.3831
	Sarbaz	0.2534	0.1600	0.3339
	SibandSuran	0.4297	0.2999	0.5431
	Fanuj	1	1	1
	Qasr − eQand	0.5603	0.3697	0.7392
	Konarak	0.7603	0.5156	1
	Mehrestan	0.5160	0.3760	0.6336
	Mirjaveh	0.8740	0.7479	1
	NikShahr	3029	0.2641	0.3857
	Nimruz	0.7671	0.8245	0.6808
	Hamun	0.9264	0.9909	0.8295
	Hirmand	0.8548	1	0.6367
2014	*Iranshahr*	0.5001	0.4884	0.5080
	Chabahar	0.3862	0.3614	0.4044
	Khash	0.4803	0.5960	0.4078
	Dalgan	0.6696	0.8112	0.5914
	Zabol	1	1	1
	Zahedan	0.4024	0.2569	0.5182
	Zehak	0.8107	0.9668	0.5072
	Saravan	0.3415	0.2918	0.3800
	Sarbaz	0.2610	0.1810	0.3288
	SibandSuran	0.4220	0.3267	0.5066
	Fanuj	1	1	1
	Qasr − eQand	0.5688	0.3967	0.7233
	Konarak	0.8144	0.5304	1
	Mehrestan	0.4985	0.3875	0.5953
	Mirjaveh	0.8666	0.7243	1
	NikShahr	0.2937	0.2535	0.3949
	Nimruz	0.8116	0.8868	0.6987
	Hamun	0.9094	0.9593	0.8317
	Hirmand	0.8707	1	0.7234
2015	*Iranshahr*	0.4616	0.4166	0.4934
	Chabahar	0.4203	0.3190	0.4971
	Khash	0.5551	0.5942	0.5305
	Dalgan	0.9194	0.7762	1
	Zabol	1	1	1
	Zahedan	0.4217	0.3077	0.5204
	Zehak	0.7558	0.9603	0.3279
	Saravan	0.3531	0.2772	0.4187
	Sarbaz	0.2740	0.1672	0.3654
	SibandSuran	0.4478	0.3500	0.5361
	Fanuj	1	1	1
	Qasr − eQand	0.5829	0.4406	0.7124
	Konarak	0.7916	0.5398	1
	Mehrestan	0.5149	0.4027	0.6159
	Mirjaveh	0.8508	0.7255	0.9505
	NikShahr	0.3139	0.2678	0.4069
	Nimruz	0.7679	0.8140	0.6959
	Hamun	0.9085	1	0.7774
	Hirmand	0.8394	1	0.63082

Continuation of the table 2

$Year$	$County$	$OverallSustainability$ $Efficiency$ $model(10)$	$Efficiencyof$ $EnvironmentalStage$ $model(11)$	$Efficiencyof$ $EconomicStage$ $model(12)$
2016	$Iranshahr$	0.4328	0.3997	0.4565
	$Chabahar$	0.4079	0.2888	0.5003
	$Khash$	0.5477	0.5701	0.5334
	$Dalgan$	0.7037	0.7705	0.6660
	$Zabol$	1	1	1
	$Zahedan$	0.4431	0.2917	0.5604
	$Zehak$	0.7823	1	0.4920
	$Saravan$	0.3464	0.2629	0.4124
	$Sarbaz$	0.6240	0.1802	1
	$SibandSuran$	0.4303	0.2609	0.5739
	$Fanuj$	1	1	1
	$Qasr-eQand$	0.5638	0.3939	0.7197
	$Konarak$	0.7642	0.5284	1
	$Mehrestan$	0.5118	0.3351	0.6544
	$Mirjaveh$	0.7703	0.6129	0.9027
	$NikShahr$	0.5907	0.158739	0.9635
	$Nimruz$	0.7647	0.7878	0.7231
	$Hamun$	0.9026	0.906	0.8960
	$Hirmand$	0.8322	0.8347	0.8287
2017	$Iranshahr$	0.5532	0.4809	0.6032
	$Chabahar$	0.4514	0.2263	0.6367
	$Khash$	0.7236	0.6863	0.7460
	$Dalgan$	1	1	1
	$Zabol$	1	1	1
	$Zahedan$	0.5087	0.3004	0.6720
	$Zehak$	0.7952	0.9266	0.5908
	$Saravan$	0.4431	0.3610	0.5041
	$Sarbaz$	0.4003	0.2092	0.5595
	$SibandSuran$	0.4403	0.2412	0.6021
	$Fanuj$	1	1	1
	$Qasr-eQand$	0.5693	0.3528	0.7632
	$Konarak$	0.7446	0.4909	0.9159
	$Mehrestan$	0.5546	0.3925	0.6720
	$Mirjaveh$	0.8163	0.7367	0.8727
	$NikShahr$	0.3208	0.2442	0.5633
	$Nimruz$	0.8098	0.9409	0.6259
	$Hamun$	0.9093	1	0.7874
	$Hirmand$	1	1	1

Table 3: Results of Sustainability Assessment of Agricultural Practices in Sistan and Baluchestan Province with Weight Restrictions

$Year$	$County$	$OverallSustainability$ $Efficiency$ $model(15)$	$Efficiencyof$ $EnvironmentalStage$ $model(16)$	$Efficiencyof$ $EconomicStage$ $model(17)$
2013	$Iranshahr$	0.4788	0.3286	0.5919
	$Chabahar$	0.2968	0.1750	0.4004
	$Khash$	0.4253	0.4976	0.3771
	$Dalgan$	0.6037	0.7214	0.5354
	$Zabol$	1	1	1
	$Zahedan$	0.3979	0.2785	0.4998
	$Zehak$	0.5445	0.5419	0.5464
	$Saravan$	0.3186	0.2708	0.3589
	$Sarbaz$	0.2286	0.1599	0.2877
	$SibandSuran$	0.4224	0.3151	0.5182
	$Fanuj$	0.7555	0.4920	1
	$Qasr-eQand$	0.5591	0.3482	0.7555
	$Konarak$	0.7167	0.3921	0.9815
	$Mehrestan$	0.5050	0.3909	0.6036
	$Mirjaveh$	0.8739	0.7479	1
	$NikShahr$	0.2659	0.1830	0.3439
	$Nimruz$	0.6558	0.6193	0.6834
	$Hamun$	0.8717	0.9552	0.8179
	$Hirmand$	0.7849	0.6275	0.8912
2014	$Iranshahr$	0.4982	0.4884	0.5048
	$Chabahar$	3856	0.3614	0.4033
	$Khash$	4786	0.5960	0.4050
	$Dalgan$	0.6553	0.8111	0.5692
	$Zabol$	1	1	1
	$Zahedan$	0.4021	0.2569	0.5177
	$Zehak$	0.6148	0.6594	0.5880
	$Saravan$	0.3386	0.2918	0.3748
	$Sarbaz$	0.2473	0.1810	0.3035
	$SibandSuran$	0.422	0.3267	0.5066
	$Fanuj$	0.7586	0.492	1
	$Qasr-eQand$	0.5688	0.3967	0.7233
	$Konarak$	0.8144	0.5304	1
	$Mehrestan$	0.4985	0.3875	0.5953
	$Mirjaveh$	0.8589	0.6978	1
	$NikShahr$	0.2579	0.1794	0.3322
	$Nimruz$	0.6731	0.6183	0.7075
	$Hamun$	0.8562	0.8556	0.8567
	$Hirmand$	0.7317	0.7531	0.7195
2015	$Iranshahr$	0.4535	0.4166	0.4795
	$Chabahar$	0.4117	0.319	0.4819
	$Khash$	0.5314	0.5942	0.492
	$Dalgan$	0.8956	0.7761	0.9633
	$Zabol$	1	1	1
	$Zahedan$	0.4068	0.2962	0.5014
	$Zehak$	0.592	0.6132	0.5776
	$Saravan$	0.3428	0.2715	0.4036
	$Sarbaz$	0.2646	0.1672	0.348
	$SibandSuran$	0.4393	0.35	0.5199
	$Fanuj$	0.7554	0.5457	0.9501
	$Qasr-eQand$	0.5712	0.4406	0.69
	$Konarak$	0.7916	0.5398	1
	$Mehrestan$	0.5086	0.4027	0.6038
	$Mirjaveh$	0.8497	0.7255	0.9486
	$NikShahr$	0.289	0.207	0.3665
	$Nimruz$	0.6601	0.6413	0.675
	$Hamun$	0.8594	1	0.7645
	$Hirmand$	0.7015	0.7036	0.7001

Continuation of the table 3

Year	County	OverallSustainability Efficiency model(15)	Efficiencyof EnvironmentalStage model(16)	Efficiencyof EconomicStage model(17)
2016	Iranshahr	0.4312	0.3997	0.4538
	Chabahar	0.3993	0.2888	0.4851
	Khash	0.5321	0.5701	0.5079
	Dalgan	0.6923	0.7704	0.6483
	Zabol	1	1	1
	Zahedan	0.4396	0.296	0.5533
	Zehak	0.5908	0.5649	0.6074
	Saravan	0.3442	0.2629	0.4086
	Sarbaz	0.624	0.1802	1
	SibandSuran	0.4237	0.2421	0.5741
	Fanuj	0.7552	0.492	1
	Qasr − eQand	0.5638	0.3939	0.7197
	Konarak	0.7642	0.5284	1
	Mehrestan	0.5058	0.3129	0.6565
	Mirjaveh	0.7703	0.6128	0.9021
	NikShahr	0.5109	0.1587	0.8148
	Nimruz	0.6376	0.5326	0.7255
	Hamun	0.8501	0.7892	0.896
	Hirmand	0.6724	0.5479	0.7528
2017	Iranshahr	0.513	0.4443	0.5605
	Chabahar	0.412	0.2047	0.5844
	Khash	0.6439	0.6259	0.6549
	Dalgan	0.9651	1	0.9467
	Zabol	1	1	1
	Zahedan	0.4455	0.3284	0.5399
	Zehak	0.5701	0.5773	0.5653
	Saravan	0.3901	0.3559	0.4168
	Sarbaz	0.3385	0.209	0.4506
	SibandSuran	0.4301	0.314	0.5319
	Fanuj	0.7677	0.511	0.984
	Qasr − eQand	0.5692	0.3535	0.7638
	Konarak	0.6874	0.5247	0.8046
	Mehrestan	0.5372	0.4302	0.6192
	Mirjaveh	0.7909	0.7366	0.8295
	NikShahr	0.2701	0.1729	0.3612
	Nimruz	0.6784	0.7306	0.6439
	Hamun	0.8679	1	0.7874
	Hirmand	0.8758	0.6818	1

Table 4: Maximum Required Human Resources

County	Maximum Required Human Resources without Weight Restrictions					Maximum Required Human Resources with Weight Restrictions				
	2013	2014	2015	2016	2017	2013	2014	2015	2016	2017
Iranshahr	0.5	1	0.5	0.5	0.88	0.5	1	0.5	0.5	0.93
Chabahar	0.43	1	0.5	0.5	0.84	0.56	1	0.5	0.5	0.5
Khash	0.50	1	0.91	0.5	0.87	1	1	0.5	0.5	0.5
Dalgan	0.5	0.56	0.5	0.5	0.84	0.5	0.5	0.5	0.5	0.5
Zabol	1	1	1	1	1	1	1	1	1	1
Zahedan	0.5	0.5	0.50	0.5	0.63	0.5	0.5	0.59	0.5	0.83
Zehak	0.5	1	1	0.5	0.50	0.5	0.5	0.5	0.5	0.92
Saravan	0.5	0.58	0.5	0.5	0.82	0.5	0.5	0.5	0.5	0.95
Sarbaz	0.49	1	0.5	0.5	0.87	0.81	1	0.5	0.5	0.89
SibandSuran	0.5	0.5	0.58	0.5	0.72	0.5	0.5	0.61	0.5	0.69
Fanuj	1	1	1	1	1	0.5	0.5	0.6	0.5	0.54
$Qasr - eQand$	0.5	0.5	0.58	0.5	0.68	0.5	0.5	0.63	0.5	0.54
Konarak	0.5	0.5	0.5	0.5	0.59	0.5	0.5	0.5	0.5	0.74
Mehrestan	0.5	0.5	0.58	0.5	0.84	0.5	0.5	0.61	0.5	0.89
Mirjaveh	0.5	0.5	0.5	0.5	0.71	0.5	0.5	0.5	0.5	0.84
NikShahr	0.5	0.5	0.5	0.5	0.50	0.5	0.5	0.5	0.5	0.86
Nimruz	0.5	0.5	0.62	0.5	0.53	0.5	0.5	0.64	0.5	0.84
Hamun	0.5	0.5	0.67	0.5	0.84	0.5	0.5	0.66	0.5	0.54
Hirmand	0.5	0.5	0.5	0.5	0.84	0.5	0.5	0.5	0.5	0.5

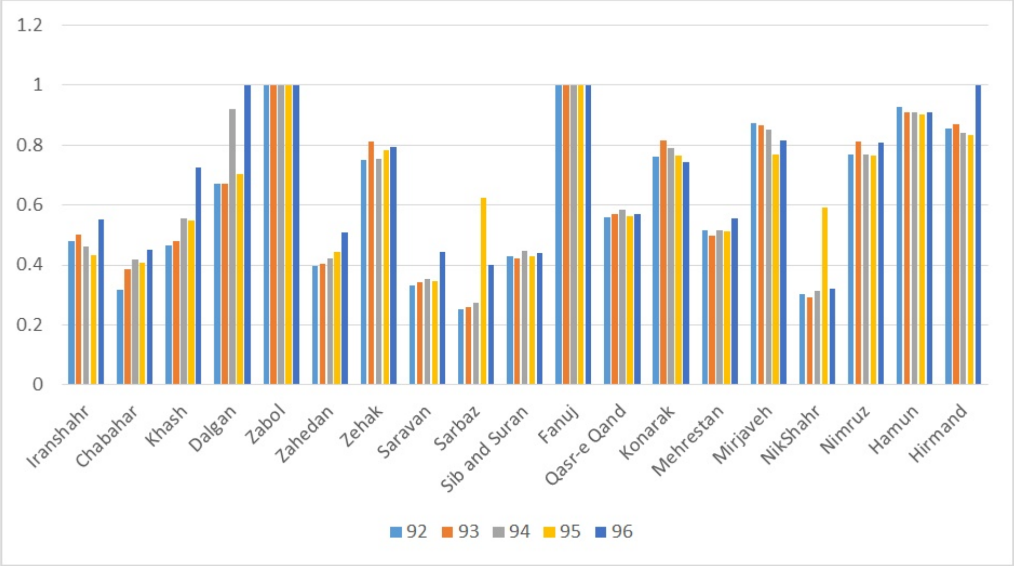

Figure 4: Overall Sustainability Efficiency without Weight Restrictions

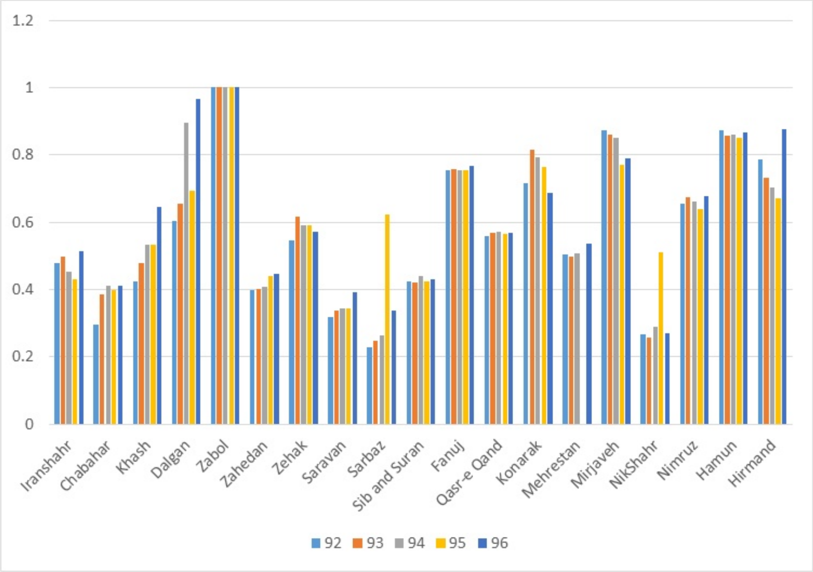

Figure 5: Overall Sustainability Efficiency with Weight Restrictions

4.1 Discussion of Results

The results of the sustainability assessment of agricultural practices in Sistan and Baluchestan Province without and with weight restrictions are presented in Tables (2) and (3), respectively. According to Table (2), Zabol and Fanuj have created the greatest cultivated areas by optimally using water and human resources. Therefore, they have reached the sustainabilitythreshold in the environmental stage. Moreover, these counties have succeeded in increasing production volume per cultivated area by optimally using agricultural inputs such as fertilizers and pesticides, and hence increasing the revenues of farmers. Therefore, they have succeeded in achieving the sustainability efficiency of agricultural practices for the economic stage so far. And generally it can be concluded that these counties have almost developed sustainable agricultural practices. In 2017, Dalgan and Hirmand Counties performed similar to Zabol and FanujCounties. Hamun County ranks the second insustainable agricultural development among all the counties during the given years except for 2015. In 2015, Dalgan County ranked the second in this respect.

During 2013, 2014, and 2015, Sarbaz County had the poorest sustainability performance. In 2016 and 2017, Saravan and NikShahr Counties had the poorest sustainability performance. Other counties have not succeeded in becoming sustainable because of the lack of sustainability for both stages at the same time.

According to Table (3), Zabol County is the only county which has increased production volume per cultivated area by using water resources optimally and improving irrigation methods. This has led to an increase in the revenues of the farmers in this county. In the first environmental stage, this county created the best output, cultivated area, by using the inputs water and human resources. That is, Zabol achieved the sustainability efficiency in the first stage with respect to the two environmental and social indicators. Similarly, the second stage created the best economic outputs, given the cultivated area created in the first stage and human resources shared between the two stages. Again the sustainability efficiency was achieved in the second stage with respect to the two environmental and social indicators. Therefore, it can be concluded that Zabol has reached the sustainability efficiency thresholdin both environmental and economic stages. However, other counties have failed to achieve sustainability efficiency because of inefficiency of either of the two stages.

Mirjaveh County achieved sustainability efficiency in the economic stage in 2013 and 2014 but lacked the overall efficiency because of inefficiency of the environmental stage. Fanuj had a similar performance in 2013, 2014, and 2016, Konark did so in 2014, 2015, and 2016, Sarbaz did so in 2016, and Hirmand did so in 2017. Hamun achieved sustainability efficiency in the environmental stage in 2015 and 2017 and was inefficient in the economic stage. Therefore, it lacked overall efficiency. This inefficiency should be dealt with by the authorities and farmers.

Other counties did not achieve sustainability efficiency in either of the two stages. Therefore, this inefficiency should be dealt with by the authorities and farmers. Moreover, according to Table (2), the best performance was from Zabol and Fanuj in all years. Hamun achieved the second rank in all years except for 2015. However, according to Table (3), the best performance in all years was from Zabol. The sustainability efficiency of Fanuj was reduced in 2013, leading to its fourth rank, and it achieved the $5th$ and $6th$ ranks in all other years. The second rank was achieved by Hamun in 2013, 2014 and 2016 and in 2015 and 2017, the second rank was achieved by Dalgan. According to Tables (2) and (3), the performance of Hamun underwent less changes than that of Fanuj. Therefore, it can be concluded that Hamun outperformed Fanuj. According to these tables, the worst situation was related to Sarbaz in 2013, 2014 and 2015 and also to Saravan and NikShahr in 2016 and 2017. Therefore, it can be concluded that the results in Table (3) are more accurate than those in Table (2).

Figures (4) and (5) illustrate the overall sustainability efficiency of the counties of Sistan and Baluchestan Province in the two environmental and economic stages. According to these figures, the overall efficiency, sustainability threshold, is represented by 1, and there are 4 efficiency areas as follows: The first efficiency area is between 0.8 and 1, the second efficiency area is between 0.6 and 0.8, the third efficiency area is between 0.4 and 0.6, and the fourth efficiency area is between 0.2 and 0.4. Therefore, according to these efficiency areas presented in Figures (4) and (5), the following results are presented: According to Figure (4), Zabol and Fanuj had constant overall sustainability efficiency, reaching the sustainability threshold. But according to Figure (5), this only true for Zabol. According to these figures, Hamun, Qasr-e Qand, Mehrestan, and Sib and Suran Counties had upward and downward sustainability efficiency curves in some of the given years. According to Figure (5), this is also true for Fanuj, which is placed in the second sustainability efficiency area. According to both figures, Hamun is placed in the first sustainability efficiency area, and Qasr-e Qand, Sib and Suran, and Mehrestan are placed in the third sustainability efficiency area. The overall efficiency of Qasr-e Qand is said to be better than Mehrestan, and that of Mehrestan is better than that of Sib and Suran.

Khash, Zahedan, Saravan, and Chabahar had a slight downward curve in some years but the general tendency was an upward curve. According to both figures, Khash was placed in the third sustainability efficiency area from 2013 till 2016, and in 2017 it reached the second sustainability efficiency area. Zahedan was placed in the third sustainability efficiency area, and Chabahar was placed in the fourth sustainability efficiency area in 2013 and 2014, reaching the third sustainability efficiency area in 2014 and 2017. According to Figure(4), Saravan was placed in the fourth sustainability efficiency area from 2013 till 2016, reaching the third sustainability efficiency area in 2017. In contrast, according to Figure (5), it was placed in the fourth sustainability efficiency area in all years.

In the case of Iranshahr and Nimruz, according to Figures (4) and (5), they had an upward curve from 2013 till 2014, and after a decreasing trend for two consecutive years, they had an upward curve in 2017. In Figure (5), Zehak had a similar performance to these two counties but it had alternating upward and downward curves every year, as indicated by Figure (4). Iranshahr, according to Figures (4) and (5), was placed in the third sustainability efficiency area. And Nimruz, according to Figure (4), was placed in the first and second sustainability efficiency area in 2014 and in other years, respectively. In contrast, according to Figure (5), it was placed in the second sustainability efficiency area in all years. According to Figure (4), Zehak was placed in the first and second sustainability efficiency areas in 2013 and in all other years,respectively. According to Figure (5), it was placed in the third and second sustainability efficiency areas in 2013 and in all other years, respectively.

According to Figures (4) and (5), Mirjaveh had a slight upward curve in all years except for 2017, which had a downward curve. According to Figure (4), it was placed in the second and first sustainability efficiency areas in 2016 and in all other years, respectively. According to Figure (5), it was placed in the second and third sustainability efficiency areas in $2013-2015$ and in 2016 and 2017, respectively.

Konarak had a generally upward curve from 2013 to 2014 and a generally downward curve afterward. And according to Figures (4) and (5), it was placed in the first and second sustainability efficiency areas in 2014 and in all other years, respectively.

NikShahrhad a downward curve from 2013 to 2014 and after an upward curve for two years it had a downward curve again in 2017. According to Figures (4) and (5), it was placed in the third and fourth sustainability efficiency areas in 2016 and in all other years, respectively.

Sarbaz had an upward curve from 2013 till 2016 and a downward curve in 2017. According to Figure (4), it was placed in the second, third, and fourth sustainability efficiency areas in 2016, 2017, and in all other years, respectively. According to Figure (5), it was placed in the second and fourth sustainability efficiency areas in 2016 and in all other years, respectively.

According to Figure (4), Dalgan had alternating downward and upward curves every year. However, according to Figure (5), it had anupward curve from 2013 till 2015, a downward curve from 2015 till 2016, and a downward curve from 2016 till 2017. According to Figures (4) and (5), it was placed in the second sustainability efficiency area in 2013, 2014 and 2016 and in the first sustainability efficiency area in 2015 and 2017.

According to Figure (4), Hirmand had an upward curve from 2013 till 2014, and after a downward curve for two years, it had an upward curve again in 2017. According to Figure (5), it had a downward curve from 2013 till 2016 and an upward curve in 2017. According to Figure (4), it was placed in the first sustainability efficiency area, and 2017 it reached the sustainability threshold. And according to Figure (5), it was placed in the second and first sustainability efficiency areas in $2013-2016$ and in 2017, respectively.

Moreover, according to Table (4), the maximum number of required human resources is calculated. For example, in the case of Iranshahr County, the maximum number of required human resources in the first stage for 2013 is calculated as follows: $(0.50 \times 112851) = 56425.5$. Therefore, it can be concluded that the first stage even needs less than 56425.5 human resources. Any number of human resources beyond that is unnecessary and surplus. Similarly, the maximum number of required human resources in the second stage is calculated as follows: $(1-0.50) \times 112851 = 56425.5$. For 2014 this would be equal to $(1 \times 112851) = 112851$. This indicates that the first stage even needs less than this number of human resources. The results of other counties in the given years are similar to those of Iranshahr.

5 Conclusion and Suggestions

This study proposed a network DEA model, consisting of the two environmental and economic stages, for assessing the sustainability level of agricultural practices in Sistan and Baluchestan Province. In the first environmental stage, water and human resources were regarded as the inputs, and cultivated area was regarded as the output. In the second economic stage, human resources and cultivated area were regarded as the inputs, and revenues and production volume were regarded as the outputs. For assessing the sustainability level of agricultural practices of each county in Sistan and Baluchestan Province, network DEA models were proposed without and with weight restrictions. They were used to determine the overall sustainability efficiency and the stagewise sustainability efficiency of each county in 2013 till 2017. For reaching the sustainability efficiency threshold, each county needed toreach the sustainability efficiency threshold in both stages at the same time. If any county does so, its sustainable agricultural practices can be developed with respect to the dimensions of sustainable development in the future. If a county fails to achieve sustainability efficiency in the first stage, the farmers should receive training by the respective authorities in new irrigation methods, the substitution of agricultural products needing less water for those needing more water to increase production volume per cultivated area, and high density planting to reach sustainability efficiency threshold. In the case of inefficiency in the second economic stage, the respective authorities should adopt some measures such as financial support for farmers, guaranteed purchase of agricultural products, establishment of cooperatives, and encouragement of farmers to cultivate those products with less adverse harmful effects on the environment and higher yields to be able to reach sustainability efficiency threshold. Therefore, the results of this study can be beneficial to future sustainable agricultural development in Sistan and Baluchestan Province. Moreover, some models were proposed for optimal use of human resources in each stage. Regarding these models, the maximum required human resources were determined. Since the data of 5 years of agricultural practices in the province is available, which is used in this paper, the future studies can be conducted on the sustainability of agricultural practices based on imprecise stochastic, interval, and fuzzy data.

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Azizallah Kord
Ph.D Student of Mathematics
Department of Mathematics
Kerman Branch, Islamic Azad University

Kerman, Iran
E-mail: kordaziz@yahoo.com

Ali Payan
Associate Professor of Mathematics
Department of Mathematics
Zahedan Branch, Islamic Azad University
Zahedan, Iran
E-mail: apayan_srb@yahoo.com

Sabar Saati
Associate Professor of Mathematics
Department of Mathematics
North Tehran Branch, Islamic Azad University
Tehran, Iran
E-mail: ssatim@yahoo.com