Sigma J Eng Nat Sci, Vol. 41, No. 3, pp. 503−511, June, 2023

Sigma Journal of Engineering and Natural Sciences
Web page info: https://sigma.yildiz.edu.tr
DOI: 10.14744/sigma.2023.00057

Research Article

The linear programming model for predicting the level of labour employment after dam failure by using dummy variable technique

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ARTICLE INFO

Article history
Received: 28 February 2021
Revised: 14 June 2021
Accepted: 18 October 2021

Keywords:
Dam Failure; Dummy Variable; Linear Programming; Sustainable Development; Agricultural Employment

ABSTRACT

One of the most important indirect economic consequences of dam failure (DF) is decrease the employment of agricultural sector (EOAS) downstream of the dam, its accurate estimation is difficult due to multi-layer effects of (DF). The main purpose of this study is to predict rate of employment by considering qualitative and quantitative impacts of DF by using dummy variable (DV) regression models technique in estimating income functions (IF) and production of crops functions (PFs) in the AS and using the functions in linear programming model (LPM) for optimal allocation of labour. The results of model showed that with 36% decrease in accessible water resource after DF, proportionate with the decreasing trend, the level of labour employment has decreased about 23% in downstream area of the dam. The results of this research have good conformity with former findings such as simulation method for failure embankment which is equal to 25%. So, combination of LPM with DV regression for predicting unemployment rate originated from DF and managing social and economic crisis in line with sustainable development is a realistic and accurate method.

Cite this article as: Torabi HA, Najarchi M, Mazaheri H, Jafarinia R, Izadikhah M. The linear programming model for predicting the level of labour employment after dam failure by using dummy variable technique. Sigma J Eng Nat Sci 2023;41(3):503−511.

INTRODUCTION

The most important social indexes of sustainable development include employment, unemployment rate and rate of change in unemployment showing quality and welfare rate, evolution and community excellence which is underlined in the eighteen chapter of agenda 21 of UNDP related to water program for sustainable production of food and rural sustainable development [1]. In sustainable

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This paper was recommended for publication in revised form by Regional Editor Hijaz Ahmad

agriculture, exploitation of available facilities for reaching the pre-determined goals with maximum efficiency in economic, social and ecological indexes and emphasizing social and cultural structure of the studied region are considered [2]. The role of water resources like dams is important in economic fertility and social welfare so that all social and economic activities are mainly dependent on providing water and quality of water [3].

Destruction of dams and its floods not only lose the construction investment but also cause heavy and uncompensable losses to villages, cities, agriculture lands, industrial installations, roads and other construction plans in the shoal, which has great social, political, environmental and economic consequences [4].

Dam failures result in loss of human life and cause owner's loss and community loss the assets that will be affected by a dam failure require a brief description of the inundation area.

These assets can be combined into two groups, direct loss and indirect loss. The first group includes residential property, commercial and industrial property, public property, infrastructure and those assets that exist because of the project. The second group includes societal consequences and environmental damages. The direct loss upon failure can be estimated by a survey of the inundation area or using the census data [5]. Loss of life is a very important factor in Benefit-cost analysis approach based on the life quality index [6]. Benefit-cost factor as a tool for damage assessment of DF was described, in this method, the value of dam is equal to the total lost structural costs and flow of future interests, indirect loss of economic activities is equal to losing output of all economic and service sections because of un accessibility to the capital and labour after flood phenomenon and DF [7]. The improved and optimized framework of the Becher`s method was presented for determining the combined risk of DF in assessing new dams and available dams by Hall Kuchran [8].

According to American National Infrastructure Protection Plan (NIPP) report, the economic consequences of DF are divided into direct and indirect consequences. Direct economic consequences are those which are caused directly by DF flood. Losses of income or profit related to products and services resulting from the dam construction are also among the direct costs of DF, one of the most important indirect economic consequences of DF is that EOAS will be and as a result, agriculture incomes are decreased affected [9]. Some studies have been already done concerning the optimization of water sources allocation and optimal allocation of labour in AS, in normal conditions of dam operations, and also a calculation of economic losses amount caused by DF. Calculation of economic losses, related to the DF phenomenon, a consequent flood is very difficult and sometimes impossible due to its multi-layer effects, wide range and quality nature. Use of DV as a technique and approach, in measuring economic consequences of quality variables for calculation of income function (IF) and agriculture producing function (APF) in a water catchment basin is important and resolver, for the programming of politicians in different possible scenarios after assumptive DF.

A regression model in abnormal and normal periods include both quantity and quality variables. In this regression model, the dependent variable not only depends on the quantity variable but also depends on the quality variable as well. Fig 1 and fig 0 are attributed to wartime and peacetime periods respectively. The variables which are specified in this way, are called dummy, binary or qualitative variables. Some advantages of above mentioned methods are studying the importance of implicit value attributed to the lost life due to DF and estimating the loss of flood after DF based on the present value of future losses but estimating economic losses based on data-output table of economic sections due to the complexity of work without considering the environmental costs and social costs after DFare improvable points of previous studies. For solving the problem and considering qualitative and quantitative effects of DF, applying the technique of DV in estimating IF and PFs agricultural products with regression model and using the IF as objective function (OF) and PFs as subject to (St) in LPM have been innovative ideas and the study has some differences with previous similar studies [10].

For predicting loss of life (LOL) from severe flooding events, an expression for LOL in terms of warning time (WT), the size of the population at risk (PAR), and the forcefulness of the floodwaters (Force) is derived from the historical record of dam failures and flash flood cases via logistic regression use of DV in Testing for Equality between Sets of Coefficients in Linear Regressions, when WT is coded dichotomously e.g zero for WT < 1.5 hr and one for WT 1.5 hr [11].

The production function (PF) of Iran AS estimated by using DV from 1980 to 1988 (coincided with Iraq-Iran war), the results derived from the calculation of natural SW and GW efficiencies show that marginal efficiency and average natural SW and GW has been different and with meaningful function coefficients, in comparison with the time in which war conditions were not considered in the PF [12].

The price and family costs sensitivity to energy consumption estimated in the household sector of urban and rural areas, with DV regression attitude towards measuring energy and strain in India [13].

An optimization model is used for maximizing net income of land in exploiting a dam [14].

A separable LPM, considering a set of technical factors That may influence the profit of an irrigation project. The model presents an OF that maximizes the net income and specifies the range of water availability. It is assumed that yield functions in response to water applications are available for different crops and describe very well the water-yield relationships. The LPM was developed genetically, so that, the rational use of the available water resource could be included in an irrigation project, Specific equations were developed and applied in the irrigation project Senator Nilo Coelho, located in Petrolina-Brazil Based on the water-yield functions considered, cultivated land constraints, production costs and products prices [15]. The optimization model algorithm of water allocation to agriculture plants with limited water amount is popularized to a single purpose reservoir, in this way, they codified the optimization standard of water dropping for a single purpose reservoir [16]. There is not a meaningful difference between the genetic algorithm model as a new model and LPM in water sources management and presentation of results for a specific subject [17]. At Florida university of America studied the LPM for optimization of water supply for irrigation of Bangladesh agricultural areas. He used the National Sample Survey Organization (NSSO) data of 2009-2010 and defined DV in the regression equation, which was 0 for villages and 1 for cities [18]. The main purpose of this research is to allocate EOAS by using the IF and PFs were estimated by using a DV technique in regression of econometric model and EViews8 software and maximizing the IF as objective function and considering PFs and other effective factors as subject to (St) model with LINGO14 software.

MATERIALS AND METHOD

The location and specifications of the water basin and Mamloo Dam, Varamin water basin, which is one of the Iranian agricultural areas, has an area of 1250 square kilometers (Km²). As Varamin is near Tehran .Longitude: 52° - 42, from the beginning of the cone of Jajrood river. Latitude: 35° - 28, from the beginning of the cone of the Jajrood river Altitude from sea level: about 1100 meters(M). The plain height in the border with the salt desert: about 950 M. The average length: equal to 45 kilometers (Km).

Data Resources

Statistic reports of 1990 to 2016 including water cultivation area, capital, labor, natural SW and GW consumption of the AS area, amount of crops production and income (in Rials) classified by the ministry of Agriculture and the ministry of Power are as follows:

1. Extraction and collection of data related to water needed for crops irrigation, divided by each crop, for every months.
2. Extraction and collection of accessible amounts of natural SW and GW in the area.
3. Calculation of the information related to the allocated water from Mamloo dam in order for agricultural, municipal and industrial uses from 2010 to 2016.
4. Estimation and determination of the best fitting of the income function and the PF of 7 different crops which are considered as the holders of 98% of agricultural income of the area, with the help of econometrics, E views 8 software in before DF and after DF using DV.
5. Using LNGO 14 software in order To maximize the objective income function (OIF) with LPM, in two situations: normal operation of the dam and definition of different scenarios for acritical status of supposed DF
6. Comparison between model results and previous research methods.

Econometrics

This study explains the use of DV as a technique for the estimation of agriculture crops function and also income function of water basin AS after the DF with the help of econometric models and EViews8 software.

function form of Transcendental is one of the most widespread function forms, used in empirical estimation especially in the agriculture sector. Function form of Transcendental model is as follows:

$$Y_t = A \sum_{i=1}^{n} X_i^{\beta_i} e^{\Upsilon_i x_i} \tag{1}$$

In this function form, e is the Logarithm base with the function form of independent variables that have been added to Cob and Douglas function as the power, in which β_i, Υ_i are fixed and the mentioned function is changed to linear form through logarithm operation. Assumptions of normal classic regression models are truthful in the function and can be estimated by Ordinary Least Squares.

$$\text{Ln}\, Y_i = \beta_0 + \beta_1 \ln x_1 + \beta_2 \ln x_2 + \cdots + \beta_i \ln x_i + \Upsilon_1 X_1 + \cdots + \Upsilon X_i + \varepsilon_t \tag{2}$$

Explanatory independent variables including: X_1= groundwaters, X_2= surface waters are in terms of M.C.M, X_3= labour is in terms of 1000 people/hectare , X_4= capital is in terms of Milliard Rials; X_5= cultivation area is in

Table 1. Specifications and Storage Capacity of Mamloo Dam,Tehran, IRAN

Type:	Clay or earth core	Basin(area)KM²:	1750
Crest length (M):	807	Average input in long term annually (M.C.M):	268
Level of crest from the sea level (MM):	1308	normal Water level (M):	1303
The core embankment volume (M.C.M):	1.05	Normal level in the reservoir (M):	250
Total volume of the dam body(M.C.M):	7.34	Minimum water level in reservoir (M):	1257
Fundament height (M):	90	Normal level in the surface reservoir (KM²):	7.76

terms of hectare, and Y_i= the dependent variable is in terms of Milliard Rials (or kg).

The crops PF and income function (IF) of the area in normal conditions of dam operations are estimated as follows:

$$\text{Ln } Y_i = \beta_0 + \beta_1 \ln x_1 + \beta_2 \ln x_2 + \cdots + \beta_5 \ln x_5 + Y_1X_1 + \cdots + Y_5X_5 \quad (3)$$

For the DF condition , the following function was considered in order to determine the function of crops and IF.

$$\text{Ln } Y_i = \beta_0 + \beta_1 \ln x_1 + \beta_2 \ln x_2 + \cdots + \beta_5 \ln x_5 + Y_1X_1 + \cdots + Y_5X_5 + D_t \quad (4)$$

In which D_t is a DV and is equal to one ($D_t = 1$) at the time of DF, otherwise, it is equal to zero ($D_t = 0$).

Linear Programming Model

The structure of the programming is as follows:

objective function Provisions formation using a series of equations or non-equations Considering non-negative provision If X1, X2,…Xn are deciding variables, the intended standard which is called as OF,is defined as belows [6]:

$$F(X)=C^T . X = C_1X_1 + C_2X_2 \ldots\ldots + C_nX_n \quad (5)$$

In which $C^1, C^2, \ldots C^n$ are real numbers and C^T is the transposed vector of C. In LPM, all decision variables are a non-negative and standard form of each LPM problem which can be as belows :

$$\text{MAX } Z=C_1X_1 + C_2X_2 + \cdots + C_nX_n \quad (6)$$

Subject to:

$$\begin{gathered} a_{11}X_1 + a_{12}X_{2+\cdots+a\_1n\ X\_n \leq b\_1} \\ a_{21}X_1 + a_{22}X_2 + \cdots + a_{2n}X_n \leq b_2 \\ a_{m1}X_1 + a_{m12}X_2 + \cdots + a_{mn}X_n \leq b_m \end{gathered} \quad (7)$$

$$X1, x2\ldots.Xn \geq 0 \quad (8)$$

In these relations:

Z: objective function

C: n vector, which is a dimension of OF coefficients

X : n vector, a dimension of decision-making variables

B: m vector, a dimension of right side coefficients , showing accessible sources.

RESUTLS AND DISCUSSION

Estimation of the Income Function (If) of As Before DF Status

The best fitness of the Transcendental area of IF before the DF by using Eviews 8 software was estimated to create relations between inputs and outputs [10].

LNY = 3.38332 - 0.5354637*LNX1 - 0.2533126*LNX2 + 0.0813253*LNX3 + 1.2742051*LNX4 - 0.000176446*X4 (9)

Estimation of Income Function of As After DF Status

The best fitness of the transcendental area IF for after DF status by using Eviews 8 software was estimated to create relations between inputs and outputs by using the DV approach [10].

LNY = 1.167627 + 0.230648*Dt + 5.130783e-06*X3 - 0.00028585*X4 - 0.22473809*LNX1 + 1.117063*LNX4 (10)

Estimation of Production of Crops Functionsof As Before and After DF Status

According to the mentioned methodology articles, transcendental function before and after the DF for each crop is estimated separately which are 14 functions in total (table 2and table3), and are used as limiting functions in LPM in LINGO software.

The results of classic assumptions investigation including multicollinearity and heteroskedastic and also normality of residuals sentences did not affect the estimated models of income and crops functions.

The results of the t-Statistic investigation showed that all the estimated coefficients for all income functions, production of crops functions (PFs) in the AS, both normal and abnormal operations (supposing dam failure and using DV in functions) by OLS method are meaningful.

Table 2. Estimation of production of crops functions (PFs) of AS before DF status

9.676- 0.115*lnx1 - 0.1989*lnx3 + 0.2914*lnx4 + 0.000131601*lnx5 - 0.003561*X2 + 0.0008754*X3 - 0.002428*X4 =Z1
5.8- 0.009581*X1 + 0.34018*lnx1 - 0.0008*X4 + 0.2584*lnx4 + 0.00012352*X5- 0.96*lnx2 + 0.0109*lnx3 =Z2
8.118 + 0.1949*lnx1 - 0.187*lnx2 - 0.3897*lnx4+ 5.42*lnx5- 0.0198*X1 + 0.001626*X2 + 0.0018*X4 - 0.0012199*X5 + 0.0001189*X3 =Z3
51.01145 + 0.00454376*X2 - 0.0036576*X4 + 0.0038979*X5 - 0.0448648*lnx2 + 0.181099*lnx4 - 8.99075*lnx5=z4
21.899803+ 0.026025488*X1 - 0.0386051*X2 - 1.0104088*lnx1 - .0030240*X4 + 0.4353135*lnx4=Z5
6.6 - 0.088708*lnx3- 0.03179*lnx4 + 0.254622*lnx5+ 0.001049*X1+ 0.000718*X3 + 0.0010459*X2 =Z6
7.529- 0.187*lnx1 + 0.0562*lnx2+ 0.5817*lnx3 + 0.42*X1 - 0.0009479*X3 =Z7

Table 3. Estimation of the production of crops functions (PFs) of AS after DF status

47.081-0.510851*lnx1- 0.2079*lnx3 + 1.916*lnx4 + 0.01405*X3 -0.0024*X4 + 0.000513*X5-5.915*lnx5 - 0.3131*DT=Z1
11.5354 - 0.259209*lnx1+ 0.118*lnx3 + 0.098011*lnx4 - 0.001925*X4 - 0.2910491*DT-0.00989*X2=Z2
5.18+ 0.108*lnx2 + 0.651*lnx4 - 0.0832*lnx3 + 0.009696*X1 + 0.0003501*X5 - 0.194*DT + 0.115551*lnx1 =Z3
7.168 + 0.109*lnx1 - 0.11273*lnx2 + 0.16514*lnx4 - 0.0083*X1 + 0.011020*X2 - 0.0036*X4 - 0.114874*DT =Z4
-102.898 + 0.8689*DT - 0.03837*X2 + 0.132*lnx2 + 8.7923*lnx5 + 0.17153*lnx3 + 0.017553*X4=Z5
6.366 - 0.31898*lnx1+ 0.4992*lnx5 - 0.051*DT + 0.0058*X1 + 0.0544*lnx2 +0.066*lnx4+0.000992*x4 + 0.001*X3=z6
0.112- 0.04694*DT + 0.019*lnx4 + 0.0292*lnx2 - 0.100989*X4 - 0.04867*lnx1+ 0.01*X1=Z7

The results of the F-statistic investigation revealed that all the regression models related to IFand PFs in the AS before and after the DF by OLS method are meaningful.

The results of the R Squre-statistic investigation showed that in the functions of income and crops production of the agriculture area before and after the DF (supposing dam failure) estimation by OLS method, dependent variable changes (any) by independent variables are described with a very high percentage (mostly more than 97%).

Durbin-Watson statistic, for recognizing Autocorrelation by OLS method of all estimated functions indicates the in Autocorrelation (if DW=2, non-Autocorrelation; if DW=0, complete positive Autocorrelation is available; if DW=4, means complete negative Autocorrelation), thus the raters are the best linear unbiased estimation (BLUE) and efficient.

Allocation of the Optimized Labour Before and After the Dam Failure

The results of LPM solution by LINGO 14 software for the dam normal operation and different scenarios in dam failure for the year 2016 (generable for all periods) are presented in Table 5 in order to the allocation of optimized SW, GW sources and labour with following assumptions:

LPM for The Allocation of Optimized Water Sources and Labour in As Before DF (in 2016)

MODEL:

MAX = 3.283323 - 0.53546*LNX1 - 0.25331*LNX2 + 0.08132*LNX3 + 1.2102051*LNX4 + 0*LNX5 + 0*X1 + 0*X2 + 0*X3 - 0.000176446*X4 + 0*X5 (11)

St:
1) Xi<= A_i;
2) Xi>=0;
3) $\text{Ln } Y_i = \beta_0 + \beta_1 \ln x_{1i} + \beta_2 \ln x_{2i} + \cdots + \beta_5 \ln x_{5i} + \Upsilon_1 X_{1i} + \cdots + \Upsilon_5 X_{5i}$; (12)
4) ZiN>= C_i
END.

LPM for the Allocation of Optimized Water Sources and Labour in As After DF (in 2016)

MODEL:

MAX = 1.1696 + 0.230648*DT + 0*x1+0*x2 + 5.130783e - 06*X3 - 0.00028585*X4+0*x5 - 0.20473809*LNX1 + 0*lnx2 + 0*lnx3 + 1.107063*LNX4 + 0*lnx5 (13)

St:
1) Xi<= A_i;
2) Xi>=0;
3) DT=1;
4) $\text{Ln } Y_i = \beta_0 + \beta_1 \ln x_{1i} + \beta_2 \ln x_{2i} + \cdots + \beta_5 \ln x_{5i} + \Upsilon_1 X_{1i} + \cdots + \Upsilon_5 X_{5i+Dt}$; (14)
5) ZiN>= C_i
END.

A_i is fixed ZiN is the amount of crops in normal status, respectively. Ln Yi is the crop production function of crop i. The function Results the allocation of the optimized SW and GW, before and after the dam failure.

Sensitivity analysis for five scenarios

Sensitivity analysis is provided for all scenarios, which is typically presented in Table 4 for scenario number No2 for the allocation of optimized water sources and labour in AS after DF in 2016.

Assuming DF in the best behaviour, by considering 1 to 5 scenarios in table 5 and figures 1 and 2, it is seen that after DF, the amount of available surface water is equal to 71-170 MCM but allocable SW in the best scenario (NO5) is maximum 89 MCM and in comparison with optimal allocation before DF, Which is equal to 139 MCM, Total amount of accessible water sources of AS in critical condition, decreases by 36% in average in comparison to before non-optimum DF behaviour.

Proportionate with the decreasing trend, the avrage rate of labours employment the AS of region reached from 1271 Man-Day,before DF to 1096 Man-Day which is equal to 13.7% decrease in downstream area of the dam. The decrease in rate of labours employment shows an increase in migration rate in AS and probability of social phenomenon occurrence of farmers migration from the region so sustainable development in AS faces with a problem.

This results are also in good accordance with the findings from failures in national city keystone with HAZUS-MH software and developed model C GS according to GS

Table 4. Sensitivity analysis for scenario No. 2:

sensitivity analysis for scenario No2			
Objective Coefficient Ranges			
	Current	Allowable	Allowable
Variable	Coefficient	Increase	Decrease
X1	0.000000	0.1409571E-01	0.4110400E-01
X2	0.000000	INFINITY	0.2907128E-01
X3	0.9130783E-05	0.1556304E-02	0.9130783E-05
X4	-0.2858500E-03	0.1419590	INFINITY
X5	0.000000	0.5248721E-03	INFINITY
LNX1	-0.5211281	0.4829914	2.361689
LNX2	0.000000	0.1197419	INFINITY
LNX3	0.000000	0.2222709	INFINITY
LNX4	1.237163	16.92599	1.018873
LNX5	0.000000	0.4558087E-02	6.661542
Z1	0.000000	0.1304267	0.3525541E-03
Z2	0.000000	INFINITY	2.941473
Z3	0.000000	INFINITY	1.499206
Z4	0.000000	6.547592	1.066824
Z5	0.000000	0.5184180E-03	INFINITY
Z6	0.000000	INFINITY	0.9130783E-02
Z7	0.000000	1.458926	INFINITY

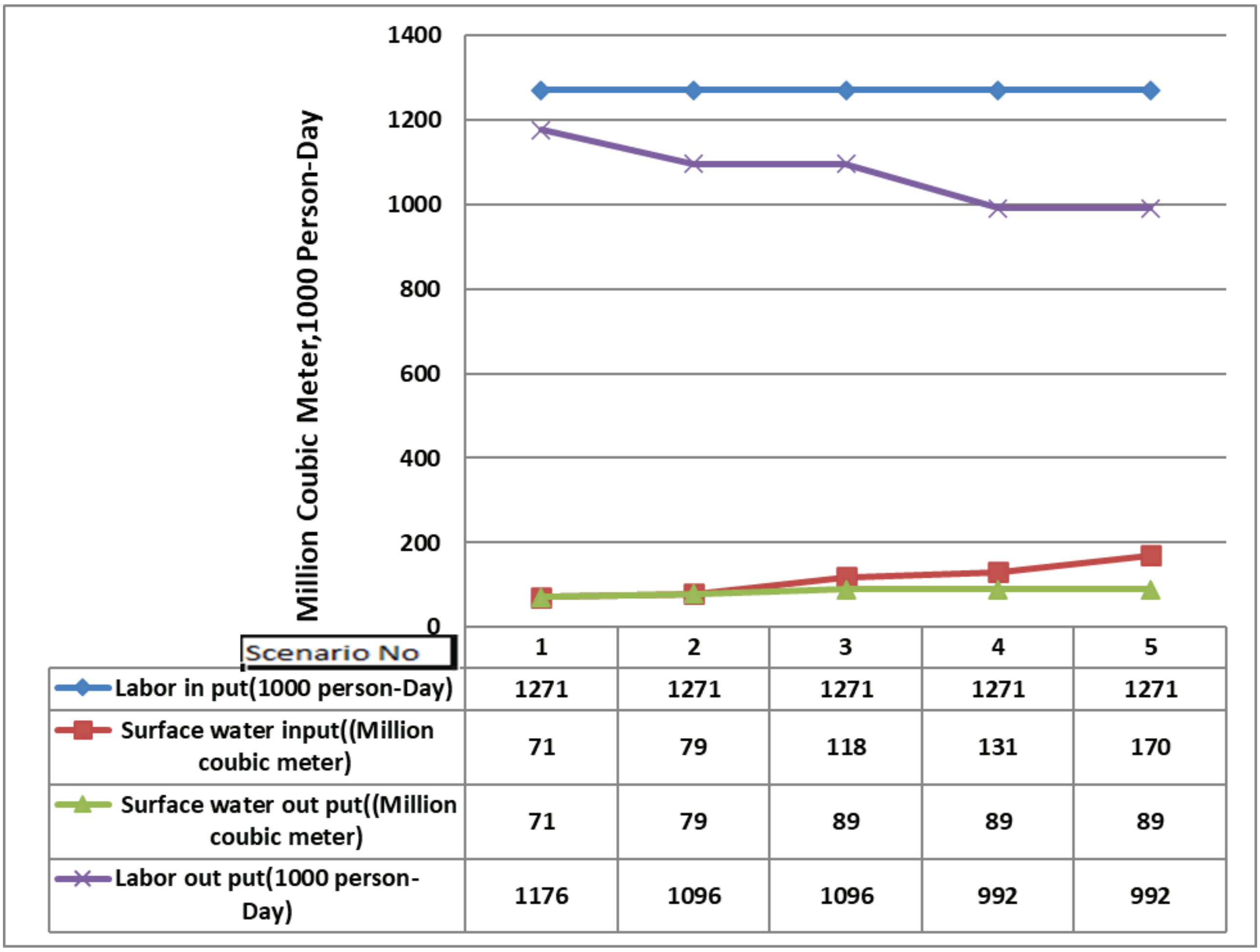

Figure 1. Exceedance curve of SW input, SW output, Labore input and output at the various scenarioes (2016).

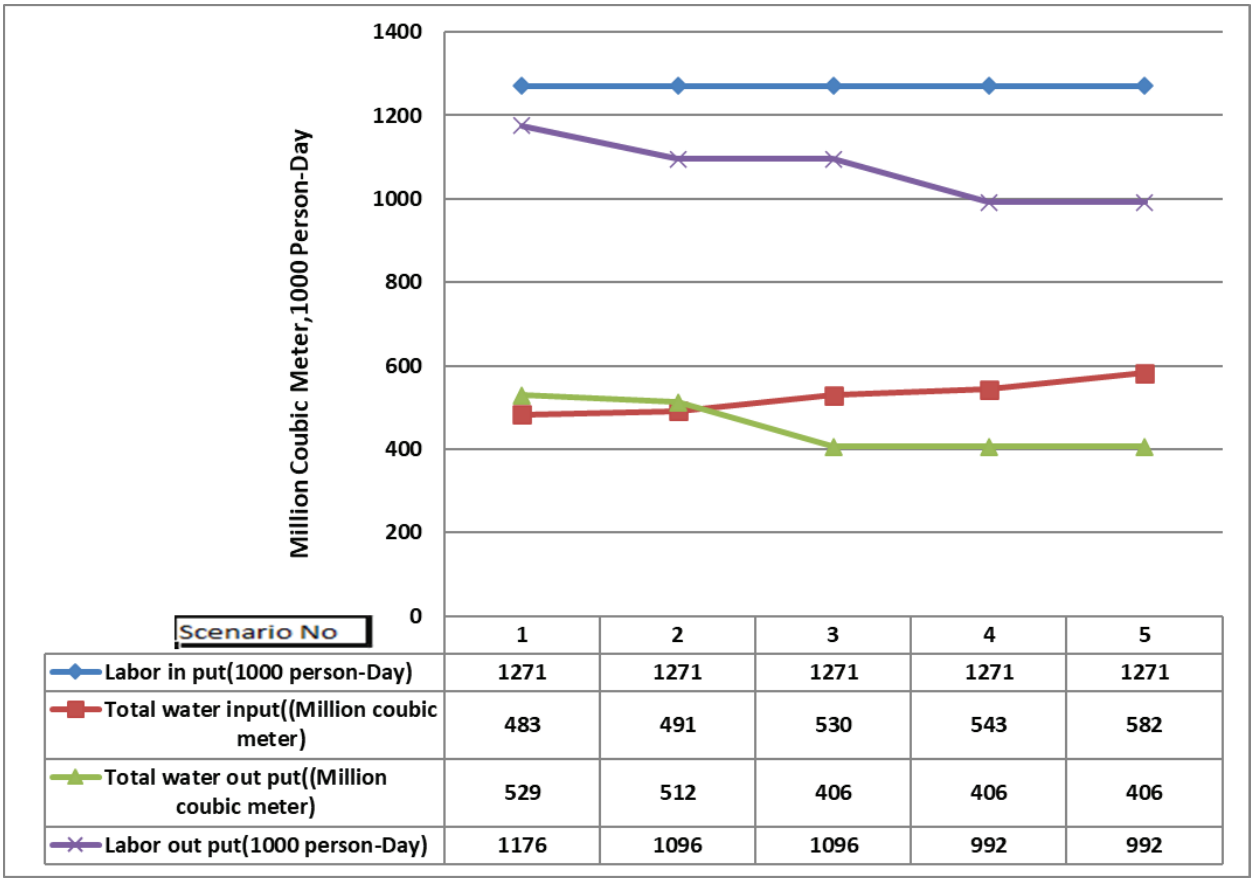

Figure 2. Exceedance curve of labore with total water input and output at the different snarioes of DF (2016).

Table 5. Comparing the allocation of the optimized SW, GW and labours of AS before and after DF (2016)

variable	Normal position		scenarioes for dam failure									
			scenarioe-1		scenarioe-2		scenarioe-3		scenarioe-4		scenarioe-5	
	input	out put	input	out put	input	out put	input	out put	input	out put	input	out put
GW	412	355	412	458	412	433	412	317	412	317	412	317
SW	210	180	71	71	79	79	118	89	131	89	170	89
Total Water	622	535	483	529	491	512	530	406	543	406	582	406
Labore	1271	1271	1271	1176	1271	1096	1271	1096	1271	992	1271	992
Income	3011	4064		2275		2440		2592		2592		2592
Remark			$x_2$input=0.25*262		$x_2$input=0.30*262		$x_2$input=0.45*262		$x_2$input=0.50*262		$x_2$input=0.65*262	
			X_1input equal of average long time and x_3 ,x_4, x_5 are constant and assume equal Normal position									

data for earth dam reservoir, which is equal to 25% [9] , and results of economic assessment as consequences of DF which were estimated by American Office of Internal Affairs for Improving technical, Safty and Security Services of Colorado States showing about 25% decrease in labour after DF as defined in table 6 below [19].

According to report by Katrina Jessoe, at extreme heat and dry weather conditions increases migration domestically from rural to urban areas and may decrease local

Table 6. Impact Types of DF is applied to each county

Impact Types	percentage
Labor Reduction	25
Capital Reduction	25
M&I Water Supply Reduction	15
M&I Water Supply Reduction	10
Tourist Visit Reduction	30

employment by up to 1.4% and may increase migration by 1.4% [20].

A report prepared by the International Labour Organization (ILO) for the G20 Climate Sustainability Working Group (CSWG) under the Argentine G20 Presidency in 2018 shows that the increasing frequency and intensity of various environment-related hazards) climate change(caused or exacerbated by human activity have already reduced labour productivity. Between 2000 and 2015, 23 million working-life years were lost annually at the global level as a result of such hazards. Among the members of the G20, China, Brazil and India were the most affected countries, with respectively 8.7, 3.2 and 1.5 working-life years lost per person per year during the period 2008–15. Projected temperature increases will make heat stress more common, reducing the total number of work-hours in the G20 countries by 1.9 per cent by 2030, with a greater effect on agricultural workers and on workers in emerging countries. Agricultural workers will be the worst affected, accounting for 66 per cent of the projected global hours lost owing to heat stress in 2030. This is a consequence of the physical nature of their work and the fact that it is undertaken outside, and also because a large number of workers are engaged in agriculture in the areas most likely to be affected by heat stress in the future [21].

This result also supports work by Luca Marchiori, who show that weather anomalies and climate changes have an important impact on the rates of migration in sub-Saharan Africa, they conclude that a minimum of about 5 million people have migrated between 1960 and 2000 due to anomalies in local weather in sub-Saharan Africa, this represents 0.3 per thousand individuals or 128,000 people every year [22].

Some other important results show that by considering figures 1 and 2 due to the lack of dam, potential resources of available SW in 2-5 scenarios are practically not usable in the AS so it causes a decrease level labour and it remains in a constant level and employment rate after DF is the only function of GW sources.

CONCLUSIONS

In this study, a chance constraint linear programming optimization was applied to use DV technique for the estimation of AS income function for five scenarios, predetermined in the possible amount of accessible SW. This optimization method is also used in order to estimate agriculture crops production function in downstream of the dam in the critical status of dam failure.The objective function of the model was set to maximize the income function of the AS region with the accessible SW, GW sources. It also optimizes labour of AS before and after the dam failure by using DV regression models. These models politicize the amount of agriculture crops and assume other production factors are fixed in order to the optimization water supply and labour of AS. An appropriate method for revealing optimized accessible SW,GWand labour in famine or after the dam failure is Applying mentioned technique in a LPM that maximizes the objective function with definition of different scenarios. Considering the proposed results in this study and the comparison between them and previous studies indicated that this technique describes the effects of qualitative and quantitative factors. Applying a DV technique in estimating IF of AS and PFs of products in the downstream of dam and maximizing the estimated IF with limitations such as PFs, policy-made values of agricultural products, available values of production inputs and describing different scenarios of access to the SWsources (after DF) through LPM for studying indirect economic consequences of DF, unemployment of labours in the AS downstream of the dam such as calculating employment rate of labours is a suitable approach.

AUTHORSHIP CONTRIBUTIONS

Authors equally contributed to this work.

DATA AVAILABILITY STATEMENT

The authors confirm that the data that supports the findings of this study are available within the article. Raw data that support the finding of this study are available from the corresponding author, upon reasonable request.

CONFLICT OF INTEREST

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

ETHICS

There are no ethical issues with the publication of this manuscript.

REFERENCES

[1] Bedrich M, Suzanne B. Sustainable indicator, UNDP; 1999.

[2] Akbari N, Ranjkash M. Investigating the productivity growth of all factors of production in Iran's agricultural sector. Agric Econ Develop 2004;44:117−142.

[3] Christer N, Catherine A, Reidy MD. Fragmentation and flow regulation of the World's large river systems. Science 2005;308:405−407. [CrossRef]

[4] U.S. Water Resources Council. Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies U.S. Government Printing Office, Washington DC, 20402, 1983.

[5] U.S.Water Resources Council. Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies, U.S. Government Printing Office, Washington, USA, 2012.

[6] Huai ZU, Jiang H, Zhi PW. Optimizationof reinforcement strategies for dangerous dams considering time-averaged system failure probability and benefit-cost ratio using a life quality index. Nat Hazards 2013;65:799–817. [CrossRef]
[7] Baecher G, Pate W, Neuville R. Risk of dam failure in benefit-cost analysis. Water Resour Res 1980;16:449–456. [CrossRef]
[8] Cochrane H. The economics of dam failure another look at catastrophic losses. Water Resour Res 1989;25:1931–1938. [CrossRef]
[9] Ekstrand ER. Estimating Economic Consequences for Dam Failure Scenarios. USA: U.S. Department of the Interior Bureau of Reclamation; 2000. Report Number: EC-2000–01.
[10] Torabi HA, Najarchi M, Mazaheri H, Jafarinia R, Izadikhah M. Optimization in water resources at dry weather conditions before and after the dam failure by using dummy variable regression approach. J Appl Eng Sci 2021;11:61–68. [CrossRef]
[11] Michael LD, Gary HM. Predicting loss of life in cases of dam failure and flash flood. Risk Analys 1992;13:193–204. [CrossRef]
[12] Yavary GR, Sashvary N. Determining surface and subsurface water productivity in the agriculture sector of Iran. Agric Econ Develop 2011;76:167–181.
[13] Alok KP. Measuring energy intensity and elasticity in India, a dummy variablea approach for unit level househ. Jindal J Bus Res 2014;3:77–92. [CrossRef]
[14] Dariane AB, Huges TC. Application of crop yield function in reservor operation. Water Resour Bull 1991;27:649–656. [CrossRef]
[15] Frizzone RD, Coelho D, Dourado N. Linear programming model to optimize the water resource use in irrigation projects: An application to the senator nilo coelho. Sci Agric 1997;54:136–148. [CrossRef]
[16] Ghahraman B, Sepaskhah AR. Linear and Non linear optimization model for allocation of limited water supply. Irrig Drain 2004;53:39–34. [CrossRef]
[17] Kumar DN, Raju KS, Ashok B. Optimal reservoir operation for irrigation of multiple crops using genetic algorithms. J Irrig Drain Eng 2012;132:123–129. [CrossRef]
[18] Hasan S, Mohammad FA. Linear programming model to optimize water supply and cropping area for irrigation a case study for Kalihati. Glob J Res Eng 2015;15:19–24.
[19] Munger D. Economic Consequences Methodology for Dam Failure Scenarios. Denver, Colorado: U.S. Department of the Interior Bureau of Reclamation Technical Service Center Security, Safety and Law Enforcement; 2009. Report No: EC-2009–01.
[20] Jessoe K, Manning DT, Taylor JE. Climate change and labour allocation in Rueaa Mexico: Evidence from annual fluctuations in weather. Econ J 2016;128:230–261. [CrossRef]
[21] International Labour Organization. The employment impact of climate change adaptation. Geneva: International Labour Organization; 2018.
[22] Marchiori L, Maystadt JF, Schumacher I. The impact of weather anomalies on migration in Sub-Saharan Africa. J Environ Econ Manag 2012;63:355–374. [CrossRef]