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The Study on Shadow Price of Greenhouse Gases Emission in Iran: Case of Dairy Farms

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Abstract: The aim of this study was estimation of environmental costs of agricultural greenhouse gases emissions in dairy farms. The sample was 85 dairy farms which were selected by simple random sampling method in 2006. The methodology was output distance function to derive estimates of greenhouse gases' shadow prices. In this study dairy farms' share in environmental costs in Mashhad and Iran was estimated 10688 and 67910300 million rials, respectively. Thus, it is recommended that policy makers use some methods like environmental taxes, improving management and carbon sequestration to reduce these kinds of costs. Results can help policy makers to decide more appropriate with considering the externality costs.

Key words: Undesirable (bad) output, output distance function, shadow price, dairy farm

INTRODUCTION

Greenhouse gas emissions out of different sources are one of the most important factors which threat environment thus they have caused lots of problems in herbaceous, animal and environmental domains. Levels of greenhouse gases (GHGs) in the atmosphere have increased significantly since the industrial revolution. Evidences indicate GHGs contribute to climate changes. Climate change, due to increasing greenhouse gas concentrations in the atmosphere, can be attention as one of the most serious environmental risks facing humankind. Mitigation of climate change requires significant reductions of greenhouse gas emissions.

In recent years, many treatments have been approved to manage global environment better. In 1990s, some international protocols were passed in order to control greenhouse gases' emissions. One of them was Kyoto protocol, on the base of which, countries should report greenhouse gas emissions of each sector in each year. Quantification of GHGs emissions is of scientific, social and political important issues. To understand and to manage reduction of GHGs emissions the whole system should be considered (Phetteplace *et al*., 2001), not just the components which conventionally have been used for policy reporting purposes (Intergovernmental Panel on Climate Change, 1996).

Although lots of studies have been done on greenhouse gas emissions in all around the world, environmental costs of these pollutants have not been considered clearly. For example, many studies have been done on shadow prices and environmental costs of other pollutants but not greenhouse gas emissions.

Rezak and Campbell (2007) demonstrated the use of inequality restricted generalized maximum entropy estimation to calculate shadow price of effluence in a distance function framework. They estimated the shadow prices of sulfur dioxide, nitrogen oxides, carbon dioxide and mercury emissions from a panel of 260 coal-fueled US electric power plants. This modeling procedure delivers results which are consistent with existing abatement cost evidence produced with both deterministic

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approaches and forecasting models. Their results implied that it may not be possible to duplicate the remarkable success of the SO_2 trading system for the other pollutants because of their greater industry abatement cost homogeneity.

Hailu and Veeman (2001) compared the conceptual merits and empirical performance of alternative approaches which can be employed to find environmental effects of pulp and paper industry in Canada. They compared input distance function, output distance function, nonparametric methods and index number approaches. Results showed each one of the methods has relative strengths and weaknesses.

Kwon and Yun (1999) estimated marginal abatement costs of airborne pollutants in Korea's power generation sector with use of output distance function. Results showed wide variations in the marginal abatement costs by the type of plant implying that Korea's regulatory policy on pollution has not achieved the cost-efficiency in reducing emissions.

Kwon *et al*. (2006) analyzed the appropriateness of the current tariffs for district heating in Korea. For this purpose, they used output distance function and estimated the shadow price of heat produced from cogeneration. The empirical results showed that the current heat tariff determined by public energy policy might be undervalued by about 15-53%. This implied that the retail price of district heating in Korea might be distorted at least in sense of economics.

Murty *et al*. (2006) used the input distance function for the Indian sugar industry. Results showed firms from sugar industry of India had to reduce production of sugar or incurred additional input costs to reduce pollution as the environmental regulations. It means that the firms had binding environmental constraints. The mean environmental efficiency was estimated as 0.85 implying that the industry had to incur an input of 15% more to reduce pollution for a given level of production.

Casey and Holden (2006) showed if a continued increase in specialization occurs in both dairy and beef sectors in Ireland it will be difficult to reduce GHG emissions. The existence of a middle-ground whereby beef can be supplied from the dairy industry while maintaining productivity within the dairy industry is perhaps the best option a shift towards very intensive milk production could see a reduction in animals crossing over to the beef industry due to lack of breed suitability for beef productivity.

Salnykov and Zelenyuk (2006) showed that countries value pollutants proportionally to their impact on human health (i.e., hazardous pollutants have the highestshadow prices). Also, found that in both rich and poor countries can be fully environmentally efficient, while most of the countries in transition (CITs) are inefficient.

An agricultural operation is a complex ecosystem containing flows of C and N that are influenced by climatic conditions and management practices. Although plant, soil and animal interactions add complexity to GHG accounting, they also provide more avenues for emission reduction. In order to this point that agriculture is one of the biggest methane (CH_4) and nitrous oxide (N_2O) producers, necessity of control and attention to production methods in agriculture for sustainable development and conforming to international treaties in order to decrease the greenhouse gases is important. In order to protocol commitments Iran should report greenhouse gas emissions of each economic sectors like agriculture sector. Dairy farms are also a source of greenhouse gas (GHG) emissions, mainly from enteric fermentation (methane) and manure management (methane and nitrous oxide). In most countries dairy nitrogen manure output and GHG emissions are becoming more decoupled from production in the sense that the output of these environmental risk indicators per unit of milk has fallen over time.

Data shows the number of industrial dairy farms and cattle (head) are 12667 and 1287759, respectively in Iran among which there are 2683 dairy farms (first position in country) with 175117 head cattle (third position in country) in Khorasan Province. With agriculture ministry's information until 2006, there are 725 industrial dairy farms with 41285 head dairy cows in Khorasan Razavi Province, Mashhads' (the capital city of Khorasan Razavi Province) share of industrial dairy farms and head dairy cows are 176 and 15782, respectively. Reducing the harmful environmental impacts of milk production, particularly in relation with water pollution and ammonia emissions, is a major objective of agro-environmental policy measures affecting the dairy sector. With regarding to the importance of this sub-sector in greenhouse gas emissions, Iran's commitments, lack the estimation of greenhouse gas emissions, ignorance of milk producers and policy makers related to greenhouse gas emissions in animal husbandry and non regarding of greenhouse gas environmental costs in milk producing, it is necessary to estimate the amount of greenhouse gases' emissions and calculate greenhouse gases' shadow prices. These kinds of information are very important because they could be helpful for understanding dairy cows' share and position in greenhouse gases' emissions. These kinds of estimations could be effective for policy makers and managers to use encouragement tools in short run and punishment tools in long run for decreasing greenhouse gases' emissions with which bad environmental effects of these gases would be controlled. The objectives of the study were to: (I) estimate the GHG emissions for the dairy system; (ii) assess GHG emissions per functional unit; (iii) assess the shadow price of GHG emissions in dairy farms and (iv) estimate the environmental cost of GHG emissions in dairy farms.

MATERIALS AND METHODS

Methodology

A firm's production technology could be modeled in different ways: the production function, the profit function or the cost function. Then Hotelling's Theorem and Shephard's Lemma allow one to derive compatible input demands and output offers with optimization behavior. Approach of this study to modeling the production process departs from earlier studies which use cost functions (Reynaud, 2003) or production functions (Wang and Lall, 2002) and instead uses a distance function to measure technology. The input distance function completely describes multiple output technology and is dual to the cost function (Fare and Primont, 1995).

The input distance function has an obvious advantage over production functions in allowing the possibility of multiple outputs and joint production. Another advantage of the input distance function over the cost function is that neither any information on input prices, nor the maintained hypotheses of cost minimization are required. Moreover, the distance functions allow one to calculate the shadow prices of the inputs, as the observed prices of inputs in the developing countries are not market clearing prices especially for the commodities like water. Similar to other analysis of production and technology, we calculate ease of substitution among the various inputs. Using parameter estimates of input distance function, Morishima and Allen elasticity of substitution are computed. Morishima elasticity is viewed as a more appropriate measurement of substitutability when the production process has more than two inputs (Blackorby and Russell, 1989).

In this part shadow price of greenhouse gases will be derived by using output distance function and its dual relationship with revenue function.

For this purpose, consider a firm employing a vector of inputs $x \in R_+^N$ to produce a vector of outputs $y \in R_+^M$. R_+^N and R_+^M are positive and they belonging to an N and M dimensional euclidean spaces.

We represent the production technology with output correspondence denoted by P:

$$P(x) = \{y \in R_+^M : x \text{ can produce } y\} \tag{1}$$

The x vector is the input vector which can produce the output vector y. P(x) has several properties. The assumptions about the disposability of outputs are one of them. It's very important in the context of a firm that produces good and bad outputs. The assumption of strong or free disposability about the technology is as fallows:

$$\text{If } y \in P(x) \text{ and } y^* \leq y \rightarrow y^* \in P(x) \quad (2)$$

Under this assumption we can reduce some outputs without decreasing other outputs. It is only assumed for the production of desirable goods (Chambers *et al*., 1998). The assumption of weak disposability says:

$$\text{If } y \in P(x) \text{ and } 0 \leq \theta \leq 1 \rightarrow \theta y \in P(x) \quad (3)$$

This assumption emphasizes that if a firm wants to reduce the bad output, it would be possible only by simultaneously decreasing the good output. One of them is non-empty set including zero vectors with respect to all $x \in R_+^N$, which is bounded from above and is a closed and convex set (Chambers, 1988). To derive the marginal abatement cost, we define output distance function:

$$D_0(x, y) = \min\{\theta : y/\theta \in P(x), \theta > 0\} \quad (4)$$

The output distance function is homogenous and convex with respect to the outputs.

To derive the shadow price of greenhouse gas emissions, it's necessary to use the duality between the revenue function and the output distance function as follow:

$$R(x,p) = \max_y\{py : D_0(x,y) \leq 1\} \quad (5)$$

$$D_0(x,y) = \max_y\{py : R(x,p) \leq 1\} = \min_\theta\{y/\theta \in P(x), \theta > 0\} \quad (6)$$

where, P is a shadow price vector of outputs and would be non-zero for the normal good. The revenue function can be derived from the output distance function by maximization with respect to output, while the output distance function is obtained from the revenue function by maximization over output prices.

The shadow prices of greenhouse gases are unknown and must be computed. Färe *et al*. (1993) has suggested the ratio of the shadow price of output I to that of the output j:

$$\frac{r_i^*}{r_j^*} = \left(\frac{\partial D_0(x,y)/\partial y_i}{\partial D_0(x,y)/\partial y_j}\right) \quad (7)$$

If I denotes an undesirable output, j denotes a desirable output and with this assumption that the observed price of y_j equals its shadow price, the shadow price r_i of undesirable output y_i can be calculated according to the following formula:

$$r_i^* = r_j^*\left(\frac{\partial D_0(x,y)/\partial y_i}{\partial D_0(x,y)/\partial y_j}\right) \quad (8)$$

The Empirical Model

In this study we use LCA method to estimate the greenhouse gas emissions related to each dairy farm in Mashhad at 2006. Ceuterick (1996, 1998) compiled examples of complete LCAs for single crops and production processes. Kramer *et al*. (1999) used part of the methodology to assess GHG emissions related to Dutch crop production system. Flessa *et al*. (2002) similarly evaluated GHG emissions from two farming systems in southern Germany and showed the important contribution of individual gases to climate change. De Boer and Imke (2003), Cederberg and Mattson (2000) and Haas *et al*. (2001) further shown the possibilities of using LCA to compare agricultural production systems.

In this model pollutants as undesirable goods including N_2O, CH_4 and CO_2 related to each dairy cow and the amount of each one is measured in kg per year.

The good output is milk which is measured in kg per year and inputs are the number of labor, energy amount, food and area related to each dairy cow.

This study uses the following translog function to estimate the output distance function:

$$\begin{aligned}LnD_0 &= \alpha_0 + \sum_{m=1}^{4}\alpha_m LnY_m + \sum_{k=1}^{4}\beta_k LnX_k + 0.5\sum_{m=1}^{4}\sum_{m'=1}^{4}\alpha_{mm'}LnY_m LnY_{m'}\\ &+0.5\sum_{k=1}^{4}\sum_{k'=1}^{4}\beta_{kk'}LnX_k LnX_{k'} + \sum_{k=1}^{4}\sum_{m=1}^{4}LnX_k LnY_m + \varepsilon\end{aligned}$$

where, X_1 is area amount, x_2 is energy amount, x_3 is labor amount and x_4 is food amount.

The output distance function is homogenous of the first degree in outputs. The homogeneity and symmetry conditions are imposed as follows:

$$\begin{cases}\alpha_1+\alpha_2+\alpha_3+\alpha_4=1\\ \alpha_{11}+\alpha_{12}+\alpha_{13}+\alpha_{14}=0\\ \alpha_{12}+\alpha_{22}+\alpha_{23}+\alpha_{24}=0\\ \alpha_{13}+\alpha_{23}+\alpha_{33}+\alpha_{34}=0\\ \lambda_{k1}+\lambda_{k2}+\lambda_{k3}+\lambda_{k4}=0 \qquad \forall k\end{cases}$$

$$\begin{cases}\alpha_{12}=\alpha_{21}\\ \alpha_{13}=\alpha_{31}\\ \alpha_{14}=\alpha_{41}\\ \alpha_{23}=\alpha_{32}\\ \alpha_{24}=\alpha_{42}\\ \alpha_{34}=\alpha_{43}\\ \beta_{kk'}=\beta_{k'k} \quad \forall k,k'\end{cases}$$

With imposing these conditions, the output distance function is changed as follows:

$$\begin{aligned}-LnY_1 &= \alpha_0 + \sum_{m=2}^{4}\alpha_m LnY_m^* + \sum_{k=1}^{4}\beta_k LnX_k + 0.5\sum_{m}^{4}\sum_{m'}^{4}\alpha_{mm'}LnY_m^* LnY_{m'}^*\\ &+0.5\sum_{k=1}^{4}\sum_{k'=1}^{4}\beta_{kk'}LnX_k LnX_{k'} + \sum_{k=1}^{4}\sum_{m=1}^{4}\gamma_{km}LnX_k LnY_m^* + u + \varepsilon\end{aligned}$$

where, Y_m^* is a normalized output $(Y_m^* = Y_m / Y_1)$ and u are non-negative error terms $(u \sim N^+(\mu, \sigma_u^2))$ in which μ is estimated by model.

The shadow price is estimated by the following formula:

$$P_{Y_m} = P_{Y_1}\cdot\left(\frac{\alpha_m + 0.5\sum_{m'}^{M}\alpha_{mm'}LnY_{m'} + \sum_{k=1}^{K}\gamma_{km}LnX_k}{\alpha_1 + 0.5\sum_{m'}^{M}\alpha_{1m'}LnY_{m'} + \sum_{k=1}^{K}\gamma_{k1}LnX_k}\right);\ \forall_m \geq 2$$

Data

The data used in this study were obtained through survey of 85 dairy farms of Mashhad in Khorasan Razavi Province during the year 2006. This study is done in 2006. This study used the emission coefficient factors, which was suggested by IPCC (Tier1) and the life cycle assessment (LCA) method in order to estimate the amount of CH_4, CO_2 and N_2O related to dairy farms.

RESULTS AND DISCUSSION

Table 1 show that the amount of CH_4, CO_2 and N_2O and all gases (eq CO_2/year) are 5260145.9-5710378.5, 263942580, 13121, 378473037 -387927922.8 kg, respectively.

This study considered three pollutants of CH_4, CO_2 and N_2O as undesirable outputs, desirable output is milk and inputs are energy, labor, food and dairy farm area, for estimating undesirable outputs (bad outputs) shadow prices of the output distance function is estimated by frontier 4.0. Table 2 provides the estimation results; present model is normalized translog function.

The lost parameters are calculated by imposing the homogeneity and symmetry conditions. Then shadow prices of pollutants for each sample calculated. The means of the shadow prices of each pollutant is showed on Table 3. This figures show that shadow prices of methane and nitrous oxide have significant difference from zero. So, in order to decreasing of pollutants, must decrease total output level that produce less good output or must use methods for decreasing of pollution.

Means of the shadow prices of CH_4, CO_2 and N_2O are 1654.2, 159.7 and 1618.4 Rials per kg, respectively. Which means decreasing 1 kg CH_4, 1 kg CO_2 and 1 kg N_2O will respectively opportunity cost 1654.2, 159.7 and 1618.4 Rials. In other words, for decreasing 1 kg of CH_4, N_20 and CO_2, must decrease value of milk producing respectively 1654.2, 1618.4 and 159.7 Rials or increase the same of inputs. This result can use in policy making and determining of environmental fees. Regard to shadow price of GHGs, milk will produce more than if current producing price. In fact, if environmental costs of GHGs added to other costs, milk price will increase. Although the shadow price of CO_2 is not significant but we use it in environmental costs' calculation. Results show that while the shadow price of N_2O with the least amount of emission is 1618.4 Rials kg^{-1}, the CO_2's with the largest amount of emission is 159.7 Rials kg^{-1}.

After estimating the shadow prices, the amount of greenhouse gases' emissions with Iran Agriculture Ministry Data for sample, for dairy cows in sample, for all dairy cows in Mashhad, for dairy farms in Mashhad, for dairy farms in Khorasan Razavi, for dairy cows in Khorasan Razavi, for all dairy farms in Iran and for all dairy cows in Iran are calculated. Table 4 shows the results. Share if Iran's dairy farms in creating of environmental GHGs costs is 33958700 million Rials.

Sample dairy farms have economies of scale ($\overline{ES} = 0.4$). So, by increasing of scale, average production costs of dairy farms will decrease. In this situation, if total inputs utilization 100% increase, total production will increase 40% (Table 5). Production elasticity of labor is negative. In other hands, elasticity of area and energy is positive and less than of one. Also, elasticity of dairy farm nutrition is positive and more than of unit.

Table 6 shows the ratio of greenhouse gases' shadow prices to milk price. The results show that these ratios are 0.61, 0.058 and 0.59 for CH_4, CO_2 and N_2O, respectively.

Table 1: Result of the amount of CH_4, CO_2 and N_2O related to dairy farms estimation

GHG	Emission (kg)
CH_4	526014.59-571037.85
CO_2	26394258
N_2O	1312.1
All gases emissions (eq CO_2/year)	37847303.7-38792792.28

Table 2: Estimation of normalized translog function

Variables	Coefficient	t-statistic	Significant level
C	2.157	0.35	ns
$_{1}Y$	-1.69	#	#
$_{2}Y$	2.60	2.20	***
$_{3}Y$	0.89	2.01	***
$_{4}Y$	-1.80	-5.10	***
$_{1}X$	-0.37	-1.30	ns
$_{2}X$	-0.95	-1.40	ns
$_{3}X$	0.0347	0.30	ns
$_{4}X$	0.489	0.51	ns
$_{1}Y\,_{1}Y$	1.1338	#	#
$_{2}Y\,_{1}Y$	-0.53	#	#
$_{3}Y\,_{1}Y$	-0.1864	#	#
$_{4}Y\,_{1}Y$	-0.4174	#	#
$_{2}Y\,_{2}Y$	-0.11	-1.40	ns
$_{3}Y\,_{3}Y$	-0.014	-1.04	ns
$_{4}Y\,_{4}Y$	-0.003	-0.64	ns
$_{3}Y\,_{2}Y$	0.21	2.44	***
$_{4}Y\,_{2}Y$	0.43	2.97	***
$_{4}Y\,_{3}Y$	-0.0096	-0.47	ns
$_{1}X_{1}Y$	-0.243	#	#
$X_{21}Y$	0.2635	#	#
$X_{31}Y$	-0.059	#	#
$X_{41}Y$	-0.225	#	#
$X_{12}Y$	-0.077	-1.40	ns
$X_{22}Y$	-0.30	-2.64	***
$X_{32}Y$	0.23	-2.50	***
$X_{42}Y$	0.19	1.50	ns
$X_{13}Y$	-0.11	-3.80	***
$X_{23}Y$	0.0035	0.077	Ns
$X_{33}Y$	-0.021	-0.55	ns
$X_{43}Y$	0.10	1.40	ns
$X_{14}Y$	0.43	31.80	***
$X_{24}Y$	0.033	1.80	**
$X_{34}Y$	-0.15	-6.40	***
$X_{44}Y$	-0.065	-1.50	ns
$X_{1}X_{1}$	-0.004	-0.84	ns
$X_{2}X_{2}$	0.032	0.55	ns
$X_{3}X_{3}$	0.077	2.59	***
$X_{4}X_{4}$	0.056	0.89	ns
$X_{3}X_{4}$	-0.11	-1.40	ns
$X_{1}X_{2}$	0.022	0.83	ns
$X_{1}X_{3}$	-0.011	-0.38	ns
$X_{1}X_{4}$	-0.003	-0.128	ns
$X_{2}X_{3}$	-0.0034	-0.082	ns
$X_{2}X_{4}$	-0.073	-0.58	ns
σ^2	0.00028	0.00028	ns
γ	0.05	0.05	ns
LLF	227076.00		
λ_{LRT} = mixedχ^2	0.021		ns

**At 5% significance level, ***At 5% significance level, ns no significant, # second stage calculated

Table 3: Shadow price of GHG

Shadow price	Mean of price (Rials)	t-statistic	Results of H_0 test
CH_4	-1654.2	-12.34	Rejected
CO_2	-159.7	-1.60	Accepted
N_2O	-1618.4	-9.70	Rejected

Table 7 shows the greenhouse gases' environmental costs related to production of 1 L milk. To produce 1 L milk, the environmental costs of CH_4, CO_2 and N_2O are respectively 21.2, 126.6 and 0.05 Rials and the whole greenhouse gases' environmental costs related to production of 1 L milk is 147.8 Rials.

Table 4: The amount of greenhouse gases' emissions and the environmental costs

	GHG		
Emission	CH_4 (kg)	CO_2 (kg)	N_2O (kg)
Sample	571037.9	26394258	1289.317
Dairy cows in sample	280673	12693412.16	649.83
Dairy farms in Mashhad	1182384	54651640	2669.645
All dairy cows in Mashhad	5991192.1	27325820	1334.82
Dairy farms in Khorasan Razavi	4870617	225127495	10997.12
Dairy cows in Khorasan Razavi	2435309	112563747	5498.56
All dairy farms in Iran	7512681571	347248000000	16962497
All dairy cows	3756340785	173624000000	8481249

	CH_4	CO_2	N_2O	Total
Environmental cost related to GHG_s	(million rials)			
Sample	939.16228	4563.99933	1.74353	5504.90514
Dairy cows in sample	464.28928	2027.13792	1.05168	2492.47888
Dairy farms in Mashhad	1955.90007	8727.86693	4.31094	10688.07794
All dairy cows in Mashhad	977.95003	4363.93346	2.15547	5344.03896
Dairy farms in Khorasan Razavi	8056.97470	35950	17.75814	44027.59377
Dairy cows in Khorasan Razavi	4028.48735	17980	8.87907	22013.79689
Dairy farms in Iran	12430000	55460000	27400	67910300
All dairy cows	62140000	27730000	13700	33958700

Table 5: Economic scale and elasticity of production's inputs

Variables	Size
Economic scale	0.40
Area elasticity	0.43
Energy elasticity	0.06
Labor elasticity	-0.66
Nutrition elasticity	1.41

Table 6: Shadow price to milk price ratio

GHG	Shadow price to milk price ratio
CH_4	0.610
CO_2	0.058
N_2O	0.590

Table 7: GHG's environmental costs related to producing 1 L milk

GHG	Environmental cost (Rials)
CH_4	21.20
CO_2	126.60
N_2O	0.05
Total	147.80

Finally, results show the ratio of greenhouse gases' environmental costs to milk gross revenue. Results show that greenhouse gases' environmental costs are 5504905140 and gross revenue is 16066957000 Rials; the ratio is 0.34. Based on Lehtonen *et al*. (2006) and Petersen *et al*. (2003), price of GHGs equivalent CO_2 was 85 dollar t^{-1}. Salnykov and Zelenyuk (2006) showed that shadow price of CO_2, SO_2 and NO_x are -109.42, -7989.9 and -66506 dollar t^{-1} for all sector of Iran. Regard to these figures, annual environmental costs of sample dairy farm will be 3297387.3 dollar and 349135.1 euro. Also, this study is done in dairy farm for first time in Iran. One objectives of this study was generating data of GHGs emission in dairy farm and the estimating of shadow price and environmental costs of GHGs in Iran. Therefore, results of this study can not compare with other studies.

CONCLUSION

In this study, the shadow prices of greenhouse gases emissions related to dairy farms is estimated. The output distance function is been used, because CH_4, CO_2 and N_2O are undesirable outputs related to milk production. The estimations showed that CH_4, CO_2 and N_2O are respectively 1654.2, 159.7 and 1618.4 Rials. It's crystal clear that these environmental costs are high; they are externality costs which must be controlled. For this purpose more studies with more details need to be proposed. It is recommended that policy makers use some methods like environmental taxes, improving management and carbon sequestration to reduce these kinds of costs. Results can help policy makers to decide more appropriate with considering the externality costs.

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