Applying of DEA approach to optimize the energy required and GHG emission for greenhouse vegetable productionin Algeria

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Abstract: In last twenty years, Algeria has experienced an important agricultural development driven by a prosperous in market gardening in plastic greenhouses due the favorable climatic conditions and the government's policy. In aim to optimize the energy requirement and GHG emission, a data have been collected from 29 farmers which present qualitatively of greenhouse vegetable growers from the most productive sub-provinces of Biskra region (south of Algeria). Among the various parametric and non-parametric methodsto optimize the energy consumption, DEA is the most common non parametric method applied. The results revealed,that the optimum energy requirements for vegetable greenhouse calculation indicated that, 108.50 GJ ha^{-1} could be saved distributed on machinery (1.38 GJ ha^{-1}), diesel oil (4.68 GJ ha^{-1}), infrastructure (9.35 GJ ha^{-1}), fertilizers (17.08 GJ ha^{-1}), farmyard manure (12.05 GJ ha^{-1}), pesticides (3.93 GJ ha^{-1}) and electricity (60.03 GJ ha^{-1}). The calculation of total GHG emission provided 4511,410 and 1517,482 kgCO2eq.ha^{-1} as present and target units, respectively. In this study, applying DEA approach to energy optimization could allow to GHG emission showed reducing the total GHG emission about 2993,928kgCO2eq.ha^{-1} in vegetable greenhouse production.

Key words: greenhouse cultivation, input-output analysis,GHG emission,DEA,Algeria

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1 Introduction

During last twenty years, Algeria has experienced a notable agricultural development driven by a prosperous in market gardening in plastic greenhouses due tothe favorable climatic conditions and the government's policy (Nouraniand Bencheikh, 2017). As results of this development, Biskra province becomes the first producer of early vegetables nationally (Allache et al., 2015) where, the surface occupied by the greenhouse has increased by 528.52% over the last20 years (Belhadi et al., 2016).

Agriculture is both a producer and consumer of energy (Bahrami et al., 2011). It uses large quantities of locally available non-commercial energies, such as seed, manure and animate energy, and commercial energies directly and indirectly in the form of diesel, electricity, fertilizer, plant protection, chemicals, irrigation water and machinery (Kizilaslan, 2009). Efficient use of energies helps to achieve increased production and productivity and contributes to the economy, profitability and competitiveness of agriculture sustain-ability in rural living (Singh et al., 2002).While several works across the world have been conducted to optimize the energy consumption in greenhouse vegetable production, for example,Firoozi et al. (2014)optimized an energy consumption efficiency for greenhouse cucumber production in Lorestan and Markazi Provinces of Iran, Banaeianet al. (2012) published a paper entitled Greenhouse strawberry production in Iran, efficient or

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inefficient in energy,while for other crop, several studies have been conducted on rice, wheat, tomato.However,no studies have been published on energy input – output efficiency and Greenhouse Gas (GHG) emission optimization of greenhouse vegetable production in MENA region. Furthermore, all papers published didn't take into considerations in energy analysis and GHG estimation the infrastructure as in considerable input.

With these observations in mind, this study addresses to determinethe energy use efficiency, wasteful uses and target energy requirement for greenhouse vegetable production in Biskra province, southern of Algeria in order to optimize the energy consumption and GHG emissions.

2 Materials and methods

2.1Survey

According Rekibi (2015),Biskra province occupies over 32% of national production of protected crops which make it the first producer of early vegetable in Algeria. For this reason, this study has been carried out in this region. An investigation was conducted in Biskra province during the season 2014-2015. The study employedface-to- face persona linter views using questionnaires which compound sections providing the economic characteristics, practices and management of the farm. The data have been collected from 29 farmers which present the qualitatively of greenhouse vegetable growers from the most productive sub-provinces of Biskra. In these areas, the vegetables produced most extensively are tomato, cucumber, eggplant and pepper.

2.2 Energy pattern

Energy requirements in agriculture are divided into two groups, direct and indirect. In this study, direct energy includes human labor, diesel, water for irrigation and indirect energy includes seeds, fertilizers, Farmyard manure, chemicals, machinery and infrastructure. Based on the energy equivalents of the inputs and outputs (Table 1), the metabolisable energy was calculated.

Table1 Energy equivalent of inputs and outputs in greenhouse vegetable production

Energy source	Unit	Energy equivalent (MJ unit^{-1})	Reference
Inputs			
Human labor	h	1.96	Singh et al. (2002)
Machinery	h	62.7	Singh et al. (2002)
Diesel oil	l	45.4	Bojacá et al. (2012)
Infrastructure	kg		
Steel		33	Medina A, et al (2006)
Polyethylene		9.9	Medina A, et al (2006)
Synthetic fiber		1.2	Medina A, et al (2006)
PVC (PolyVinylChloride)		11.6	Medina A, et al (2006)
Fertilizers	kg		
N		60.6	Ozkan et al. (2004)
P_2O_5		11.1	Ozkan et al. (2004)
K_2O		6.7	Ozkan et al. (2004)
Farmyard manure	kg	0.3	Bojacá et al. (2012)
Pesticides	kg		
Fungicides		216	Mohammadi and Omid (2010)
Insecticides		101.2	Mohammadi and Omid (2010)
Plant materials			
Plantlets	unit	0.2	Bojacá et al. (2012)
Water for irrigation	m^3	0.63	Bojacá et al. (2012)
Electricity	(kW h)	3.6	Ozkan et al. (2004)
Output			
Tomato, cucumber,egg, plant, pepper	kg	0.8	Ozkan et al. (2004)

To analysis the energy flow, energy ratio (energy use efficiency) (ER), energy net (EN), energy productivity (EP) and specific energy indexes were calculated as follows:

$$\text{Output} - \text{input ratio (ER)} = \frac{\text{Energy output (MJ ha}^{-1})}{\text{Energy input (MJ ha}^{-1})} \quad (1)$$

$$\text{Energy productivity (EP)} = \frac{\text{Total output (kg ha}^{-1})}{\text{Energy input (MJ ha}^{-1})} \quad (2)$$

$$\text{Energy Net (EN)} = \text{Energy output (MJ ha}^{-1}) - \text{Ener} \quad (3)$$

$$\text{Specific energy} = \frac{\text{Energy input (MJ ha}^{-1})}{\text{Vegetable output (kg ha}^{-1})} \quad (4)$$

2.3 Dataenvelopment analysis

Among the various parametric and non-parametric methodto optimize the energy consumption, Data envelopment analysis (DEA)is the most common non parametric method applied.Since its introduction, the DEA method has been an exponential success.In 2007, Emrouznejad et al. (2008) identified more than 4,000 published research articles on the DEA method in scientific journals or reference books. This method was developed by Charnes et al. (1978, 1981) to evaluate the efficiency of a US federal program of resource allocation to schools named "Program Follow Through" (Huguenin, 2013).

The DEA method makes it possible to evaluate the performance of the organizations (called decision-making units -DMUs-) that transform resources (inputs) into benefits (outputs). The DEA model has been described in detail by several authors (Banaeianet al. 2012). Thus, a detailed description is not provided here.

Two basic models are used in DEA, each leading to the identification of a different efficiency frontier. The first model assumes that organizations evolve in a situation of constant returns to scale (constant model returns to scale -CRS-) called also CCR referred to Charnes, Cooper and Rhodes (Charnes et al. 1978). It is appropriate when all organizations have reached their optimal size. The second model assumes that organizations evolve in a situation of variable returns to scale (variable model returns to scale -VRS-) called also BCC referred to Banker, Charnes and Cooper (Banker et al. 1984). It is appropriate when organizations do not operate at their optimum size.

In the aim of selecting inputsfor DEA approach, a linear regression analysis to determineeffective energy inputs on yield was performed. The function used was of Cobb– Douglas production function form, expressed as (Singh et al., 2004; Hatirli et al., 2006; Mohammadi and Omid,2010; Banaeianet al., 2012)

$$Y_i = \alpha_0 + \sum_{i=1}^{7} \alpha_j \left(x_{ij}\right) + e_i \; ; \; i = 1,2,3,\ldots,29 \qquad (5)$$

where, Yi denotes yield the i[th]greenhouse, x_{ij} the vector of energy inputs used in the production process, human labor (x_{i1}), machinery (x_{i2}), diesel oil (x_{i3}), infrastructure (x_{i4}), fertilizer (x_{i5}), pesticide (x_{i6}), farmyard manure (x_{i7}), Plantlets (x_{i8}), water for irrigation (x_{i9}) and electricity (x_{i10})", α_0 constant term, α_j represent coefficients of energy inputs which are estimated from the model, and e_{ii}s the error term. This function and its offshoots have been used by several authors to examine the relationship between input energy and yield (Singh et al., 2004; Hatirli et al., 2006; Mohammadi and Omid, 2010; Banaeianet al., 2012).

In this study, input-oriented DEA seems more appropriate, given that it is more reasonable to argue that in the agricultural sector a farmer has more control over inputs rather than output levels (Nabavi-Pelesaraei et al., 2014).

2.3.1 Technical efficiency (TE)

Technical efficiency is a global measure of a DMU's performance. The TE can be defined as follows (Nabavi-Pelesaraei et al., 2014):

$$TE_j = \frac{u_1 y_{1j} + u_2 y_{2j} + \cdots + u_n y_{nj}}{v_1 x_{1j} + v_2 x_{2j} + \cdots + v_n x_{nj}} = \frac{\sum_{r=1}^{n} u_r y_{rj}}{\sum_{s=1}^{m} v_s x_{sj}} \qquad (6)$$

Where,ur, is the weight given to output n; yr, is the amount of output n; vs, is the weight given to input n; xs, is the amount of inputn; r, is number of outputs (r = 1, 2, …, n); s, is number of inputs (s = 1, 2, …, m) and j, represents jth of DMUs (j = 1, 2, …, k).

To solve Equation1, following Linear Programming (LP) was formulated:

Maximize: $\theta = \sum_{r=1}^{n} u_r y_j$

Subjected to$\sum_{r=1}^{n} u_r y_j - \sum_{s=1}^{m} v_s x_{sj} \leq 0$

$$\sum_{s=1}^{m} v_s x_{sj} = 1 \qquad (7)$$

$$u_r \geq 0, v_s \geq 0, \text{and } (iandj = 1,2,3,\ldots,\text{k})$$

Where θ is the technical efficiency, Model (3) is known as the input-oriented CCR DEA model assumes constant returns to scale (CRS) (Nabavi-Pelesaraei et al., 2014)

2.3.2 Scale efficiency

SE relates to the most efficient scale of operations in the sense of maximizing the average productivity(Firooziet al., 2014). Also, scale efficiency is the potential productivity gain from achieving optimal size of a DMU (Farashah et al., 2013). The relationship between technical and pure technical efficiency scores can be described by the next formula (Mousavi-Avval et al.,2011):

$$\text{Scale efficiency} = \frac{\text{Technical efficiency}}{\text{Pure technical efficiency}} \qquad (8)$$

In the analysis of efficient and inefficient DMUs the energy-saving target ratio (ESTR) index can be used, which represents the inefficiency level for each DMUs with respect to energy consumption. The formula is as follows (Firoozi et al., 2014):

$$\text{ESTR}_\text{j} = \frac{\text{Energy Saving Target}_\text{j}}{\text{Actual Energy Input}_\text{j}} \qquad (9)$$

Where energy saving target is the total reducing amount of input that could be saved without decreasing output level and j represents j_{th} DMU.

Noting here that almost of calculation was performed using the free application Win4Deap 2, version 2.1.

2.4 GHG emission

Using machinery in different farm activities, such as: production, transport, formulation, storage, distribution and application of agricultural inputs,leads to use the fossil fuel energy, which, as a result, emits CO_2 and other GHGs in the atmosphere. The present paper focused on the reduction of CO_2 emission in greenhouse vegetable production using energy optimization. Based on both CCR and BCC model, the calculation ofGHG emission for present and target units and difference between ones was performed. For this reason, standard coefficient of GHG emission implicated for each input. The coefficients of GHG emission for agriculture inputs are presented in Table 2. Subsequently, we will compute the potential of GHG reduction in greenhouse vegetable production.

Table 2 GHG emission coefficients of agricultural inputs

Input	Unit	GHG Coefficient ($kgCO2eq.unit^{-1}$)	Reference
Machinery	MJ	0.071	Nabavi-Pelesaraei et al. (2014)
Diesel fuel	L	2.76	Nabavi-Pelesaraei et al. (2014)
Chemical fertilizers	kg		
Nitrogen		1.3	Nabavi-Pelesaraei et al. (2014)
Phosphate (P2O5)		0.2	Nabavi-Pelesaraei et al. (2014)
Potassium (K2O)		0.2	Nabavi-Pelesaraei et al. (2014)
Manure	kg	0.126	Pishgar-Komleh et al. (2013)
Infrastructure	kg		
Steel		0.768	Hammond and Jones (2008)
Polyethylene		2.4	Posen et al. (2017)
Syntheticfiber		1.5	Posen et.al. (2017)
PVC		2.2	Posen et al. (2017)
Biocides	kg		
Insecticides		5.1	Nabavi-Pelesaraei et al. (2014)
Fungicides		3.9	Nabavi-Pelesaraei et al. (2014)
Electricity	kWh	0.608	Nabavi-Pelesaraei et al. (2014)

3 Results and discussion

The data werecollected from 29 vegetable protection growers in Biskra province. The average size of greenhouses is around 2.1 ha with a range from 0.25 up to 12.75 ha. All of the surveyed greenhouses were the plastic houses and metallic structures.Also, the data showed that the almost all superficies covered by greenhouse were irrigated using a drip irrigation and about 73% of visited farms were privately owned and 27% rented. In fact, the survey covered 65 farmers, other thansince the main drawbacks of deterministic frontier models-both non-parametric and parametric models are that they are very sensitive to outliers and extreme values, and that noisy data is not allowed (Pahlavan et al., 2011), farmers' selection has been conducted toassure homogeneity in the base of a specific area character.

Using Equation 1, $R^2 = 0.92$ was given by the performance of regression analysis. No significant inputs were neglected, such as: Human labor, plantlets, and water energy while analysis adopted the significant inputs and assumed seven input variables:infrastructure, fertilizers, farmyard manure, electricity, diesel oil, pesticideand machinery energy, where they present a major energy inputson vegetable yield in the studied greenhouses with 91% of total energy used. Theseven input parameter included in the model arelisted in Table 3, with descriptive statistics,for 29 greenhouses growers.According to Cooper et al. (2001), the number of DMU's should be at least three times the total number of input and output factors considered when using the DEA model (Banaeianet al., 2012).Thus,in this study, it is more than least triple ofthe selected eight input– output variable for the performance model.

Table 3 Statics description of vegetable inputs and output adopted in $MJha^{-1}$

	machinery	diesel oil	infrastructure	fertilizers	farmyard manure	pesticide	electricity	yield
Max	3762	36178,12	341728,22	252036	27720	101020,73	281842,10	200000
Min	627	425,62	7801,08	1873,52	2700	1386	1043,85	50000
Mean	1729,65	5107,5	22008,94	26990,68	13379,58	12164,44	84654,37	113724,13
SD	742,39	7414,62	61502,86	46145,70	6725,31	20590,45	70952,94	36756,82

3.1 Technical, pure technical and scale efficiency of greenhouses

Table 4 illustrates the results obtained by application of the input orientated DEA. The results revealed, the mean radial technical efficiencies of the samples under CRS and VRS assumptions were0.88 and 0.98 respectively. In plus, 51.72% of DMU's (15 units) had efficient based on CCR model; while, score of pure technical efficiency calculated as 1 in 23 farms (79.31% of total units). This implies first, that on average, vegetables greenhouses could reduce their inputs by 12% (2%) and still maintains the same output level.Increasing the technical efficiency of a greenhouse actually means less input usage, lower production costs and, ultimately, higher profits, which is the driving force for producers motivated to adopt new techniques (Firooziet al., 2014).

By application the equation 8, it is obvious that, the scale efficiency equals to 1 for the units that had a score equal to 1 in CCR and BCC model. In Figure1, the efficiency score distribution of BCC and CCR model is showed. These results presented that the difference between efficient and inefficientfarmers was caused by inputs consumption in vegetable greenhouse production. As consequence, farmers should adopt the consumption model of the efficient farmers. As can be seen in Figure1, 7 units were in the range 0.8 - 1 Based CCR; While, BCC model results illustrated that 6 farmers were equal to unity.

Table 4Results of the DEA models technical efficiency scores (technical, pure, and scale) and returns to scale

DMU	Machinery	Diesel oil	Infrastructure	Fertilizers	Farmyard manure	Pesticides	Electricity	Technical efficiency		Scale efficiency	RTS
								CRS	VRS		
1	1254	11350	10441,916	75340,40	18168	12459,360	14092,105	1	1	1	
2	3030,5	36178,125	9556,495	63917,96	16818	18556,128	2947,368	1	1	1	
3	2508	14896,875	10289,178	9968,16	4800	1764,720	10736,842	1	1	1	
4	1254	2270	9854,416	1873,52	13650	2891,928	58717,105	1	1	1	
5	1463	851,25	12727,083	16576,72	8400	6128,760	93947,368	0,825	1	0,825	irs
6	1463	16315,625	10246,330	33302,32	8550	11760,30	10892,449	0,918	1	0,918	irs
7	1254	1418,75	10292,416	26807,72	22230	5969,250	156578,95	0,726	0,924	0,786	irs
8	3135	5675	10596,916	10747,68	16800	3841,354	36013,158	1	1	1	
9	1045	7093,75	10512,416	15587,32	11076	2500,050	125263,16	0,964	1	0,964	irs
10	627	2128,125	11211,083	13345,80	6816	1386,000	50105,263	1	1	1	
11	1881	2128,125	11040,416	13320,64	8400	2023,152	156578,94	1	1	1	
12	3762	7803,125	10424,416	19341,92	22800	10602,576	10248,804	0,83	0,941	0,882	irs
13	2821,5	8512,5	9085,083	11212,08	14820	3973,050	1043,860	1	1	1	
14	1881	9931,25	10300,988	3403,76	22230	5996,160	10736,842	1	1	1	
15	2090	2837,5	341728,221	252036,00	2700	4272,000	54802,632	0,639	1	0,639	irs
16	1881	1702,5	7801,083	12439,20	15270	11579,814	78289,474	0,82	1	0,82	irs
17	1672	1418,75	10160,416	27224,08	4200	3966,480	187894,73	1	1	1	
18	1672	1418,75	10820,416	26136,52	4200	3257,280	75157,895	1	1	1	
19	1463	2837,5	10906,416	5535,44	16800	101020,73	281842,10	0,453	0,878	0,516	irs
20	1254	1702,5	11455,750	4346,96	8550	2516,580	67850,877	1	1	1	
21	1985,5	1418,75	10112,416	18032,00	2940	14253,278	56368,421	0,591	1	0,591	irs
22	1881	709,375	11432,416	20359,00	22230	46751,400	250526,31	0,67	0,854	0,785	irs
23	1254	993,125	10678,131	18431,40	17100	1729,740	89473,684	1	1	1	
24	627	425,625	13082,416	14296,72	27720	2460,530	93947,368	1	1	1	
25	1567,5	993,125	13012,988	9481,60	18900	48045,600	89473,684	0,663	0,989	0,670	irs
26	1881	1276,875	10575,528	5912,74	9810	7297,476	93947,368	0,808	1	0,808	irs
27	1254	851,25	12164,416	13343,20	15750	4879,392	125263,16	0,668	0,99	0,675	irs
28	731,5	2270	9875,166	21634,64	12600	2632,320	46973,684	1	1	1	
29	1567,5	709,375	7874,416	18774,40	13680	8253,600	125263,16	0,838	1	0,838	irs

According to the results obtained, the DMU's number 1,2,3,4,8, 10, 11, 13, 14, 17, 18, 20, 23, 24 and 28 are efficient and apply a good practice. By the same token, CRS applied and scale efficiency equals one, that is meaning these farms are functioning at the most productive scale size. In the last row of the table, the return to scale (RTS)shows that all efficient DMUs (based on technical efficiency) are functioning at Constant Return to Scale (CRS),whiles the inefficient ones are at Increasing Return to Scale (IRS), which means that for significant changes in yield and/or agricultural management adjust is necessary. The IRS indicates that an increase in output have been produced by more than the proportionate increase in input resources. The scale efficiency (SE)calculated as, in average, ass 0.88, which indicated that if the utilization of inputs efficiently, for the inefficient farmers would providing some saving in energy from the diverse sources input without any change in agricultural practices. In Biskra province, no farmers were found to function at Decreasing Return to Scale (DRS). Nabavi-Pelesaraei et al.(2016) analyzed the Energy Efficiency of White production.

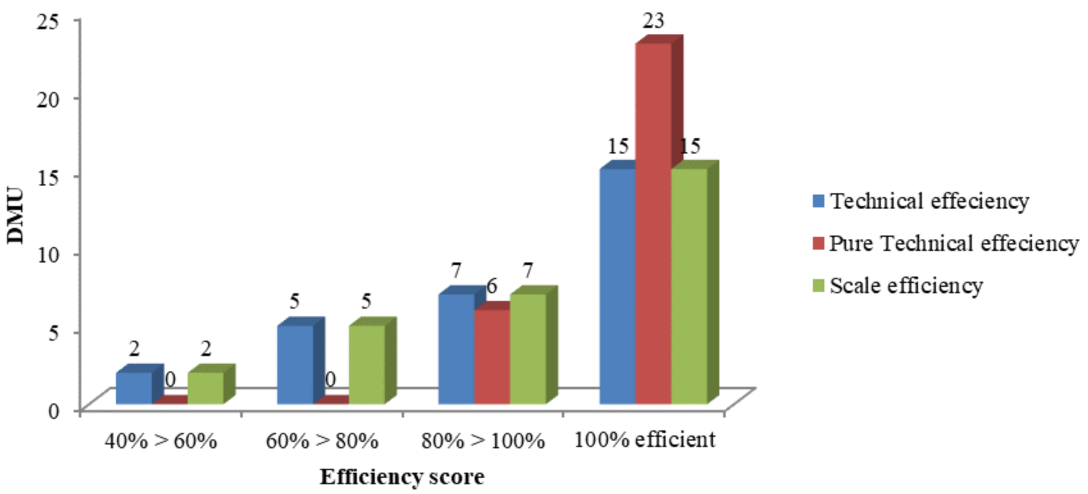

Figure 1 Efficiency score distribution

3.2 Energy saving from different energy inputs

Table 5 illustrates the optimum energy requirement and saving energy for greenhouse vegetable production according to CRS model application. Moreover, the Contribution to the savings energy is illustrated in the last column.

Table 5 Optimum energy requirement and saving energy for vegetable greenhouse production

Input	Optimum energy requirement (MJ ha^{-1})	Saving energy (MJ ha^{-1})	Saving energy (%)	Contribution to the savings energy (%)
Machinery	1379,93	349,73	20,22%	1,27%
Diesel oil	4680,45	427,05	8,36%	4,31%
Infrastructure	9348,70	12660,24	57,52%	8,62%
Fertilizers	17080,71	9909,98	36,72%	15,74%
Farmyard manure	12050,57	1329,02	9,93%	11,11%
Pesticides	3931,96	8232,49	67,68%	3,62%
Electricity	60033,21	24621,16	29,08%	55,33%
Total energy	108505,53	57529,66	34,65%	100,00%

As the table5is shown, the optimum energy requirements for vegetable greenhouse calculation indicated that, 108.50 GJ ha^{-1} could be saved distributed on machinery (1.38 GJ ha^{-1}), diesel oil (4.68 GJ ha^{-1}), infrastructure (9.35 GJha^{-1}), fertilizers (17.08 GJha^{-1}), farmyard manure (12.05 GJ ha^{-1}), pesticides (3.93 GJha^{-1}) and electricity (60.03 GJha^{-1}). As consequence, on average, about 35% of total input energy could be saved in case those farmers follow the recommendations issued from this study while keeping the actual output level of greenhouse vegetable (tomato, cucumber, eggplant and pepper) yield. Firooziet al.(2014) reported that on an average, 26.82% of the total input energy of greenhouse cucumber production in Iran could be saved.

3.3 Improvements of energy indices

Table 6 recapitulates the energy indices of actual and optimum quantities. The calculation demonstrated that the energy use efficiency was equalto 1.61 and 1.11 for actual and optimum units, respectively, with 0.51 of difference giving an improvement of 31.67%. Furthermore, by converting present to target use of energy, the energy ration, energy productivity and net energy could be improved around 31.94%, 31.46%, 19.82% and 19.80%.

Table 6 Improvement of energy indices for vegetable greenhouse production

Indices	unit	Actual quantity	Optimum quantity	Difference (%)
Energy Ration		49%	72%	31.94
Energy productivity	kg MJ^{-1}	0,618162046	0,89941929	31.46
Net Energy	MJ ha^{-1}	-92992,09115	-35462,42738	61.86
specific energy	MJ kg^{-1}	1,6176988	1,1118285	31.67

Nabavi-Pelesaraei et al. (2014) revealed that the percentage of difference between target and optimum was found about 24% for rice production. Also, Mohammadi et al. (2011) found about 14% of difference between the proportion actual and optimum of kiwifruit production.

3.4 Analysis of GHG emission

Table 7 presents the quantity of GHG emission for actual and target of units. The calculation of total GHG emission provided4511,410 and 1517,482 kgCO2eq.ha^{-1}as present and target units, respectively. Mondani et al. (2017) reported that total GHG emission for irrigated wheat agro-ecosystem was 3184.4 kg CO_2eq.ha^{-1} while it was 553.1 kg CO2-eq.ha^{-1} in dry land wheat agro-ecosystem. The total emission of 1922 kgCO_2eq.ha^{-1} and 4752 kgCO_2eq.ha^{-1}were reported by Mirasi et al. (2015)for wheat and tomato production in Iran, respectively. In similar studies, Nabavi-Pelesaraei et al. (2014) found that the total GHG emission of rice production could be decreased about 363.74 kgCO2eq.ha^{-1}using DEA approach for energy optimization. In this study, applying DEA approach to energy optimization could allow to GHG emission showed reducing the total GHG emission about 2993, 928 kgCO_2eq.ha^{-1} in vegetable greenhouse production.

Table 7 Amounts of GHG emission for efficient and inefficient farmers

Input	Present farmers (kgCO_2eq.ha^{-1})	Target farmers (kgCO_2eq.ha^{-1})	GHG reduction (kgCO_2eq.ha^{-1})
Machinery	122,806	97,975	24,831
Diesel fuel	356,089	29,774	326,316
Chemical fertilizers			
Manure	1685,827	167,456	1518,371
Infrastructure			
Steel	112,650	64,800	47,850
Polyethylene	4998,096	2875,063	2123,033
Synthetic fiber	158,715	91,298	67,417
PVC	287,804	165,554	122,250
Nitrogen	362,523	133,105	229,418
Phosphate (P_2O_5)	70,933	26,044	44,889
Potassium (K_2O)	54,900	20,157	34,743
Biocides			
Insecticides	491,991	332,963	159,028
Fungicides	40,158	27,177	12,980
Electricity	3979,262	1157,342	2821,920
Total	4511,410	1517,482	2993,928

Figure 2 is showed the contribution of each input in prospective of GHG reduction. As presented, the manure and the diesel fuel had the highest potential to the reduction of total GHG emission with nearly percentage 22.92% and 22.30%; followed by electricity (with 17.26%) and chemical fertilizers (with 15.40%). In AstanehAshrafiyeh city of Guilan province,Iran, Nabavi-Pelesaraei et al. (2014) found that the diesel fuel was the highest energy input in GHG reduction (with 59.57%) for rice production. In similar study, for greenhouses cucumber cultivation of Esfahan province (Iran), Khoshnevisan et al. (2013) reported the share of energy inputs in GHG reduction had the highest for natural gas with 52%. As first reaction, farmers should be reducedthe diesel fuel utilization since it was non-renewable energy recourses. For that reason, a number of procedures propose to this intention, such as: using renewable energy recourses like solar energy in electricity generation; adopting new tillage systems that allow tillage operations decreasing and improve soil structure; applying integrated pest management (IPM) methods in order to reduce pesticide application.

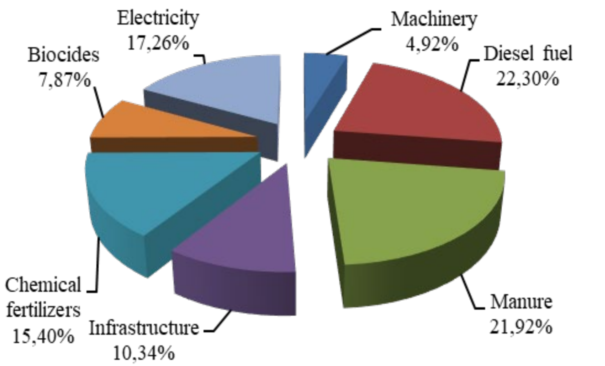

Figure 2 is showed the contribution of each input in prospective of GHG reduction. As presented, the manure and the Figure 2

Contribution of each input in prospective of GHG reduction

4 Conclusion and recommendation

This work aimed to optimizethe energy input-output and GHG emission for the protected vegetable production in Biskra province (Southern of Algeria) using DEA approach. For this reason, a survey has been conducted with 29 farmers. The results revealed from this study could be presented as follows:

1)Analysis adopted the significant inputs and assumed seven input variables: infrastructure, fertilizers, farmyard manure, electricity, diesel oil, pesticide and machinery energy, where they present a major energy input on vegetable yield in the studied greenhouses with 91% of total energy used.

2)The total energy required and GHG emitted for vegetable protected production is 183.17 GJ and 4511,41 kgCO2eq per hectare, respectively.

3)51.72% of DMU's (15 units) had efficient based on CCR model; while, score of pure technical efficiency calculated as 1 in 23 farms (79.31 % of total units).

4)The calculation demonstrates that the energy use efficiency is equal to 1.61 and 1.11 for actual and optimum units, respectively, with 0.51 of difference giving an improvement of 31.67%.

5)The calculation of total GHG emission provided 4511,410 and 1517,482 kgCO2eq.ha-1 as present and target units, respectively.

5)The manure and the diesel fuel had the highest potential to reduction of total GHG emission with nearly percentage 22.92% and 22.30%; followed by electricity (with 17.26%) and chemical fertilizers (with 15.40%).

As recommendations, the below propositions could enhance the control of energy flow and the GHG emission in protected vegetable production and also allow to the farmer improve their financial situation, namely:

1)Provided thattraining days by a qualified employerto farmers for changing their wrong behaviors and the controlled input.

2)Improving the pest management using an integrated fighting method (IPM).

3)Elaboration an awareness session for farmers regarding the GHG emission effect on the future generation.

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