Life cycle of energy-economic analysis for different cultivation scenarios of paddy production (Case study: Khuzestan Province)

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Abstract

In this study, energy and economic analysis of paddy production in Khuzestan province of Iran were studied. Paddy production in this province was analyzed under three scenarios of multiple cultivation system including (Paddy-Transplanting System) PTS, (Paddy Direct Seeding Flooding System) PDSFS and (Paddy-Upland Cultivation System) PUCS. The highest total input (87993.14 MJ ha^{-1}) and output (105400 MJ ha^{-1}) energies were related to PTS. Diesel fuel and nitrogen fertilizer had the uppermost energy use shares. Depending on the type of cultivation in PUCS, human labor has a large share of energy. Estimation of the energy ratio of PUCS method (1.34) indicates that the amount of output energy is much higher than the input energy. Productivity energy index also showed that there is no significant difference between the three methods in terms of amount of paddy relative to input energy. The specific energy of PTS method (14.19 MJ kg^{-1}) indicates large amounts of input energy relative to the amount of paddy produced. Based on the high revenue and low cost, the benefit to cost ratio at the expense of PTS method is significant. The productivity of the PUCS method was reported to be 212.65 kg $\$^{-1}$ due to the high production of paddy compared to the lowest costs.

Keywords: Energy use indices, Benefit to cost ratio, Paddy, Rice production

1. Introduction

Rice is one of the most important cereals in the world. Half of the world's population depends on rice as a staple food. Rice (*Oryza sativa, L.*) is a genus of perennial grass in the Poaceae (grass family), grown in tropical- water abundant areas around the world (Nabavi-Pelesaraei et al., 2019a). Iran is one of the major paddy producers in the Middle East. Rice produced in Iran provides about two thirds of Iran's annual consumption. The total cultivated area and yield of paddy in Iran is about 422746 ha and 47310 t, respectively (FAO, 2020). In Khuzestan province of Iran, different methods are used to cultivate rice, including Paddy-Transplanting System (PTS), Paddy Direct Seeding Flooding System (PDSFS) and Paddy-Upland Cultivation System (PUCS) methods are among the spun methods. Drought is considered as a problem in certain areas of the southern provinces, while 200,000 to 300,000 hectares in the Khuzestan province are affected by water salinity (Ministry of Jihad-e-Agriculture of Iran, 2020). Almost all local paddy cultivars have a maximum yield of 3 to 3.5 tons per hectare under standard soil conditions pH 7.0-7.5. But in the modified cultivars, this figure is 5 and 7 tons per hectare. The low yield of local species (average 2.5 to 3.5 tons per hectare), due to their excellent quality characteristics has led to more than 80% of the total rice area in Iran under cultivation of these species (Mahmuti et al., 2011).

The role of energy in the agricultural sector, especially in case of crop production, has been considered by researchers in recent years. Energy is the most important driving force of human development, capacity and ability to do work. Throughout history, people have always tried to harness energy and turn it into useful and usable forms (Saber et al., 2020). The process of conversion and consumption of energy intensified with the passage of human from the traditional stage to modernization, when the import and consumption of energy inputs in agriculture coincided with the increase of production (Kaab et al., 2019). However, increasing production in modern agricultural systems has reduced the energy efficiency of these systems compared to traditional systems and has challenged the sustainability of current agricultural systems (Gündoğmuş, 2006). Fossil fuels use have many negative environmental impacts through the release of carbon dioxide and other gases. Of course, energy consumption in the agricultural sector depends on the number of population involved in agriculture, the amount of arable land and the level of mechanization (Dalgaard et al., 2001). Efficient use of energy in agriculture is one of the important factors to achieve sustainable production in agriculture, because it saves financial resources, protects fossil resources and reduces air pollution (Camargo et al., 2013). In fact, the inherent characteristics of production resources, agricultural products and potentials that allow the agricultural sector to play a key role in the development of the economy in various ways (Tey et al., 2014). Attention to regional capacities is the basis for increasing the productivity of factors of production as a necessary precondition for economic development. Considering the limited resources and the importance of preventing the loss of resources, especially in developing countries, it is necessary to evaluate investment projects from an economic point of view (Erdal et al., 2007). This study examines the general structure of cost-benefit analysis of the performance of different rice cultivation systems in the agricultural sector of Khuzestan province. Some researchers have reported that a significant portion of greenhouse gas emissions from the agricultural sector are reduced through improved farming methods. Increasing energy consumption from diesel fuel sources and widespread use of chemical fertilizers, machinery, etc. have led to environmental issues such as greenhouse gas (GHG) emissions. Under such conditions, quantification of input and output energy during production along with environmental effects related to crop life cycle, has attracted increasing attention in agricultural management (Yadav and Mishra, 2013).

The study of the role of energy and economic in agricultural products has been considered by researchers in the agricultural sector in recent years. Khan et al. (2010) showed that in examining the energy needs of wheat, rice and barley, the energy efficiency of rice is 1.6, also stated that the highest input energy of rice fields is related to chemical fertilizers (43%). In a similar study, the ratio of water energy in canal irrigation systems in wheat, rice and barley was estimated to be 12.7%, 93.37% and 86.12%, respectively, also, the ratio of water energy in pump irrigation systems was estimated 1.19, 50.47 and 40.35, respectively (Khan et al., 2009a). Iqbal (2007) in another study on rice in Bangladesh showed that the input energy for a medium area (1-2 hectares) is 29394 MJ and the output energy is 1154444 MJ, the researchers showed that they calculated the average output and input energy for rice production on small, medium and large farms in Nigeria. The amount of input energy was reported to be about twice that of the output energy, to reduce the amount of input energy, the level of mechanization should be increased. The net energy value for the fields was 82733, 88321 and 93226 MJ ha^{-1}, respectively, the energy efficiency of large farms has been emphasized due to better management of resource use (Kosemani and Bamgboye, 2020). Also, a study conducted in China on fully mechanized rice production (FM) and semi-mechanized rice production (SM) shows that the input fuel SM was 691.19 MJ ha^{-1} less than FM. The estimate refers to the level of mechanization, in addition to fuel, fertilizer and water were other inputs that accounted for a total of 92.02% of the total input energy (Yang et al., 2022).

Khuzestan province of Iran has long been the origin of rice cultivation. The issue of water shortage is one of the most important issues in this province. The problems of Khuzestan province are due to mismanagement and use of its resources. Due to the increase in rice prices, it is necessary to study the economic viability of rice so that water resources are not wasted. Accordingly, from an ecological point of view, energy analysis in agriculture plays an important role in developing human perspectives on the ecosystem of agricultural systems. In addition, it creates an environmentalist perspective in terms of resource efficiency, energy production and increasing the efficiency of the energy input system. Given the limited energy resources, the agricultural system's reliance on inputs must be determined. This issue should then be influential in future decisions to design sustainable systems ecosystems for sustainable development. To achieve this goal, paddy production systems have been analyzed in terms of input and output energy to make rational solutions.

So far, no study has examined the energy consumption and economic for paddy cultivation in Khuzestan province. In this study, in terms of evaluating the life cycle of paddy production systems, the best systems was selected in terms of cultivation pattern. Considering the comparative advantage of different economic activities, it is one of the important aspects of economic planning. Due to the importance of paddy in Iran's agricultural economy and the need to plan the development of cultivation and export of paddy products based on comparative advantage, knowledge of comparative advantage and strengthening it is very important. Based on the comparative advantage, three method including PTS, PDSFS and PUCS which have a special place in terms of production in the agricultural sector, were studied and determined. Since this province is an important area for producing paddy crops in Iran, a comprehensive investigation of energy, economic in different paddy systems is considered as a main purpose of this study. To achieve the objectives of this research, it is necessary to perform the following evaluation steps:

- Calculation of energy indices of different paddy systems.
- Evaluate the impact points in energy production to manage energy consumption.
- Economic analysis for different paddy systems.
- Determining the best systems according to the energy consumption and economy.

2. Materials and methods

2.1. Rice cultivation methods

The data for this study was collected from Khuzestan province–Shushtar city farmers. The Shushtar city is located at latitude from 48° 35′ to 49° 12′ East and longitude from 56° 34′ to 56° 14′ North (Ministry of Jihad-e-Agriculture of Iran, 2020).

Initial data related to all types of agricultural input parameters (the quantities of seed, fertilizer, biocides, etc.), energy conduits, applied equipment and machineries, areas of land under cultivation by farmers, yield of paddy farms, etc. are randomly gathered from 200 paddy producers using a self-structured questionnaire. The method of Cochran (1977) was used to calculate the required sample size in the study.

$$n = \frac{\frac{z^2 pq}{d^2}}{1 + \frac{1}{N}\left(\frac{z^2 pq}{d^2} - 1\right)} \qquad (1)$$

Where, *n* is the required sample size, *N* is the number of farms per target population, *z* is the reliability coefficient (equals to 1.96, denoting 95% confidence level), *p* is the estimated proportion of an attribute that is present in the population (equals to 0.5), *q* is 1-p (equals to 0.5), and *d* is the permitted error ratio deviation from the average population (equals to 0.05).

2.2. An overview of energy-economic indices

Paddy production inputs include human labor, machinery, diesel fuel, chemical fertilizers, biocides, water, electricity and seeds. Data related to inputs and outputs of rice fields were collected through questionnaire design and interviews with farmers. In the next step, the amount of each input and output was calculated per hectare of arable land. Due to the different inputs and outputs of cultivation with different units, comparisons are difficult in these conditions. As a result, all inputs and outputs were converted into energy equivalents through special coefficients. The energy equivalent of each of the inputs is reported in Table 1.

Table 1

Energy inputs-output coefficients in paddy production.

Items	Unit	Energy equivalent (MJ unit^{-1})	References
A. Inputs			
1. Human labor	h	1.96	(Banaeian et al., 2011)
2. Machinery	kg yr[a]	62.70	(Ghasemi-Mobtaker et al., 2020)
3. Diesel fuel	L	56.31	(Ghasemi-Mobtaker et al., 2020)

4. Chemical fertilizers	kg		
(a) Nitrogen		78.10	(Canakci et al., 2005)
(b) Phosphate (P_2O_5)		17.40	(Canakci et al., 2005)
5. Biocides	kg	250	(Kaab et al., 2019)
6. Electricity	kWh	12	(Mohseni et al., 2018)
7. Seed	kg	14.7	(Šarauskis et al., 2018)
B. Output	kg		
1. Paddy		17	(Šarauskis et al., 2018)

[a] The economic life of machine (year).

By estimating the total input and output energies, energy evaluation indicators such as energy ratio or efficiency, energy productivity, specific energy and net energy efficiency were calculated for each planting system (Mohseni et al., 2018). The described indices were determined to evaluate the relationship between input and output energy per hectare, which according to crop type, soil type, tillage operation for seedbed preparation, type and amount of chemical and livestock fertilizers, storage, maintenance and harvesting operations changes (Mohammadi et al., 2010). The energy indicators are as follows: Energy efficiency (Equation 2) is the ratio of energy input to the system to energy output from the system. In economic definitions, energy efficiency is the amount of product (output) obtained per unit of energy consumed by the energy consuming sectors. Energy efficiency involves processes that reduce the amount of energy consumed in the production of goods and services in an economic unit and prevent unnecessary consumption (Brentrup et al., 2001); The amount of production of goods and services per unit of energy consumption is called energy productivity (Equation 3). In other words, this index shows how much added value is produced for a specific energy consumption, and the larger the index, the lower the energy consumption and the higher the energy productivity (Yang et al., 2022); Energy intensity indicates (Equation 4) the amount of energy consumption per unit of production of goods and services. The importance of this index is that it expresses the amount of energy productivity and shows how much energy is consumed to produce each unit of goods and services. Since the reverse energy intensity index is the energy productivity index, the larger the index, the lower the energy productivity. It also shows that they use more energy to produce a unit of goods and services, and vice versa (Hosseinzadeh-Bandbafha et al., 2018); Net energy gain (Equation 5) is the difference between the total amount of energy output and the input energy. This index is defined in units of level. In agricultural production, especially in crops grown for energy production, the goal is usually to achieve the maximum net energy gain.

$$\text{Energy use efficiency} = \frac{\text{Output energy (MJ)}}{\text{Input energy (MJ)}} \tag{2}$$

$$\text{Energy productivity} = \frac{\text{Production (kg)}}{\text{Input energy (MJ)}} \tag{3}$$

$$\text{Specific energy} = \frac{\text{Input energy (MJ)}}{\text{Production (kg)}} \quad (4)$$

$$\text{Net energy} = \text{Output energy (MJ)} - \text{Input energy (MJ)} \quad (5)$$

The goal in all activities, including agricultural activities, is the maximum profit. The profitability of a system is examined by economic indicators (Demircan et al., 2006). To calculate the cost of each production unit, the price of the inputs used in its production must be obtained. Expenses for purchasing seeds, fertilizers, fuel, renting machines, human labor, etc. are among the variable costs and the cost of renting land, farmer premiums and taxes are considered as fixed costs (Rajaeifar et al., 2014). The most prominent economic indicators were obtained using the following equations (Mohammadi-Barsari et al., 2016): Net profit (Equation 6) is obtained by reducing the total cost of production from gross income per hectare; Benefit-cost ratio (Equation 7) is total revenue to total cost. It is the most important economic indicator used in agricultural activities; Productivity (Equation 8) is another economic indicator that is used in economic analysis. Productivity is the weight of the product at total cost. This indicator shows the amount of product for cost. In economic matters, the effect of inflation must be taken into account.

$$\text{Net return} = \text{Gross production value } \left(\frac{\$}{\text{ha}}\right) - \text{Production costs } \left(\frac{\$}{\text{ha}}\right) \quad (6)$$

$$\text{Benefit to cost ratio} = \frac{\text{Gross production value } (\$\ \text{ha}^{-1})}{\text{Production costs } (\$\ \text{ha}^{-1})} \quad (7)$$

$$\text{Productivity} = \frac{\text{Yeild (kg)}}{\text{Production cost (\$)}} \quad (8)$$

3. Results and discussion

3.1. Energy and economic analysis

The paddy production in the study region were analyzed under three multiple cropping system scenarios based on the life cycle energy and economic, including (a) PTS, (b) PDSFS and (c) PUCS. The PTS nursery is a small piece of agricultural land in which germinated seeds are planted to become seedlings. Since rice planting in Iran is generally done by transplanting, farmers prepare the plot of agricultural land called the treasury about 6 months before the seed germination operation. In autumn the land is plowed and in late winter the soil is covered with fertilizer. They plow the land again and collect all the rocks and lumps on the soil surface. In this way, the nursery ground is ready to plant germinated seeds. Finally, the area around the treasury is covered with water so that can be stored inside the treasury. In PDSFS, which is divided into two types of stagnant and current flooding. In the stagnant flooding method, water consumption is lower than current flooding, and nutrients transfer is also lower. In the current flooding method, irrigation efficiency is low and nutrient transfer is higher, but in lands where soil permeability is high, using this method can prevent the accumulation of toxic substances and regulate soil temperature. The advantages of permanent flooding are lower costs in weed control and less irrigation supervision. Recently, using PUCS method, dry seeds are planted in a dry bed by a variety of seeders or manually at a depth of 3-4 cm of soil and immediately after that irrigation is done until the soil moisture reaches saturation. This process can continue depending on the soil texture, area conditions and soil preparation status until the end of the seedling period 25-31 days after planting and the beginning of tillering. In this method, over-irrigation of the field and creating flooding conditions and placing a fixed layer of water on the soil surface for more than 15-18 hours after planting causes suffocation of seeds, so the seeds are in the soil. Also, if there is a suitable device for sowing swollen rice seeds, it is possible to soak the seeds in water at a temperature of 25 to 30 ° C for 24 to 36 hours and then place them in the open air for 2-3 hours. Cultivated under these conditions germination and seedling emergence from the soil earlier than the dry seed and even before the second irrigation. Utilization of this planting method in the field and in the conditions of farmers, has had a relatively good growth (Ministry of Jihad-e-Agriculture of Iran, 2020).

The amount of input energy was calculated based on the amount of input consumed and agricultural operations. According to Table 2, the mean value of the total input energy for paddy production was reported by PTS (87993.14 MJ ha^{-1}), PDSFS (67351.57 MJ ha^{-1}) and PUCS (69493.40 MJ ha^{-1}) methods. In PTS method, the most energy is consumed, for transplanting operations, the seedlings are removed from the treasury and transferred to the main land. Before planting the seedlings, the nursery should be thoroughly irrigated so that the seedlings can be harvested easily and the roots will not be damaged. Due to more operations in the PTS method, its energy consumption is the highest. PTS (105400 MJ ha^{-1}), PUCS (93500 MJ ha^{-1}) and PDSFS (90100 MJ ha^{-1}) methods had the output energy from highest to lowest. In another experiment, intensive planting systems, improved and common (traditional) area in the rice field were evaluated. All energy consumption for fertilizers, seeds, plant protection, tools and machinery, transportation and crop operations in planting systems were calculated, the results showed that the average input energy in the studied systems including direct, indirect, renewable and non-renewable energies was 2424.229 MJ ha^{-1}, The total output energy in production systems was estimated at 191341 MJ ha^{-1} (Habibi et al., 2019). Another study reported that rice production consumes an average of 12906.8 MJ of energy per hectare (Ibrahim et al., 2012). The results of studies in Myanmar showed that alternative rice planting methods require significantly less input energy than conventional methods. Energy efficiency in the modified intensive planting systems method was significantly higher compared to the transplanting method and the direct planting method (Htwe et al., 2021). According to the results of rice producers in Golestan province, Iran, the types of energy inputs and outputs were calculated as 34423.28 and 120088.4 MJ ha^{-1}, respectively (Mardani et al., 2022).

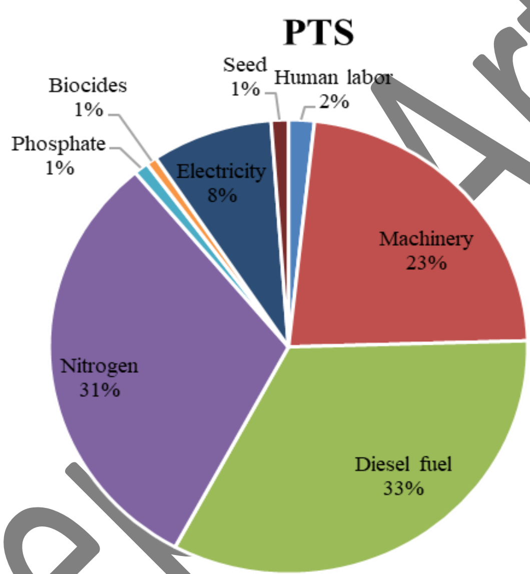
Fig. 1 shows the share of each input as a percentage, diesel fuel consumption with 33% has the highest share of energy inputs in the PTS method. In addition, nitrogen fertilizer (31%) has a significant share. As shown in Fig. 1, chemical fertilizers and diesel fuel show the highest energy inputs for rice production and are consistent with the findings of Pishgar-Komleh et al. (2011) In Iran. Due to the preparation of the treasury for rice planting and the length of the work process, human labor has the largest share of input energy in the PTS method. With the exception of nitrogen fertilizer (33%) and diesel fuel (26%) in the PDSFS method. As a result, PDSFS method consumes the most water and the amount of energy consumed due to water shortage in Khuzestan province, shows an important issue. The use of electric pumps to extract water from underground sources has increased the energy associated with these sources. As a result, electricity with 12% has a significant share in the PDSFS method. In PUCS method, diesel fuel with 10% and nitrogen fertilizer with 27% have a significant share. In this method, due to the cultivation of rice in dry land, we need the most plowing and machinery for cultivation. Also, water consumption and the use of human labor in this method are minimized. Due to the dryness of the soil, more fertilizer is needed to grow rice in this method. A comparison of the three methods mentioned is also shown in Fig. 2. Consumption of inputs such as electricity, nitrogen and human labor in PUCS method is less than PTS and PDSFS methods. The use of diesel fuel and machinery has the least energy in the PDSFS method. In a similar report, the chemical energy input from the herbicide had the largest share (53.55%), human labor had the lowest share (0.74%) of total energy consumption (Ibrahim et al., 2012). Fertilizer, fuel and water were the three major inputs for fully mechanized rice (FM) and semi-mechanized rice (SM) in China, accounting for 92.02% of total input energy (Yang et al., 2022). Energy consumption in different parts of Thailand for the production of irrigated and rain-fed rice showed that the energy of chemical fertilizers, pesticides and herbicides has the highest input energy. In addition, energy consumption is significant, which was different from the results of this study Chamsing et al. (2006), studies show that 25 percent of all energy used to produce corn in the United States comes from machinery and fuel, and 45 percent from the use of chemical fertilizers. The costs of the methods discussed are also compared in Fig. 3. PUCS method is less expensive for agriculture, due to the increase in labor costs and its shortage in agricultural areas, PUCS method is more practical.

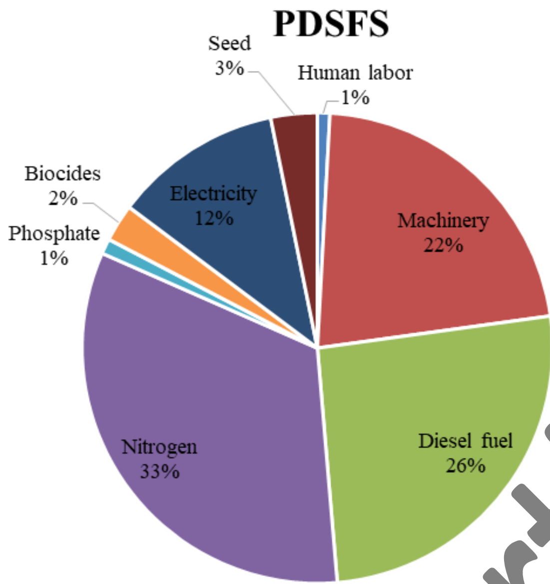
Table 2
Mean values of inputs-outputs energy equivalents in different paddy production systems in Khuzestan Province.

Items	**PTS** [a]		PDSFS [b]		PUCS [c]	
	Unit per ha	Energy use (MJ ha^{-1})	Unit per ha	Energy use (MJ ha^{-1})	Unit per ha	Energy use (MJ ha^{-1})
1. Human labor (h)	780.36	1529.51	360.65	706.87	180.32	353.43
2. Machinery (kg)	320.36	20086.57	290.63	2615.67	340.89	3068.01
3. Diesel fuel (L)	520.32	29299.22	380.59	21431.07	620.31	34929.66
4. Chemical fertilizers (kg)						

(a) Nitrogen	350.00	27335.00	350.00	27335.00	300.00	23430.00
(b) Phosphate (P_2O_5)	50.00	870.00	50.00	870.00	100.00	1740.00
5. Biocides (kg)	2.56	640.00	8.56	2140.00	6.32	1580.00
6. Electricity (kwh)	600.32	7203.84	800.56	9606.96	200.65	2407.80
7. Seed (kg)	70.00	1029.00	180.00	2646.00	135.00	1984.50
Total energy use (MJ)	**-**	**87993.14**	**-**	**67351.57**	**-**	**69493.40**
B. Output (kg)	-	-	-	-	-	-
1. PTS	6200.00	105400.00	-	-	-	-
2. PDSFS	-	-	5300.00	90100.00	-	-
3. PUCS	-	-	-	-	5500.00	93500.00

[a] Paddy-Transplanting System
[b] Paddy Direct Seeding Flooding System
[c] Paddy-Upland Cultivation System





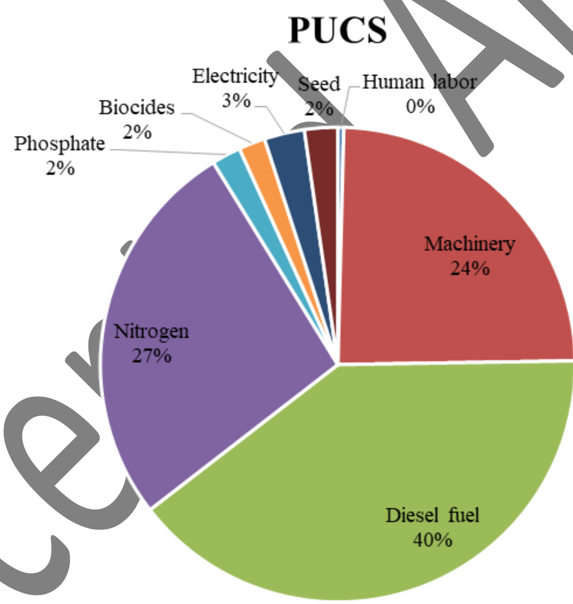


Fig. 1. Shares of energy sources in different paddy production systems in Khuzestan Province, Iran (Paddy-Transplanting System (PTS), Paddy Direct Seeding Flooding System (PDSFS) and Paddy-Upland Cultivation System (PUCS)).

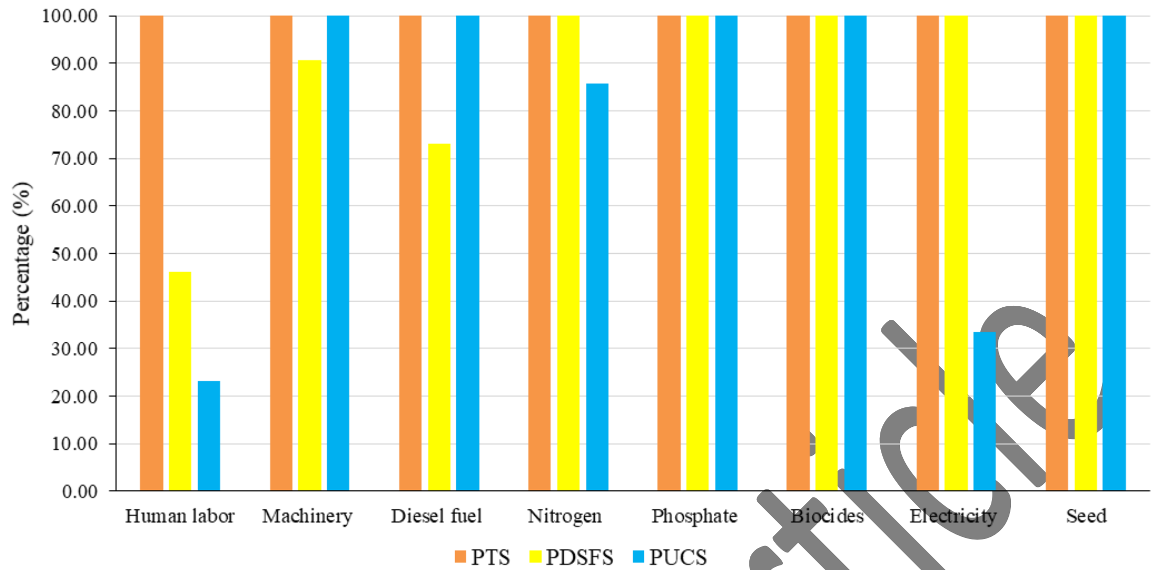


Fig. 2. Comparison between energy inputs in different paddy cultivation systems in Khuzestan Province, Iran (Paddy-Transplanting System (PTS), Paddy Direct Seeding Flooding System (PDSFS) and Paddy-Upland Cultivation System (PUCS)).

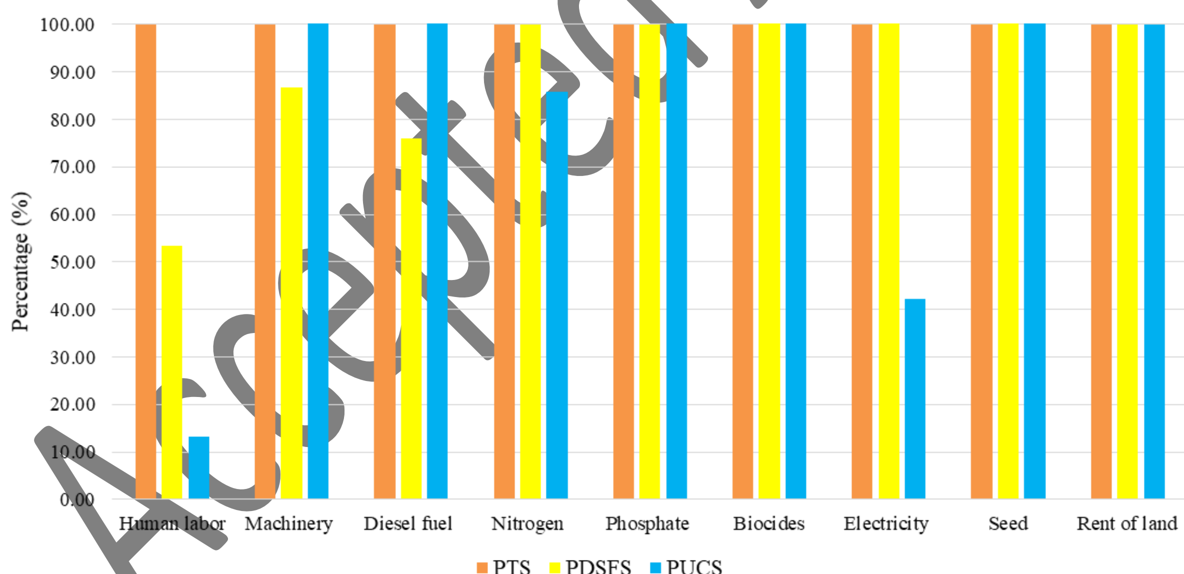


Fig. 3. Comparison between cost inputs in different paddy cultivation systems in Khuzestan Province, Iran (Paddy-Transplanting System (PTS), Paddy Direct Seeding Flooding System (PDSFS) and Paddy-Upland Cultivation System (PUCS)).

Table 3 showed the calculations of the most important energy and economic indicators, estimation of the energy ratio of PUCS method (1.34) indicates that the amount of output energy is much higher than the input energy. Productivity energy index also showed that there is no significant difference between the three methods in terms of amount of paddy relative to input energy. The specific energy of PTS method (14.19 MJ kg^{-1}) indicates large amounts of input energy relative to the amount of paddy produced. The net energy gain was reported to be positive for the three methods discussed. As a result, the output energies were higher than the input energies of PUCS (24006.6 MJ ha^{-1}), PDSFS (22748.43 MJ ha^{-1}) and PTS (17406.86 MJ ha^{-1}) methods, respectively. Energy ratio and energy productivity values vary from 1.39 to 1.67 and 0.064 to 0.070 kg MJ^{-1} for rice production in different geographical areas of Iran (Kazemi et al., 2015). Reports of energy indicators of rice production indicated that the ratio of energy and energy productivity were 4.1 and 0.3 kg MJ^{-1}, respectively (Ibrahim et al., 2012). Energy productivity for rice production in Australia was estimated at 0.41 kg MJ^{-1}, but the energy intensity was reported to be 2.44 MJ kg^{-1} (Khan et al., 2009b). The product value (3472 \$ ha^{-1}) and cost (529.60 \$ ha^{-1}) in PTS method are the highest and lowest, respectively. As a result, the net return of PTS method is 2942.40 \$ ha^{-1}. Based on the high revenue and low cost, the benefit to cost ratio at the expense of PTS method is significant. The productivity of the PUCS method was reported to be 212.65 kg $\$^{-1}$ due to the high production of paddy compared to the lowest costs. Analysis of economic benefits of rice production shows that alternative rice cultivation methods have significantly higher cost-benefit ratio than conventional methods (Htwe et al., 2021).

Table 3

Energy and economic indices and water use efficiency in different paddy cultivation systems in Khuzestan Province, Iran.

A. Energy indices (unit)	PTS [a]	PDSFS [b]	PUCS [c]
Energy use efficiency (ratio)	1.19	1.33	1.34
Energy productivity (kg MJ^{-1})	0.07	0.07	0.08
Specific energy (MJ kg^{-1})	14.19	12.70	12.63
Net energy gain (MJ ha^{-1})	17406.86	22748.43	24006.6
Water use efficiency (kg m^3)	0.89	0.64	2.20
B. Economic indices (unit)			
Total value from production (\$ ha^{-1})	3472.00	2968.00	3080.00
Total cost from production (\$ ha^{-1})	529.60	628.70	526.70
Net return (\$ ha^{-1})	2942.40	2339.30	2553.30
Benefit to cost ratio (ratio)	6.60	4.72	5.84
Productivity (kg $\$^{-1}$)	194.50	184.50	212.65

[a] Paddy-Transplanting System

[b] Paddy Direct Seeding Flooding System

[c] Paddy-Upland Cultivation System

4. Conclusions

This study analyses energy and economic in different paddy systems in Khuzestan province. The mean value of the total input energy for paddy production was reported by PTS, PDSFS and PUCS methods, were 87993.14 MJ ha^{-1}, 67351.57 MJ ha^{-1} and 69493.40 MJ ha^{-1}, respectively. Input and output energies for PTS, PDSFS and PUCS methods indicated high energy consumption in PTS method. PTS method with an energy intensity of 14.19 MJ kg^{-1} shows the highest energy consumption per paddy production. More use of electricity to pump water is an important reason for this difference. Definitely, leveling paddy lands has an effect on reducing water and energy consumption. As a result of economic, the net return of PTS method is 2942.40 \$ ha^{-1}. Based on the high revenue and low cost, the benefit to cost ratio at the expense of PTS method is significant. The productivity of the PUCS method was reported to be 212.65 kg \$$^{-1}$ due to the high production of paddy compared to the lowest costs. Due to the high labor costs in rice cultivation and the consequences of working in rice fields, the role of agricultural mechanization becomes more prominent. To achieve a sustainable production system, energy efficiency and the share of renewable energy in ecosystems must be increased. Disadvantages and problems of the rice system are high labor costs, high energy costs for pumping groundwater, water shortage due to insufficient overall supply and high cost of inputs. Optimizing energy consumption in the ecosystem of crop systems will help reduce the cost of crop operations, improve air quality, reduce greenhouse gas emissions and sustainable development. Therefore, the study of management of different paddy systems indicates a desirable method for optimizing the required inputs, performance and supply of net energy. Therefore, appropriate solutions should be used to reduce the environmental impact of agricultural production systems in order to improve productivity and achieve high yields per unit of land by increasing resource efficiency.

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