Energy use Pattern in Cotton and Groundnut Production in the Gezira scheme, Gezira State, Sudan

ABSTRACT: This research examines the energy use patterns and energy input–output analysis of cotton, and groundnut in the Gezira Scheme which is the largest irrigated scheme in Sudan. Inputs and energy sources were determined by a face to face questionnaire applied to 200 farmers. For the cotton crop, the inputs and output energy were calculated as 27659.28MJ/ha and 28084MJ/ha, respectively. Fertilizer was the highest input (62.29%), followed by water (28.10%). Energy efficiency, energy productivity, specific energy and water productivity were 1.01, 0.09kg/MJ,11.62MJ/kg, 0.31kg/m^3, respectively. For the groundnut crop, the inputs and output energy were calculated as10222.83MJ/ha and 67372MJ/ha, respectively. Water was the highest input (72.25%), followed by seeds (8.56%). Energy efficiency, energy productivity, specific energy and water productivity were 6.59, 0.40kg/MJ,2.51MJ/kg, 0.29kg/m^3, respectively.it could be concluded that these crops are heavily dependent on nonrenewable energy.

Keywords: Energy, Gezira Scheme, energy efficiency, specific energy, energy productivity.

1. INTRODUCTION

Sudan is a predominantly agricultural country with approximately 70% of its population dependent on agriculture.~~Sudan is a predominantly agricultural country. About 70% of its population depends on agriculture.~~ Crop production is a direct function of high yielding varieties, chemicals, fertilizers, mechanization and other energy inputs. Field crops are produced using energy sources ranging from human and animal power to power of heavy machinery. Energy input and yield vary with each system, influencing the ultimate output–input ratio. The relation between agriculture and energy is very close. Agriculture itself is an energy user and energy supplier in the form of bio-energy (Alam et al., 2005). Energy use in agriculture has developed in response to increasing populations, limited supply of arable land and desire for an increasing standard of living. In all societies, these factors have encouraged an increase in energy inputs to maximize yields, minimize labor intensive practices, or both (Esengun et al., 2007). The increased use of inputs such as fertilizer, irrigation water, diesel, plant protection chemicals, demands more energy in the form of human, animal and machinery. The rising price of energy, particularly of crude oil, has significant implications for profitability of agriculture. Increasing use of energy-based inputs and rising oil prices are likely to enhance the cost of production in agriculture. Effective energy use in agriculture is one of the conditions for sustainable agricultural production, since it provides financial savings, fossil resources preservation and air pollution Reduction (Uhlin, 1998). For the growth and development, energy demand in agriculture can be divided into direct and indirect, renewable, and non-renewable energies (Alam et al., 2005). The energetic efficiency of the agricultural system has been evaluated by the energy ratio between output and input. Human labor, machinery, diesel oil, fertilizer, pesticides and seed amounts and output yield values of crops have been used to estimate the energy ratio.

Energy needs for agricultural production are about 3% of the national energy consumption in developed countries and about 3.6% in developing countries (Karkacier et al., 2006; Sauerbeck, 2001). However, the energy input per hectare in developing countries for agricultural production is about 7700 MJ and in developed countries, it is about 37,900 MJ. In developing countries, human labor is the major cost item of energy; while, in developed countries, mechanization and fertilizers are the major energy inputs (Pimentel and Pimentel, 2008). The entire food system including production, processing, packaging, and transportation could require about 15% to 20% or more of a nation's energy consumption (Stout, 1990; Ziesemer, 2007). According to various studies done in this field, the process of production between 60% and 90% of consumer energy is non-renewable (Canakci et al., 2005; Ozkan et al., 2004).

Chemical fertilizers, pesticides, agricultural machinery, and other farm inputs are used extensively in modern agriculture. Crop specific fertilizer recommendation and input use may ensure economic production (Sultana et al. 2015; Hossain and Siddique, 2015). Efficient use of energy inputs in agriculture will reduce environmental impacts, prevent damage to natural resources, and improve the sustainability of agriculture as an economical production system (Kizilaslan, 2008).

Increasing energy consumption anywhere will be accompanied by increased negative effects on the environment. It is accepted that air pollution, acid rain, and especially, global climate change has been mostly caused by greenhouse gas emissions from fossil fuel combustion. In addition, use of some renewable energy sources is expensive and, as well as having technological limitations, may cause environmental impacts (Boyle, 2004). The use of mineral fertilizers and pesticides lead to higher yields in a conventional cropping system, but also requires higher energy inputs compared with organic systems (Dalgaard et al. 2001; Grastina et al. 1995). The important consideration involving fertilizer use is optimizing the use of fertilizers in agriculture for yield, soil management, soil quality, resource utilization and avoid land degradation (Siddique et al. 2017; Hossain and Siddique, 2015;). For better growth, farmers use extra nutrients. Three different kinds of fertilizer are used in agriculture: chemical, organic and biological. Chemical fertilizers have increased the yield more than other innovations in agriculture (Smil, 2008).

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Many researchers in various countries studied energy analysis to determine the energy efficiency of field crop production, such as sugarcane in Morocco (Mrini et al. 2001), soybean, maize and wheat in Italy (Sartori et al. 2005), wheat, maize, sorghum in USA (Franzluebbers and~~,~~ Francis 1995), field crops in Turkey (Canacki et al,2005,) soybean in India (Mandal, 2002), millet in Nigeria (Abubakar and Ahmed, 2010) wheat and sorghum in Sudan (Elfadil, 2018, a and b). In Sudan like any other developing country, there is a lack of data on energy expenditure and returns in agricultural production systems. To meet the growing demand of the increasing population and for exports, the productivity of agricultural inputs would require better management of food production systems. Therefore, the assessment of energy consumption for crop production is required to understand the current situation for improved use of energy resources and for future steps to be taken in order to improve vegetable production.

The aim of this study is to

1. To determine the energy input and output used in cotton and peanut production

2. To identify processes where energy savings can be achieved by changing the practices applied to increase the energy rate

3. Suggest improvements for these products to reduce energy consumption~~The aim of this study was to~~

1. ~~Determine the energy input and output used in cotton and groundnut production.~~
2. ~~Identifies operations where energy savings could be realized by changing applied practices in order to increase the energy ratio.~~
3. ~~Propose improvements to reduce energy consumption for these crops.~~

2. MATERIALS AND METHODS

The study was carried out in 200 cotton and groundnut producers in the study area. Data were collected from the growers by using a face-to-face questionnaire. The data collected belonged to the production period of 2019–2020. The data covered farmer's socio-economic variables, inputs as well as outputs data. The total energy per production unit (ha) was established by the addition of the partial energies of each input referenced to the unit of production. Energy inputs were human labor, diesel fuel, machinery, irrigation, chemical fertilizers consisting of nitrogen and phosphorous. Basic information on energy inputs and yields were entered into Excel spreadsheets. Based on the energy equivalents of the inputs and output (Table 1), the energy ratio (energy use efficiency), energy productivity and the specific energy were calculated (Sartori et al., 2005; Demircan et al., 2006; Shahan et al., 2008).

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Energy use efficiency (energy ratio)	=	$\frac{\text{Energy output (MJ/ha)}}{\text{Energy input (MJ/ha)}}$	……………..(1)
Energy productivity (kg/MJ)	=	$\frac{\text{Yield (kg/ha)}}{\text{Energy input (MJ/ha)}}$	……………..(2)
specific energy (MJ/kg)	=	$\frac{\text{Energy input (MJ/ha)}}{\text{Yield (kg/ha)}}$	………………(3)
Water productivity (kg/m^3)	=	$\frac{\text{Yield (kg)}}{\text{water applied } (m^3)}$	………………(4)
Net Energy (MJ/ha)	=	Energy outp − Energy input	……………(5)

Table 1. Energy equivalent of inputs and outputs in field crop production.

Item	Unit	Energy equivalent (MJ/unit)	Reference
A. Input			
1. Human labor	Hr	2.30	(Yaldiz et al. 1993).
2. Machinery 3. Tractor	Hr Hr	62.70 68.40	(Mohammadi et al. 2008; Erdal et al. 2007; Giampietro et al. 1992; Singh et al., 2002; Singh,2002; Singh & Mittal 1992)
4.Fuel	L	56.31	(Erdal et al., 2007; Singh et al., 2002; Mohammadi et al 2008).
5.Fertilizer			
Nitrogen Phosphate	Kg Kg	66.14 12.44	(Esengun et al. 2007; Yilmaz et al. 2005; Mohammadi and Omid 2010).
6.Pesticides	Kg L	20.90 101.20	(Canakci et al., 2005; Singh, 2002)
7.Water	m^3	1.02	(Shahan et al.,2008; Acaroglu and Aksoy, 2005; Mohammadi et al. 2008).
8.Seeds			
Cotton	Kg	11.80	Yaldiz et. al.1993; Singh, 2002
Groundnut	Kg	25.00	(Kitani, 1999)
9.Yield			
Cotton Stalk	Kg Kg	11.8 2.25	Yaldiz et. al.1993; Singh, 2002; Shresta, 1998, Zahedi et al. 2014
Groundnut seed Straw	Kg Kg	25.00 11.60	(Kitani, 1999) Ibrahim et. al. 2016.

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2.1. Data analysis

The data collected were analyzed using descriptive statistics. The energy equivalents of inputs used and output obtained are illustrated in Table 1. The data on energy use have been taken from a number of sources, as indicated in the table. Based on the energy equivalents of the inputs and output, the energy ratio (energy use efficiency) and energy productivity were calculated using equations 2 and 3.
The input energy was divided into direct energy (labor, fuel and water) and indirect energy (seeds, fertilizer, chemicals, machinery and tractors). Further, the input energy was divided into renewable energy including labor and seeds, and nonrenewable energy including fuel, chemicals, fertilizers, machinery, tractors and water (Rauf et al 2011).

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3. RESULTS AND DISCUSSION

3.1. Socioeconomic structure:

For cotton, the maximum area grown was 6.3 ha with an average of 1.1 ha. For groundnut, the area grown ranges from 0.4 to 6.70 ha with an average of 2 ha The education level was: 42.72 percent of the farmers were *khalwa*, 19.42 percent preliminary school, 27.18 secondary schools, 9.71 percent university graduates and 0.97 percent were post-graduates. About 70% of the farmers were below 50 years in age and about 11.65% were above 60. About 6.80% of the sample were females with *khalwa* education. 5.83% of the respondent agriculture is not their main job. Land preparation and soil tillage, opening furrows for manually planting of seeds, and inter-row weeding operations are mechanically carried out. Other operations are performed by hand. Land preparation and tillage were mostly accomplished by 70hp tractor along with using disk plow, harrows ditcher and ridger. Fertilizer is mainly applied through broadcasting. Spraying is done with the use of hand operated knapsack sprayer. Harvesting of cotton is done manually by direct picking. Groundnut is manually pulled from the soil, windrowed for drying and then collected in heaps and threshed mechanically.

3.2. Energy use in cotton production

3.2.1. Energy input output

The energy inputs used in cotton production and their energy equivalents, as well as the energy equivalent of the yield were presented in Table 2. As indicated in the table, the total energy input and output for cotton production in the study area was found to be 27659.28 and 28084MJ/ha, respectively, compared to 34424.19 and 41496.67 in Iran (Sami and Habib,2018) and 49736.9 and 36729.90 in Turkey (Yilmaz et al.,2005). Average cotton yield in the study area was 2380kg/ha which is lower than Iran (3517kg/ha) and higher than 1994kg/ha in China (Khan et al, 2007).

Fertilizer was the highest energy input for cotton production. About 357.06 kg of fertilizer in the form of urea and phosphorus were used on a hectare basis. This amount is equivalent to 62.29% of the total input energy used. This value is lower than 76% % in China (Khan et al,2007), but higher than 28.86% in Turkey (Yilmaz et al, 2005) and 20% in Isfahan, Iran (Zahedi, et al, 2014).

3.2.2. Energy efficiency (Energy ratio)

Based on these values output–input energy ratio for cotton production under the Gezira conditions was 1.01 (Table 3), compared to Turkey (0.74), china (1.51) and Iran (0.71).

3.2.3. Energy Productivity

Energy productivity is the term used to estimate the yield of marketable product received on per unit of energy consumed (kg/MJ). The energy productivity was calculated as 0.09kg/MJ (Table 3), which is closer to Iran (0.10kg/ha) lower than China (0.21) and higher than Turkey (0.06)

3.2.4. Specific Energy

Specific energy shows the amount of energy spent to produce a unit of marketable product (MJ/kg). It was found to be 11.62MJ/kg (Table 3), which is higher than China (4.76MJ/kg) and Iran (9.7MJ/kg).

3.2.5. Net energy

It is the difference between the output energy and input energy. It was calculated as 424.72MJ/ha (Table 3), compared to 7372.48MJ/ha in Iran and (-13007MJ/ha) in turkey.

3.2.6. Water Productivity

Water productivity is generally defined as crop yield per cubic meter of water consumption. Water productivity defined as above varies from region to region and from field to field, depending on many factors, such as crop patterns and climate patterns, irrigation technology and field water management, land and infrastructure, and input, including labor, fertilizer and machinery. In this study, water is the second highest input (7771.43 liter/ha) equivalent to 28.10% of the total energy input share. Water productivity was calculated as 0.31kg/m^3(Table 3). This value is closer to Iran and Turkey, (0.44 kg/m^3 and 0.37 kg/m^3), respectively but lower than China (0.8 kg/m^3)

Table 2. Amount and percentage of different inputs and output energy equivalent for cotton

A. Inputs	Unit/ha	MJ/ha	Percent of total input energy
Labor (hr/ha)	116.64	504.24	1.82
Machinery (hr/ha)	4.76	298.45	1.08
Tractor (hr/ha)	4.76	325.58	1.18
Fuel (l/ha)	7.14	402.05	1.45
Fertilizer (kg/ha)	357.06	17228.91	62.29
Pesticide (kg)	9.52	963.42	3.48
Water (m^3)	7619.05	7771.43	28.10
Seeds (kg)	14	165.20	0.60
B. Outputs			
Yield (kg)	2380	28084	

Table 3. Various Energy performance parameters in cotton production

Parameter	Unit	
Total Input Energy	MJ/ha	27659.28
Total Output Energy	MJ/ha	28084
Energy use efficiency	-	1.01
Yield	kg/ha	2380
Specific energy	MJ/kg	11.62
Energy Productivity	kg/MJ	0.09
Net energy (MJ/ha)	MJ/ha	424.72

Table 4. Total energy input categories for cotton production

Form of Energy	Amount (MJ/ha)	%
Direct Energy	8677.72	31.37
Indirect Energy	18981.56	68.63
Renewable Energy	669.44	2.42
Non-Renewable	26989.84	97.58
Total energy input	27659.28	100

The use of direct energy for cotton production is very high (68.63%) (Table 4), which is closer to Isfahan, Iran (68.3%), higher than China (14%) and Turkey (42.5%). There is a very extensive use of nonrenewable energy (97.58%) compared to 87.4% in Turkey,90% in China and 77.7% in Isfahan, Iran.

Fertilizer is the highest among the inputs. This excessive use suggests that the nitrogen not consumed by the plant may pollute the underground water and the environment as noted by Kaplan et al. (1999).

3.3. Energy use in groundnut production:

The inputs used and their energy equivalents, output energy equivalent are illustrated in Table 5. About 220.10 of man-hrs are needed for growing one hectare of groundnut. No fertilizers were applied, only small amount of pesticides for seed coating was used. The total energy equivalent of inputs was calculated as 10222.83MJ/ha compared to 19248.04MJ/ha in Iran.

Table 5. Amount and percentage of different inputs and output energy equivalent for groundnut.

A. Inputs	Unit/ha	MJ/ha	Percent of total input energy
Labor (hr/ha)	220.10	504.24	4.95
Machinery (hr/ha)	8.33	522.29	5.11
Tractor (hr/ha)	8.33	569.77	5.57
Fuel (l/ha)	7.23	407.12	3.98
Fertilizer (kg/ha)	-	-	-
Pesticide (kg)	2.85	59.57	0.58
Water (m^3)	7142	7284.84	71.25
Seeds (kg)	35	875	8.56
B. Outputs		62500	
Yield (kg)	2080	52000	
Straw (kg)	420	10500	

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Water had the highest share (72.25%) followed by seed (8.56%), tractor (5.57%) and machinery (5.11%), respectively. The energy inputs of pesticides were very low (0.58%) relative to the other inputs used in production. The average yield of groundnut was about 2080 kg/ha and its energy equivalent was calculated to be 62500 MJ, the straw production was 420kg/ha equivalent to 487MJ/ha resulting in a total energy output of 67372MJ/ha. Based on these values, output–input energy ratio was found to be 6.59, energy productivity was 0.40 kg/MJ, specific energy 2.51MJ/kg and water productivity was calculated as 0.57MJ/kg whereas the net energy was calculated as 57149.17MJ (Table 6).

Table 6. Various Energy performance parameters in groundnut production

Parameter	Unit	
Total Input Energy	MJ/ha	10222.83
Total Output Energy	MJ/ha	67372
Energy Use Efficiency	Ratio	6.59
Yield	kg/ha	2080
Specific Energy	MJ/kg	2.51
Energy Productivity	kg/MJ	0.40
Water Productivity	kg/m^3	0.57
Net Energy (MJ/ha)	MJ/ha	57149.17

Table 7. Total energy input classifications for groundnut production

Form of Energy	Amount (MJ/ha)	%
Direct Energy	8186.20	80.18
Indirect Energy	2026.63	19.82
Renewable Energy	1379.24	13.49

Non-Renewable	8843.59	86.51
Total Energy Input	10222.83	100

Table 7. shows that the direct energy inputs (labor, fuel and water) was 80.18% and the indirect energy (seeds, fertilizer, chemicals, machinery and tractors) was 19.82%. Further, the input energy was divided into renewable energy 13.49% (labor and seeds) and nonrenewable energy 86.51% (fuel, chemicals, fertilizers, machinery, tractors and water). From Table 7. It is clear that groundnut production is heavily dependent on direct and nonrenewable energy which may not be sustainable in the long run.

4. CONCLUSIONS

1. The production of cotton and groundnut in the study area is highly dependent on non-renewable energy inputs which may not be sustainable in the long run.
2. Energy efficiency and productivity for the two crops in the research area were very low.
3. There is a need to use high yielding varieties to increase energy use efficiency and energy productivity.
4. There is a bad need for improving water productivity because of rising competition of finite water resources, rising demand of agriculture and devastating impact of climate change.

REFERENCES:

Abubakar M.S. and D. Ahmed. 2010. Pattern of Energy Consumption in Millet Production for Selected Farms in Jigawa, Nigeria. Australian Journal of Basic and Applied Sciences, 4: 665-672. Acaroglu, M. and Aksoy, A. S. 2005. The cultivation and energy balance of *Miscanthus giganteus* production in Turkey. Biomass Bioenergy, 29, 42–48.

Acaroglu, M. and Aksoy, A. S. (2005). The cultivation and energy balance of Miscanthus giganteus production in Turkey. Biomass Bioenergy, 29, 42–48.

Alam, M. S., Alam, M. R. and Islam, K. K. (2005). Energy Flow in Agriculture: Bangladesh. American Journal of Environmental Sciences, 1(3), 213–220.

Boyle, G. 2004. Renewable energy (2nd ed.). Oxford; New York: Oxford University Press in association with the Open University.

Canakci, M. Topakci, M. Akinci, I. and Ozmerzi, A. 2005. Energy use pattern of some field crops and vegetable production: case study for Antalya region, Turkey. Energy Conversion and Management, 46, 655–666.

Elfadil, A. D. 2018. Energy use pattern for rainfed and irrigated sorghum production in the Sudan. Journal of Science, Technology and Environment Informatics, 06(01), 458-465.

Elfadil, A. D. 2018. Energy use pattern in wheat production in the Gezira and Rahad Schemes, Sudan. Journal of Bioscience and Agriculture Research, 18(01), 1470-1477.

Erdal, G., Esengun, K., Erdal, H. and Gunduz, O. 2007. Energy use and economic analysis of sugar beet production in Tokat province of Turkey. Energy, 32, 35–41.

Esengun, K., Erdal, G., Gunduz, O. and Erdal, H. 2007.Input–output energy analysis in dry apricot production of Turkey. Energy Convers Manage. 48: 592–598.

Franzluebbers A.J., Francis C.A., 1995. Energy output input ratio of maize and sorghum management systems in Eastern Nebraska. Agriculture, Ecosystems and Environment, 53: 271–278.

Giampietro, M. Cerretelli, G. and Pimentel, D. 1992. Energy analysis of agricultural ecosystem management: human return and sustainability. Agricultural and Ecosystems Environment, 38, 219–244.

Comment [GF5]: Which one is a or b?

Grastina, L. Temple, S. and Diana B. 1995. Energetic analysis of four-farming system during the conversion from conventional to organic farming system in the Sacramento Valley California. Rivista di Agronomia, 29.

Ibrahim, M.O., Faisal A.A and Yousof R.S. 2016. The chemical composition of Sudanese foodstuff (central and Eastern Sudan). Animal Resources Research Corporation (ARRC), Animal production Research Center, Khartoum, Sudan.

Hossain, M. A. and Siddique, M. N. A. 2015. Water-A limiting resource for sustainable agriculture in Bangladesh. EC Agriculture, 1(2), 124-137.

Karkacier, O., Gokalp Goktolga, Z. and Cicek, A. 2006. A regression analysis of the effect of energy use in agriculture. Energy Policy, 34(18), 3796-3800.

Kaplan, M, Sonmez, S, Tokmak, S. 1999. The nitrate content of well waters in the Kumluca region-Antalya. Turkish Journal of Agriculture & Forestry, 23:9–14.

Khan,~~.~~ S., ~~S.~~ Mushtaq, S., ~~M.~~ Hafeez, M., ~~D.~~ Dawe D. and ~~T.~~ Rana, T.~~.~~ 2007. Conjunctive water management options: Examples from economic assessment of system-level water saving through Liuyuankou Irrigation System. J. Irrig. & Drainage Sci. 56 (5) 523–539

Kitani, O. 1998. Energy and environment in agricultural engineering research. In: International Engineering Conference Bangkok. Bangkok: Thai Society of Agricultural Engineering. KOK, R., BENDERS, R M J. and MOLL, H. C. 2006. Measuring the environmental

Kizilaslan, H. 2008. Input-output energy analysis of cherries production in Tokat Province of Turkey. Applied Energy, In Press, Corrected Proof.

Mandal, K.G., K.P. Saha, P.K. Ghosh, and K.M. Hati. 2002. Bandyopadhyay, Bioenergy and Economic analysis of Soybean-based crop production system in central India. Biomass and Bio-energy 23: 337-345.

Mohammadi, A. Tabatabaeefar, A. Shahin, S.H. Rafiee, S.H. and Keyhani, A. 2008. Energy use and economical analysis of potato production in Iran a case study: Ardabil province. Energy Conversion and Management, 49, 3566–3570.

Mohammadi, A. and Omid, M. 2010. Economical analysis and relation between energy inputs and yield of greenhouse cucumber production in Iran. Applied Energy 87, 191–196.

Mrini M., Senhaji F., Pimentel D., 2001. Energy analysis of sugarcane production in Morocco. Environment, Development and Sustainability, 3: 109–126.

Ozkan, B., Akcaoz, H. and Fert, C. 2004. Energy input–output analysis in Turkish agriculture. Renewable Energy, 29, 2939–2951.

Pimentel, D. and Pimentel, M. 2008. Food, energy, and society (3rd ed.). Boca Raton, FL: CRC Press.

Rauf A. I. Mani, A. Kumar, T. Khur, A. and Satish, L. (2015). Energy use pattern of wheat production in India. Eco. Env. & Cons. 22 (1), 89-94.

Sami, M and Habib. R.2018. Energy and greenhouse gases balances of cotton farming in Iran: a case study. Acta Universitatis Agriculturae et silviculturae Mendelianae Brunensis. Volume 66(1).Pp 101-110.

Sartori L., Basso B., Bertocco M., Oliviero G., 2005. Energy use and economic evaluation of a three year crop rotation for conservation and organic farming in NE Italy. Biosystems Engineering, 91: 245–256.

Sauerbeck, D. R. 2001. CO2 emissions and C sequestration by agriculture – perspectives and limitations. Nutrient Cycling in Agroecosystems, 60, 253-266.

Comment [GF6]: 2011???

Shahan, S., Jafari, A., Mobli, H., Rafiee, S. and Karimi, M. 2008. Energy use and economic analysis of wheat production in Iran: A case study from Ardabil province. Journal of Agricultural Technology, 4(1), 77-88.

Siddique, M. N. A., Sultana, J. and Abdullah, M. R. 2017. Aggregate stability: an indicator of quality and resistivity of arable Soil. Asian Journal of Soil Science and Plant Nutrition, 1(2), 1-7.

Singh, H., Mishra, D. and Nahar, N. M. 2002. Energy use pattern in production agriculture of a typical village in Arid Zone India-Part I. Energ Convers Manag. 43(16), 2275–2286.

Singh, J. M. 2002. On farm energy use pattern in different cropping systems in Haryana, India. Master of Science. Germany: International Institute of Management, University of Flensburg.

Singh, S. and Mittal, J. P. 1992. Energy in production Agriculture. Mittal Publications, New Delhi.

Smil, V. 2008. Energy in nature and society: general energetics of complex systems. Cambridge, Mass: The MIT Press.

Stout, B. A. 1990. Handbook of energy for world agriculture. London; New York: Elsevier Science Pub. Co.

Sultana, J., Siddique, M. N. A. and Abdullah, M. R. 2015. Fertilizer recommendation for agriculture: practice, practicalities and adaptation in Bangladesh and Netherlands. International Journal of Business, Management and Social Research, 1(1), 21-40.

Yaldiz, O., Ozturk, H.H., Zeren, Y. and Bascetincelik, A. 1993. Energy usage in production of field crops in Turkey. 5. International Congress on Mechanization and Energy in Agriculture, İzmir, Turkey, pp. 527–36.

Yilmaz, I., Akcaoz, H. and Ozkan, B. 2005. An analysis of energy use and input costs for cotton production in Turkey. Renewable Energy. 30, 145–155.

Ziesemer, J. 2007. Energy use in organic food systems. Rome: Natura Resources Management and Environment Department, Food and Agriculture Organization of the United Nations.

Zahedi, M. Eshghizadeh H.R. and Mondani F. 2014. Energy Use Efficiency and Economical Analysis in Cotton Production System in an Arid Region: A Case Study for Isfahan Province, Iran. International Journal of Energy Economics and Policy 4(1), 2014, pp.43-52.

Uhlin, H. ~~(~~1998~~)~~. Why energy productivity is increasing: an I–O analysis of Swedish agriculture. Agric Syst. 56(4), 443–65.