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Research Article

APPLICATION OF THE LIFE CYCLE ASSESSMENT METHODOLOGY TO WHEAT PRODUCTION IN NORTH OF IRAN

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ABSTRACT
The suitability of the Life Cycle Assessment (LCA) methodology to analyze the environmental impact of agricultural production is investigated. This study was conducted to assess the impact of wheat production on environment under rain fed and watered farming systems in north of Iran. Life cycle assessment (LCA) was used as a methodology to assess all environmental impacts of wheat production through accounting and appraising the resource consumption and emissions. Data were collected from 72 farms by used a face to face questionnaire method during 2011 year in Guilan province. In rain fed farming system, total green house gases emissions for wheat production were calculated to be 440.4 $kgCO_{2eq}ha^{-1}$ calculated. In watered farming system, total green house gases emissions for wheat production were calculated to be 570.7 $kgCO_{2eq}ha^{-1}$.

Keywords: *Wheat, Green House Gases, Watered Farming, Rain Fed Farming*

INTRODUCTION
Wheat (*Triticum aestivum* L.) is among the oldest and most extensively grown of all crops. It is a main cereal cultivated throughout the world along with rice, barley, maize, rye, sorghum, oats and millet. Nowadays, wheat cultivars have been developed for different qualities in accordance with the development of genetic recombination (Hung *et al.,* 2008). Wheat is grown under irrigated as well as rain-fed conditions worldwide. Under rain-fed conditions the developing grains are frequently exposed to mild to severe stress at different stages of grain development (Singh *et al.,* 2008).
The excessive use of energy in developed and developing countries creates environmental, commercial, technical, and even social problems, which requires in depth investigation in order to mitigate ensuing negative impacts. Analyzing relevant information is necessary to reduce energy consumption and its environmental impacts. High available energy along with reducing the known energy resources is the key factors to develop the philosophy of optimum energy consumption. Optimum use of energy helps to achieve increased production and contributes to the economy, profitability and competitiveness of agricultural sustainability of rural communities (Singh *et al.,* 2004). Agriculture is one of the most important productive sectors, which consumes and supplies energy in the form of bioenergy (Kizilaslan, 2009).
Sustainability and as a specific aspect of it sustainable energy supply from renewable resources will be one of the top issues of society and of environmental policies in the future. Agriculture is a key driving force for renewable energy, because it is the sector which not only consumes, but also has the future potential to produce large amounts of renewable energy (Pickel *et al.,* 2012). The call to sustain our welfare is neither new, nor an invention by the economic system. The word “sustainable” is used very often and actually is a term which deeply is anchored in the human history. Life cycle management (LCM) is a powerful tool to assess sustainability in this sector and to make it operational, an easy access to high quality environmental, social and economical data through the overall life cycle of products is of great importance. To manage and efficiently steer the work in the different parts of the life cycle, different tools has to be applied such as environmental management systems, procedures for approval of chemicals, product safety, supplier evaluations, energy or water saving programs, etc (Riise and Palsson, 2011). One of the most important issues in recent century is he global warming and green house gas emission is the main factor of this change in weather conditions. There is scientific consensus that global warming poses

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one of the major environmental challenges in the future. While the bulk of the so called green house gases (GHG) originate from fossil fuel consumption (Pathak and Wassmann, 2007). Green house gas (GHG) emissions from agriculture account for 10 to 12% of all manmade GHG emissions and are the main source of anthropogenic N2O (60%) and CH (50%) (Browne *et al.*, 2011). Production, formulation, storage, distribution of the inputs and application with machinery lead to combustion of fossil fuel and use of energy from alternate sources, which also emits CO2 and other green house gases in to the atmosphere. Thus, an understanding of the emissions expressed in kilograms of carbon equivalent (kg CE) for different tillage operations, fertilizers and pesticides use, supplemental irrigation practices, harvesting and residue management is essential to identifying C-efficient alternatives such as biofuels and renewable energy sources for seed bed preparation, soil fertility management, pest control and other farm operations (Lal, 2004).
The purpose of this research is studying Application of the life cycle assessment methodology to wheat production under rain fed and watered farming systems in north of Iran.

MATERIALS AND METHODS

Materials

In order to gather the required data in this study, information related to 72 farms in Guilan province during the agricultural year 2011 was studied. The common agricultural practices to yield wheat in the area of which the study was carried out were: field preparation (plowing, disk harrowing and leveling of the soil), incorporating farmyard manure into the soil, seeding, post-seeding agricultural practices, fertilization, irrigation (water extracted from local wells by means of electrical pumps), spray pesticide, plant protection and harvesting. Farm operations of wheat production in the studied region are shown in figure 1.

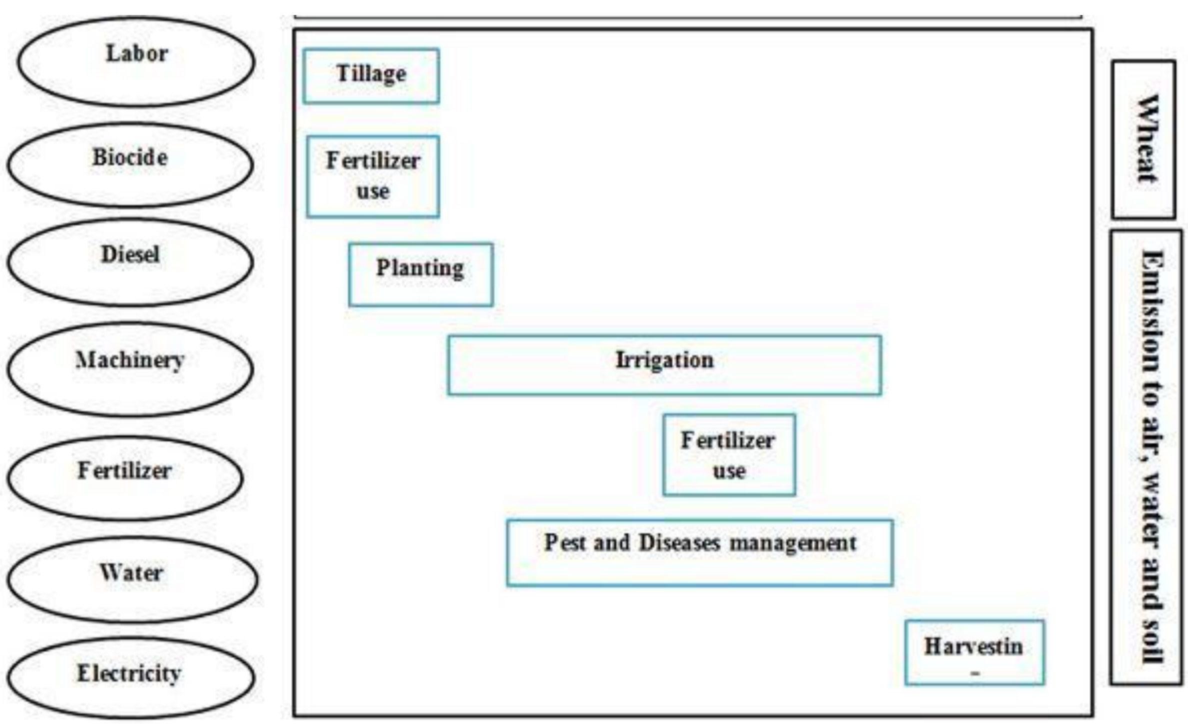

Fig. 1: Farm operations and system boundary for wheat production

Method to Calculate Green House Gases Emission

To find the amount of GHG emission of inputs in wheat production per unit area (hectare), CO_2 emission coefficient was applied (Table 1). For every GHG producers (diesel fuel, poison, chemical fertilizer, and water) the amount of produced CO_2 was calculated by multiplying the input application rate by emission coefficient that is shown in table 4 (Azarpour, 2014; Ghahderijani *et al.*, 2013).

Table 1: Amounts of inputs and their equivalent green house gas (GHG) emission for wheat production

Parameter	Unit	Quantity per Hectare (Watered farming)	Quantity per Hectare (Rain fed farming)	GHG coefficient ($kgCO_{2eq}ha^{-1}$)
Machinery	h/ha	12	12	0.071
Diesel fuel	L/ha	133	133	2.76
Nitrogen	Kg/ha	66	42	1.3
Phosphorus	Kg/ha	14	11	0.2
Potassium	Kg/ha	10	2	0.2
Poison	L/ha	3	3	5.1
Water	M^3/ha	1700	0	0.057

RESULTS AND DISCUSSION

Table 1 showed Amounts of inputs and their equivalent green house gas (GHG) emission for wheat production under rain fed farming and rain watered systems. In watered farming system results show that, about 1700 M^3 water, 133 L diesel fuel, 12 h machinery power, 66 kg/ha nitrogen fertilizer, 14 kg/ha phosphorus fertilizer, 10 kg/ha potassium fertilizer and 3 L chemical poison were used in agro ecosystems wheat production on a hectare basis. In rain fed farming system results show that, about 133 L diesel fuel, 12 h machinery power, 42 kg/ha nitrogen fertilizer, 11 kg/ha phosphorus fertilizer, 2 kg/ha potassium fertilizer and 3 L chemical poison were used in agro ecosystems wheat production on a hectare basis.

In rain fed farming system results show that, diesel fuel was the major source contributing 83.39% of total green house gases emission and followed by chemical fertilizer, poison and machinery contributing 12.99% (12.40% nitrogen + 0.50% phosphorus + 0.09% potassium), 3.48% and 0.19% of global warming potential, respectively (Figure 2). Between chemical fertilizers, nitrogen had the first rank in green house gases emission and next ranks belonged to phosphorus and potassium with 12.40%, 0.50% and 0.09%, respectively (Figure 2). In rain fed farming system, total green house gases emissions for wheat production were showed table 2 (440.4 $kgCO_{2eq}ha^{-1}$).

Table 2: Greenhouse gas emissions of inputs for wheat production

Parameter	GHG emissions ($kgCO_{2eq}ha^{-1}$) (Watered farming)	GHG emissions ($kgCO_{2eq}ha^{-1}$) (Rain fed farming)
Machinery	0.9	0.9
Diesel fuel	367.1	367.1
Nitrogen	85.8	54.6
Phosphorus	2.8	2.2
Potassium	2.0	0.4
Poison	15.3	15.3
Water	96.9	0
Total	570.7	440.4

In watered farming system results show that, diesel fuel was the major source contributing 64.32% of total green house gases emission and followed by water, chemical fertilizer, poison and machinery contributing 16.98%, 15.88% (15.03% nitrogen + 0.49% phosphorus + 0.35% potassium), 2.68% and 0.15% of global warming potential, respectively (Figure 3). Between chemical fertilizers, nitrogen had the first rank in green house gases emission and next ranks belonged to phosphorus and potassium with 15.03%, 0.49% and 0.35%, respectively (Figure 3). In watered farming system, total green house gases emissions for wheat production were showed table 2 (570.7 $kgCO_{2eq}ha^{-1}$). Applying worn out tractors in operations, improper matching of equipment to tractors and performing high energy intensity tillage operation are the most reasons for the high GHG emissions in wheat production (Dyer and Desjardins, 2003). Our estimate of GHG intensity is very similar to that reported by Khakbazan *et al.*, (2009) that Greenhouse gas emissions from wheat production can be ranged from 410 $kgCO_{2eq}ha^{-1}$, 130 $kgCO_{2eq}ha^{-1}$ depending on fertilizer rate, location and seeding system.

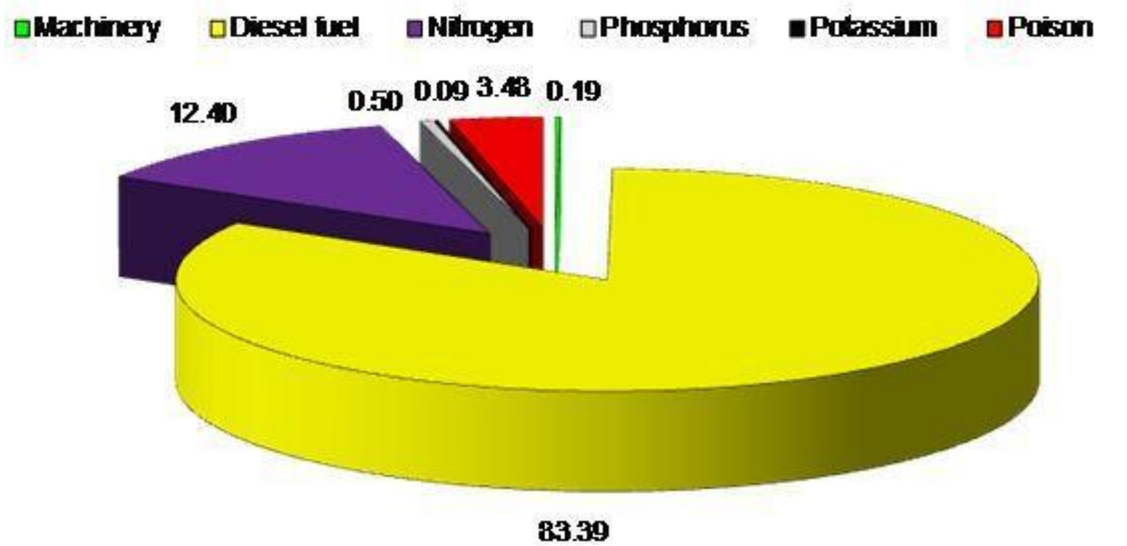

Fig. 2: The contribution of GHG emissions of wheat production in rain fed farming system

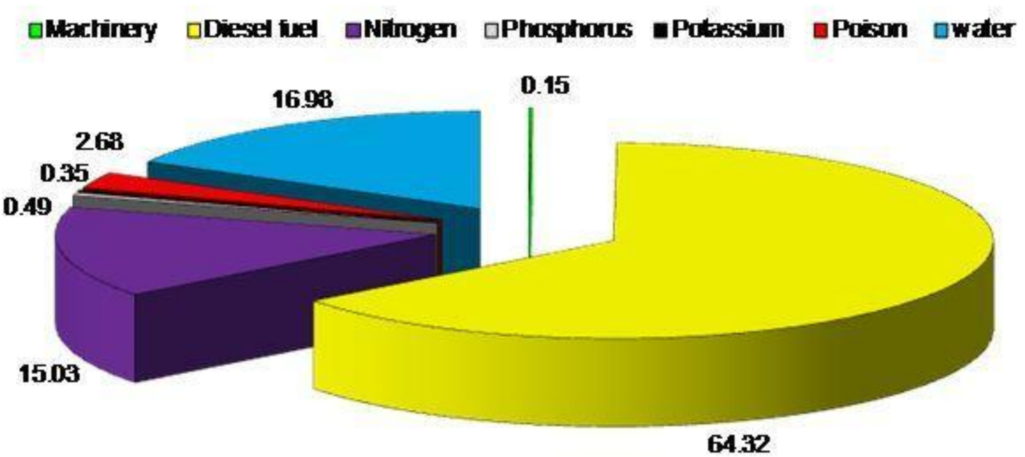

Fig. 3: The contribution of GHG emissions of wheat production in watered farming system

Ghahderijani *et al.*, (2013) analyzed life cycle assessment of wheat production in Iran found that greenhouse gas emissions from wheat production can be ranged from 756.11 $kgCO_{2eq}ha^{-1}$. Global warming potential (GWP), eutrophication potential (EP), human toxicity potential (HTP), terrestrial eco-toxicity potential (TEP), oxidant formation potential (OFP) and acidification potential (AP) were calculated as 2620.86 kg CO2 eq.t-1 (tonne of grain), 14.25 kg PO4-2 eq.t-1, 1111.7 kg 1,4-DCB eq.t-1, 10.59 kg 1,4-DCB eq.t-1, 0.0073 kg ethylene eq.t-1 and 19.07 kg SO2 eq.t-1, respectively (Khoshnevisan *et al.*, 2013).

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Conclusion

Life cycle assessment (LCA) is defined as the compilation and evaluation of the inputs, outputs and potential environmental impacts of a product system throughout its life cycle‖. Thus, LCA is a tool for the analysis of the environmental burden of products at all stages in their life cycle. In rain fed farming system, total green house gases emissions for wheat production were calculated to be 440.4 $kgCO_{2eq}ha^{-1}$ calculated. In watered farming system, total green house gases emissions for wheat production were calculated to be 570.7 $kgCO_{2eq}ha^{-1}$.

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