Environmental Sciences Vol.17 / No.1 / Spring 2019

211-238

Comparative assessment of on-farm greenhouse gases emission from male-headed and female-headed rice farms in Babol County (Mazandaran Province, Iran)

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Received: 2017.12.10 Accepted: 2018.12.29

Veisi, H., Valiollahi Bisheh, A., Mahdavi Damghani, A.M. and Khorramdel, S., 2019. Comparative assessment of on-farm greenhouse gases emission from male-headed and female-headed rice farms in Babol County (Mazandaran Province, Iran). Environmental Sciences. 17(1):211-238.

Introduction: Since the emission of greenhouse gases (GHGs) has changed the chemical composition of the atmosphere, a wide global consensus has emerged on the anthropogenic accumulation of GHGs in the atmosphere. Women have a vital role in agriculture, but the gap in gender-based studies on the significant effects of agriculture on carbon emissions through production has not yet been filled. Therefore, a detailed analysis of how the gender factor affects GHGs emission is essential. In this sense, the present study investigated the effect of farmers' gender on global warming potential (GWP) in rice production systems during 2014-2015 in Babol County in Mazandaran Province, Iran. To this end, GHG emissions from male- and female-head rice farms were compared using the carbon input ($kg.C.equivalent.ha^{-1}$) and output ($kg.C.equivalent.ha^{-1}$), sustainability indices, and carbon efficiency.

Material and methods: The data was gathered from 120 rice farmers (60 males and 60 females) through questionnaires and face-to-face interviews. The methodology of the Intergovernmental Panel on Climate Change was used to calculate the GHGs emission of each farm. Each GHG such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) has GWP, which is the warming influence relative to that of carbon dioxide. Emissions were measured in terms of a reference gas, CO_2 and reported based on CO_2 equivalent. The method was restricted to a farm boundary and extracted into spreadsheets, which compute the baseline CH_4 and

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N_2O emissions for each farm. The indices of sustainability were estimated by assessing the temporary changes in output/input or (output-input)/input ratios of C to determine the share of anthropogenic GHGs emission in the atmosphere to determine the intensity of energy flow, carbon savings, and GHG emissions from women-headed and men-headed rice farms.

Results and discussion: The results demonstrated considerable differences between farms headed by women and headed by men in terms of GWP (2930.31 and 3291.35 kg.CO_2.equivalent.ha^{-1} for female-headed and male-headed farms, respectively) since more agricultural inputs were employed in farms headed by men. The dominant share of GWP for farms headed by men and women from the highest to the lowest was due to fossil fuels, machinery, and N fertilizers. The indices of carbon efficiency and carbon sustainability were respectively 3.88 and 2.88 in farms headed by women, and 3.55 and 2.55 in farms headed by men.

Conclusion: The largest proportion of GHGs emission was due to fossil fuels in both female-headed and male-headed farms. This was attributed to outdated diesel pumps, excessive machinery traffic in agroecosystems, incompatibility between the power and performance of the equipment with the requirements of female-headed farms, and the relatively low price of fossil fuels. In line with these results, it can be concluded that resource-use patterns for the establishment, production, harvesting, and transportation in the rice fields are compatible with landscapes and masculine norms. Females, like males, used machinery and tools that consumed large amounts of fossil fuels; however, female-headed farms were smaller and wasted more energy, which in turn increased the level of mitigation. The findings suggested that farms by women produced fewer GHGs because the carbon input was used in a more environment-friendly manner than in the male-headed farms. Finally, several "soft" policies, such as gender-sensitive capacity development programs, are proposed to address the share of farmers in the emission of GHGs from subsistence farming systems on a gender basis.

Keywords: Gender, Greenhouse gases emission, Rice production, Global warming potential.

Introduction

The global environment has changed sharply with the contribution of human beings to global warming (Vitousek *et al*., 1997; Tubiello *et al*., 2013; Ergas and York, 2012). Since the emission of greenhouse gases (GHGs) has changed the chemical composition of the atmosphere, a wide global consensus has emerged on the anthropogenic accumulation of GHGs in the atmosphere (IPCC, 2007; Houghton *et al*., 2001). Although physicists and naturalists have developed sophisticated atmospheric models and sociologists have investigated the positions of various groups on the actual nature of global climate change (GCC) (Ungar, 1992; McCright and Dunlap, 2000), there are few studies conducted by sociologists that analyze the human contributions to GHGs emission (Rosa and Dietz, 2012). Consequently, there is an asymmetry in our concept of GHGs emissions and global climate change (GCC), and while there is a growing understanding of how GHGs affect climate, there is inadequate knowledge of the anthropogenic factors that drive GHGs emission.

Women have a vital role in agriculture

(World Bank, 2009; Team and Doss, 2011), but the gap in gender-based studies on the significant effects of agriculture on carbon emissions through the production and release of GHGs (Ergas and York, 2012) has not yet been filled. A detailed analysis of how the gender factor affects GHGs emission is essential. The lower social status of women prevents them from employing their specific knowledge of weather patterns, crops, health, and etc. for making decisions, which could be useful for their families and wider communities (Ravon, 2014). The majority of existing literature agrees that the gender variable should be considered for emissions and that the mitigation and adaptation capacity of men and women differ in terms of GCC (Jost *et al*., 2016; Dankelman, 2002; Denton, 2004; Esk *et al.,* 2011). In particular, discussions based on the economy of the GCC should include discrepancies in the characteristics of the emissions according to the gender factor.

Traditionally, women are actively involved in rice production in Iran. It is estimated that rice production is responsible for 11.25% of global GHG emissions (Tubiello *et al*., 2013). Rice is a staple food in Iran and rice production accounts for 6.29% of total cereal production (Rassam *et al*., 2015). Worldwide, rice supplies 8% of the food energy to almost one billion people (Denton, 2004). With the increase in pressure for rice production, women, who provide most of the work in this area, may have to contend with dwindling resources and climatic stresses that will adversely affect productivity. Despite numerous attempts to specify the flow of energy and GWP in different Iranian agroecosystems (e.g., Mohammadi *et al*., 2014; Yousefi *et al*., 2014a; Khoshnevisan *et al*., 2013), the gender of this subject has remained intact. To understand how emissions arise and determine potentially mitigating measures, it is essential that environmental scientists and social and political researchers determine the effects of interactions between the social and environmental aspects of agriculture.

The present study investigated the role of gender in GCC. To this end, GHG emissions from men and women head rice farms were compared using the carbon input (kg.C.equivalent.ha^{-1}) and output (kg.C.equivalent.ha^{-1}), sustainability indices, and carbon efficiency. Dankelman's theory (2002) about the role of gender and its interactive relationship with GCC (adapted from Wamukonya and Skutsch (2002)) was analyzed in five areas: (1) patterns of use of gender-specific resources that can degrade the environment; (2) the gender-specific effects of GCC; 3) gender-specific points of view on mitigation and adaptation; (4) gender dimensions in the decision making on GCC; and (5) gender inequality in access to education, training and technology related to the CCG (Dankelman, 2002). A transitional approach based on the agenda developed by Kronsell (2013) was applied to incorporate gender into GHGs reduction strategies. The transitional approach challenges institutionalized norms and deals with oppressive power relations in addition to increasing participation through: (1) a substantial reduction in fossil fuels-related GHGs emission from rice production; (2) farmers' share of GHGs emission from a gender perspective (Wamukonya and Skutsch, 2002) and; (3) design of gender-sensitive capacity development programs such as normative or cultural landscapes. Gender mainstreaming requires policies and plenary programs on climate and women-centered policies that support and empower women to participate on their own behalf (Alston, 2014).

Material and methods

This section describes the proposed methods including the estimation of GHG emissions, GWP, carbon output/input, and carbon sustainability.

Study area and data collection

This study was conducted in Babol County in Mazandaran Province, Iran in the 2014-2015 production year. The province of Mazandaran is located between 35°46′ and 36°58′ N latitude and 50°21′ and 54°08′ E longitude. Table 1 shows the climatic variables and soil properties of the study area. Mazandaran Province was selected because of its large area under rice cultivation and the participation of women in their agricultural sector, especially rice production systems. This province and two other northern provinces (Gilan and Golestan) have supplied 77.21% of the total rice production in 2014-2015 (Ministry of Jihad-e-Agriculture, 2015). GHGs emission from Iran's agricultural sector was estimated 13.97 million tons in 2007, which represents approximately 3% of the total GHGs emission in different sectors of Iran (Sekhavatjou *et al*., 2011). On the other hand, statistical information estimates that more than half of the rice workforce is carried out by women. This involves the sterilization of seeds, seeding in the treasury, transplanting, nursery care, weeding, fertilization, spraying, harvesting, and transportation of the products to the warehouse.

Table 1. The average annual soil properties and climatic variables in Mazandaran Province, Iran

pH	EC ($dS.m^{-1}$)	K (ppm)	P (ppm)	OC (%)	Dominate class of texture	Precipitation (mm)	Temperature (°C)	Sunshine hours (h)	Relative humidity (%)
7.4	2.1	125.0	9.0	1.3	Silt loam	653.40	17.40	1898.80	78

Kazemi *et al*. (2015)

The sample size consisted of 120 respondents that involved men and women from five villages. It was estimated using a formula adopted by Noordzij *et al.* (2010), where random sampling was applied to obtain a sample size of 120 rice-producing households from five selected villages with a confidence level of 95% and a precision level of 5%. Bailey (1994) noted that 30 cases are minimum sample size for studies in which an analysis of statistical data should be performed regardless of the size of its population. A total of 120 respondents were from a list of households headed by women as well as men headed households selected randomly. The five randomly selected villages were picked from two purposively selected regions (or parts) of Babol County that were famous for rice production. Since the objective of this study was the women with the power and the opportunity to make decisions about the management of rice farms, especially about the consumption of energy inputs, all women were widowed or divorced. Rural women (especially married women) participate in rice production systems mostly to provide labor for various processes of rice production systems, rather than gaining the opportunity to decide on the use of inputs. Most of them will have the opportunity to personally manage family farms after their divorce or the death of their spouse. Even in such circumstances, due to cultural, economic and social barriers, women often have a lower priority than other male relatives (brother, father and others) to manage farms. Despite women, the marital status of men does not often affect the management of their cash crop production systems, since men have a higher priority than women in making decisions about the activities of family farms. The data were collected through a questionnaire about households headed by women and headed by men, which was designed to cover a sample of 60 respondents headed by men (including those surveyed by the husband) and 60 respondents headed by women. All inputs and outputs of rice production were analyzed using the SPSS software. Descriptive and inferential statistical treatments, such as frequency, percentage, mean, student's t-test, and Pearson's correlation coefficient were applied to the data.

Estimated GHGs emission and GWP for rice production

There are two common methods of approximating the GHGs emission from agrochemical inputs. One method estimates the amount of energy used for all processes in production, along with packaging, transportation, and application, and then estimates the GHGs emission (3.6 MJ = 1 kWh = 0.411 kg.CO_2 equivalent), while the other estimates the GWP of each agrochemical input. As no data has been provided by previous studies on the amount of energy released during exothermic chemical reactions, it is difficult to calculate the amount of external energy needed during the production of agrochemical inputs.

Although the total energy figure provides some indication of the relative emissions of different agrochemical inputs, it is neither exhaustive nor reliable for the analysis (Maraseni *et al*., 2007). For this reason, the second method of estimating the GWP of agrochemicals was applied in the current study. The GWP shows the relative contribution of gas to the greenhouse effect and is determined as the cumulative radiation force between the present and the future caused by a unit mass of gas emitted in the present (Yousefi *et al*., 2014b). The amount of GHGs emission from agricultural inputs such as fossil fuel, chemical fertilizers, electricity, biocides, and machinery are not the same (Pratibha *et al*., 2015; Koga and Tajima, 2011; Yousefi *et al*., 2014b). Therefore, comprehensive GHGs emission expressed in kilograms of carbon equivalent for different agricultural practices is necessary to recognize C-efficient alternatives such as renewable energy sources for seedbed preparation, soil fertility management, pest control, and other operations of the farm (Lal, 2004)

The methodology of the Intergovernmental Panel on Climate Change (IPCC) (2007) was used to calculate the GHGs emission of each farm. Each GHG such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) has GWP, which is the warming influence relative to that of carbon dioxide. Emissions are measured in terms of a reference gas, CO_2 (IPCC 1995) and reported on the basis of CO_2 equivalent (IPCC, 2007). The method was restricted to a farm boundary (Eckard, 2002) and extracted into spreadsheets, which compute the baseline CH_4 and N_2O emissions for each farm. The total GHG emissions are calculated as follows (Guinee *et al*., 2010):

$$\text{Greenhouse Effect} = \sum GWP_i \times m_i \qquad (1)$$

Where m_i is the mass (kg) of the emission gas. This value is presented in CO_2 equivalents.

Table 2. Greenhouse gas (GHG) emissions coefficients of agricultural inputs

Inputs	Unit	GHG Coefficient ($kg.CO_2.equivalent.unit^{-1}$)	Reference
Machinery	MJ	0.071	(Khoshnevisan *et al*., 2013)
Fossil Fuel	L	2.76	(Khoshnevisan *et al*., 2013)
Chemical Fertilizers			
(a) Nitrogen (N)	kg	1.3	(Lal, 2004)
(b) Phosphate (P_2O_5)	kg	0.2	(Lal, 2004)
(c) Potassium (K_2O)	kg	0.2	(Lal, 2004)
Biocides			
(a) Herbicides	kg	6.3	(Lal, 2004)
(b) Insecticides	kg	5.1	(Lal, 2004)
(c) Fungicides	kg	3.9	(Lal, 2004)

The GHGs emission was calculated by multiplying the application rate of inputs (agricultural machinery, fossil fuels, and agrochemical inputs) with their corresponding emission coefficients (Table 2). The GHGs emission can be expressed per unit of land used in rice production, per unit weight of grain production, or per unit of input or output energy (Soltani *et al*., 2013). Pearson's correlation coefficient and the student t-test were applied to assess the relationship between farm size and the GHG emission footprints of rice in male-headed and female-headed farms.

Carbon output and input and sustainability of rice production

Various methods have been presented to evaluate the sustainability of an agro-ecosystem. Soil scientists use soil quality and health, economists use energy productivity or total factor productivity, social scientists use the sustainable rural livelihood framework, engineers evaluate the energy-use efficiency, and ecologists use energy coefficients (Lal, 2004). Pratibha *et al*. (2015) used a holistic approach to measure the sustainability of an agricultural system by assessing the temporary changes in output/input or (output-input)/input ratios of C to determine the share of anthropogenic GHGs emission in the atmosphere. As done by Pratibha *et al*. (2015), the current study estimated the indices of sustainability according to the formula in Table 3 to determine the intensity of energy flow, carbon savings, and GHG emissions from women-headed and men-headed rice farms.

Table 3. Description of carbon parameters used in this study

Parameters	Description	Abbreviation	Unit
Global Warming Potential	Total GHG Emission Converted into CO_2 equivalent	GWP	$kg.CO_2.equivalent.ha^{-1}$
GHG Emission	Total GHG Emission Converted into CO_2 equivalent	GHG	$kg.CO_2.equivalent.ha^{-1}$
Carbon Input	(Total GHG Emission in CO_2 equivalent) × 12/44	CI	$kg.C.equivalent.ha^{-1}$
Carbon Output	Total Biomass (Paddy + Straw) × 0.4	CO	$kg.C.equivalent.ha^{-1}$
Carbon Sustainability Index	(C Output-C Input)/C Input	CSI	-
Carbon Efficiency	C Output/C Input	CE	-

(Pratibha *et al.,* 2015)

Results and discussion

Demographic information and economic conditions

Table 4 shows that there was no significant difference between men and women farmers with respect to the average age (men = 51.65 years; women = 53.15 years). The results showed that few farmers (20% of men and 11.7% of women) were below 40 years of age. The USDA National Agricultural Statistics Service (NASS) in 2012 revealed that the average age of farmers continued to rise during 1982-2012. Among the main operators, 6% were under 35 years, 61% were 35 to 64 years, and 33% were 65 years and older. The older age groups all increased in number (USDA NASS, 2012). The farmers' unwillingness to retire is a big obstacle for younger farmers because if the older farmers do not give up work, there would not be many spots for the newer generation. Moreover, another important reason that farmers are turning gray is the spiraling cost that includes the cost of land, equipment, taxes, crop insurance, fuel, and supplies, which greatly reduce the profit margin. Taking into account the increasing population growth, the trickle of younger farmers decelerates the adopting of ingenious and sustainable farming methods to achieve global food security (Foley, 2014).

The current findings disclosed that female farmers were more poorly educated than men. The majority of female farmers (65%) were illiterate, while only a few (16.7%) male farmers were illiterate. More than two-thirds of the world's illiterate people are women who live in rural areas (BRIDGE, 2014). Despite the improvement of education, it is one of the most effective factors in promoting knowledge about sustainable agriculture practices (Tatlidil *et al.*, 2009). Inappropriate educational conditions for women often restrict their enterprise options and their ability to participate in vocational and technical training (World Bank, 2009). On the other hand, the agricultural sector cannot disregard well-educated farmers, because they can better adapt themselves to variations in financial and environmental conditions (OECD, 2001). In the present study, male farmers had more family members (3.67) than female farmers (2.67). This significant difference between men and women in terms of family size may indicate that male farmers derive more profits from labor.

The results showed that the availability of financial credits for both genders was poor, but for women farmers, it was comparatively worse; 75% of female farmers faced very low availability of financial credits. Parveen (2008) reported many obstacles for females when accessing credit and productive resources in Bangladesh. This was attributed to the lack of technical knowledge, restrictions on land ownership, heavy housework, and other social and cultural circumscriptions. There was also a significant difference between male and female farmers with respect to the on-farm income (males = $3201.44 per year and females = $1102.92 per year). The majority of women (58.3%) earned less than $1000 per year on farm income, while 43.3% of men earned more than $3000 per year. This difference was strongly related to the size of the farm (males = 0.78 ha and females = 0.48 ha) that caused men to have much more product to sell. Horrel and Krishnan (2006) stated that in Zimbabwe, approximately three-quarters of households headed by women and two-thirds of households headed by men were below the poverty line of Z$ 8315. Their results showed that about two-fifths of households headed by widows earned less than Z$ 2500 per year per person. Women face exceptional challenges with respect to their lifecycle and reproductive roles, which may strongly affect their participation on and off-farm (Peterman *et al*., 2014). Dadzie and Dasmani (2010) found that male farmers also benefited much more from off-farm income than Ghanaian farmers. It was reported that male farmers also had a greater tendency to reinvest their on-farm income than female farmers. On the other hand, women often have limited access to assets, especially those assets which are necessary for agricultural production. This restricts their capability to manifold both in terms of the kinds of crops grown and to benefit from any agricultural market option (World Bank, 2009). Therefore, more resources and support from extension services can surely improve women's income and family welfare. Furthermore, reducing the time burden of women enables them to spend more time on income-generating activities (World Bank, 2005).

GWP of rice production

Table 5 shows the greenhouse gas (GHG) emissions, from rice farming inputs in both female-headed rice farms (FHRFs) and male-headed rice farms (MHRFs) in Mazandaran Province. The average GWP was 2930.31 kg CO_2 equivalent ha^{-1} in female-headed and 3291.35 kg CO_2 equivalent ha^{-1} in male-headed farms which revealed that male-headed farms generally produced more emissions per unit of product than female-headed farms. Rice is among the products with the highest total GHG emissions (Mohammadi *et al*., 2014; Nabavi-Pelesaraei *et al*., 2014) due to the high amount of energy consumption in the rice production systems (Pimentel, 2014). Hokazono and Hayashi (2012) examined the environmental impact of rice agro-ecosystems in Japan and found that the share of direct field emission (mainly CH_4) was about 75% of the total GWP in conventional systems (CH_4 is emitted from flooded paddy fields as a soil-associated GHG emission (Yagi *et al*., 1997; Naser *et al*., 2007)).

Their results showed that rice production in Japan used significant inputs of energy and created substantial CO_2 emissions from fossil

Table 4. Demographic information and economic condition of female and male farmers

	Men			Women				
	Frequency	**Percent**	**Mean**	**Frequency**	**Percent**	**Mean**	**Student's *t* test**	**Sig. ($P = 0.05$)**
Availability of financial credits								
Very low	34	56.7		45	75			
Low	17	28.3		13	21.7			
Medium	7	11.7		2	3.3			
High	1	1.7	-	0	0	-	-	-
Very high	1	1.7		0	0			
Total	60	100		60	100			
Education								
Illiterate	10	16.7		39	65			
No diploma degree	35	58.3		20	33.3			
Diploma degree	12	20	-	1	1.7	-	-	-
University degree	3	5		0	0			
Total	60	100		60	100			
Age								
		12			20		**Mean**	**Frequency**
40 ≥	26	43.3	51.65	7	**Percent**	**Mean**	**Student's *t* test**	**Sig. ($P = 0.05$)**
41-55	22	36.7		28	11.7			
56 ≤	60	100	51.65	25	46.7	53.15	0.736	0.463
Total				60	41.7			
Family size	14	23.3			100			
2 persons ≥	33	55	3.67	29				
3-4 persons	13	21.7		25	48.3			
5 persons ≤	60	100	3.67	5	41.7	2.67	3.868	0.000
Total				60	10			
On-farm income per year	15	25			100			
1000$ ≥	19	31.7	3201.44	35				
1000-3000$	26	43.3		22	58.3			
3000$ <	60	100	3201.44	3	36.7	1102.92	5.215	0.000
Total					5			

fuels, energy and other agricultural energy inputs such as seeds, chemical fertilizers, biocides and machinery employed in raising seedlings, field operations such as tillage, paddling, fertilization, biocide spraying and harvesting, transport of harvested farm products and grain drying. The total GWP was reported 847 kg CO_2 equivalent ha^{-1} for soybean (Mohammadi *et al*., 2013), 1137 kg CO_2 equivalent ha^{-1} for wheat (Soltani *et al*., 2013), 1105.7 kg CO_2 equivalent ha^{-1} for barely, 1063.5 kg CO_2 equivalent ha^{-1} for canola (Mohammadi *et al*., 2014), and 12864.84 kg CO_2 equivalent ha^{-1} in corn production systems in Iran (Yousefi *et al*., 2014a).

The significant variation between female- and male-headed farms in terms of GWP ($t = 6.37$; $p < 0.00$) stemmed from the use of different tillage operations, fertilizer and biocide consumption, irrigation practices, harvesting and residue management and energy from alternative sources which also emit CO_2 and other GHGs

(Lal, 2004). The reason for the difference in the consumption of inputs in female- and male-headed farms could be related to the fact that women have limited access to inputs and production factors (Bisheh *et al*., 2017; Peterman *et al*., 2014) as they experience more social and economic limitation than men (FAO, 2010). Although the restricted access of females to productive resources limits the use of fossil-based inputs and reduces the GWP in their farms, the asymmetries in terms of ownership, access and control of livelihood assets (land, water, energy, credit, knowledge and labor) negatively affect female-owned food production systems (World Bank, 2009). In Burkina Faso, due to the lower amount of fertilizers and labor usage, the plots managed by women have lower yields in all cultivated crops than male-managed plots (Udry *et al*., 1995). The lack of availability of fertilizers in Ghana has led to fallowing as the primary investment in the land; however, the longer land lies fallow, the greater the loss of land is in case of insecure tenure. On the other hand, shorter fallows reduce the yield because the soil fertility is compromised. Females have less tenure security and sacrifice profits per hectare with shorter fallows. The decrease in production decreases the potential income of females and the availability of food for household consumption (Goldstein and Udry, 2005).

Apart from the restricted access of females to agricultural inputs, their ecological-friendly attitude towards farming management should not be overlooked (Bisheh *et al*., 2017). They are more concerned about the health of the environment and their families and the risks associated with biocides and are more aware that men are alternative approaches to pest control, such as the use of advantageous insects (Birah *et al*., 2016; Hülsbergen *et al*., 2001).

GHG emissions from on-farm fossil fuel

The total fuel usage and GHG emissions per liter of fuel were used to compute the total GHG emissions of fossil fuel consumption. The amount of fuel consumed in the establishment, production, harvest, and transportation of rice from agricultural surveys was obtained. An analysis showed that fossil fuel emissions were 1478.08 kg CO_2.equivalent.ha^{-1} in female-headed rice farms and 1605.36 kg.CO_2.equivalent.ha^{-1} in male-headed rice farms (Table 5). This translated into 50.44% of the total GWP in female-headed and 48.77% in male-headed farms (Fig. 1). The results of the student t-test revealed significant differences between female-headed farms (1478.08 kg.CO_2.equivalent.ha^{-1}) and male-headed farms (1605.36 kg.CO_2.equivalent.ha^{-1}, $t = 4.73$; $p < 0.00$) in the GHG emissions of fossil fuel consumption (Table 5) of the machinery. The higher GHGs emission of this input in male-headed farms could be due to their greater access to agricultural machinery and equipment (275.35 h machinery in MHRFs and 253.23 h machinery in FHRFs were used). The increased commercialization of agriculture has created farming systems that rely heavily on external inputs (such as agrochemicals and machinery). These systems often bypass women, because females are often short of access to fertilizers, high-yielding seed varieties, tools, and machinery, such as irrigation equipment and plows, which can significantly improve their productivity (Women, 2015). Gilbert *et al*.

(2013) in their assessment of the gender gap in agricultural productivity in Malawi and

Table 5. Amounts of inputs and outputs of rice production and CO_2 equivalent (kg.CO_2.equivalent.ha^{-1}) emission from various sources in female-headed and male-headed farms

Input sources	Unit	Quantity per unit area (ha)		CO_2 Equivalent (kg.CO_2.equivalent.ha^{-1}) emission		Student's *t*-test	Sig. ($P = 0.05$)
		Female-headed farms	Male-headed farms	Female-Headed Farms	Male-headed farms		
Machinery	h	253.23	275.37	1127.29	1225.87	5.24	0.000
Fossil fuel	L	535.54	581.65	1478.08	1605.36	4.73	0.000
Chemical fertilizers	kg	317.19	450.16	283.51	401.98	3.89	0.000
(a) Nitrogen (N)	kg	200.07	283.58	260.09	368.66	3.74	0.000
(b) Phosphate (P_2O_5)	kg	92.91	95.27	18.58	19.05	0.17	0.861
(c) Potassium (K_2O)	kg	24.22	71.30	4.84	14.26	3.71	0.000
Biocides	kg	7.66	10.96	41.44	58.14	5.51	0.000
(a) Herbicides	kg	3.42	4.32	21.53	27.23	3.46	0.001
(b) Insecticides	kg	2.79	4.19	14.22	21.37	3.92	0.000
(c) Fungicides	kg	1.46	2.45	5.68	9.54	3.17	0.002
GWP		-		2930.31	3291.35	6.37	0.000
Paddy	kg	5331.81	5490.99	-	-	0.50	0.620
Straw	kg	2405.10	2567.57	-	-	1.09	0.277
Total output	kg	7736.91	8058.56	-	-	0.68	0.506

Tanzania, demonstrated that women's access to agricultural machinery was significantly restricted compared to that of men. They reported 18% of the gender gap in Malawi and 8% in Tanzania in terms of employing machinery that was due to women's limited access to educational opportunities, land, and markets, or because women earned a lower income from selling their products. The program that promoted buying irrigation pumps by women in Kenya and Tanzania could not be successful, because two people were needed to operate the irrigation pumps and use their legs for pedaling, which was against the predominant cultural norms (Njuki *et al*., 2014). New agricultural technologies and machinery must be more efficient in order to ensure investments, context-sensitive, culturally admissible for females, and meet a priority need. Furthermore, women need both knowledge and financial credits to access them (Carr and Hartl, 2010).

The results of the current study for fossil fuel consumption agreed with the evidence from earlier studies (AghaAlikhani *et al*., 2013; Bautista and Minowa, 2010; Birah *et al*., 2016; Esk *et al*., 2011; Pishgar-Komleh *et al*., 2011) that clarified the important effective share of fossil fuel input among the types of energy used for crop production. Nabavi-Pelesaraei *et al*. (2014) stated that diesel fuel had the highest GHG emissions with 1124.46 kg.CO_2.equivalent.ha^{-1} in rice agro-ecosystems. Pishgar-Komleh *et al*. (2012) as well revealed that the diesel fuel with 32.79% of total GHG emissions was one of the most impressive GHGs in the total GWP of potato production systems.

Fifty years ago, manual labor was the only energy input used in rice production. Human and animal power has now been replaced with heavy machinery and equipment that use high amounts of energy. It is expected that the use of fossil fuels will have a greater contribution to the total GWP in current agro-ecosystems (Liu *et al.*, 2015; West and Marland, 2002). Kazemi *et al.* (2015) reported that the high fuel consumption in Iran's agricultural systems was caused by outdated machinery and irrigation pumps. They stated that the major reason for the high use of fossil fuel was the temporary depreciation of machinery.

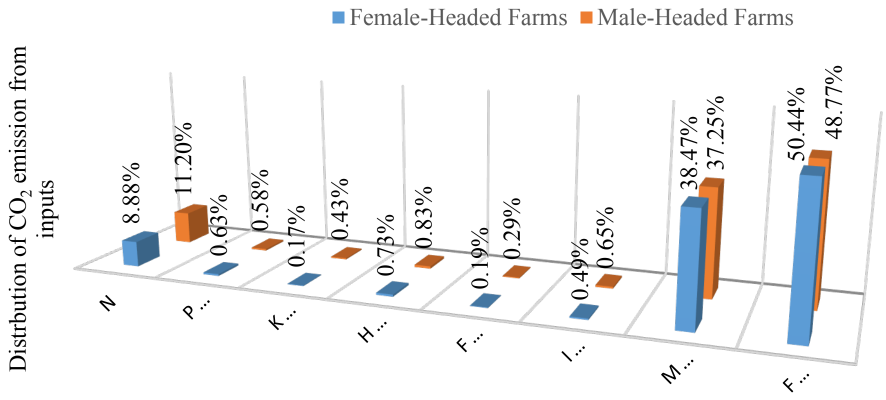

Fig. 1- The distribution of CO_2 ($kg.CO_2.equivalent.ha^{-1}$) emission from different inputs for rice production in female- and male-headed farms

GHG emissions from agrochemical inputs

Based on the results provided in Table 5, the total GHGs emission from the usage of chemical fertilizers was 283.51 and 401.98 $kg.CO_2.equivalent.ha^{-1}$ in female- and male-headed farms, respectively. The results showed a noticeable variation between male-headed and female-headed agro-ecosystems in terms of GHG emissions of N (FHRFs = 260.09 and MHRFs = 368.66 $kg.CO_2.equivalent.ha^{-1}$; $t = 3.74$; $p < 0.00$) and K fertilizers (FHRFs = 4.84 and MHRFs = 14.26 $kg.CO_2.equivalent.ha^{-1}$; $t = 3.71$; $p < 0.00$). However, there was no significant variation in terms of GHGs emission from P fertilizers (Table 5). Since P fertilizers enable plants to develop strong stems, healthy roots, and large fruit, both male and female rice farmers attempt to use sufficient amounts of them. It seems that the best financial situation condition ($3201.44 per year) of male farmers provides them greater access to fertilizers than females ($1102.92 per year). Female farmers in some parts of the world are only half as likely as men to consume fertilizers on their farms (FAO, 2011). There are many reasons for women’s limited usage of fertilizer. Fertilizers are mainly sold in amounts too large for poor women to purchase, particularly due to women's limited cash capitals. Females usually have lots of difficulties to access to transportation and carry bags of fertilizers home. Access to fertilizers in rural areas is often restricted, meaning that women who have fewer opportunities to leave the village have difficulties to obtain fertilizers (World Bank, 2009). Nevertheless, they are aware that soil fertility increases yield and their alternative approaches to improve soil fertility often make up for the lack of access to fertilizers (Kerr *et al*., 2007). Haile *et al*. (2001) stated that in Ethiopia, the high price of fertilizers prompted female heads of poor households to permit livestock owned by relatives to graze on their farms. Their findings also revealed that women used food leftovers in their production systems to improve soil organic matter.

As mentioned earlier, N fertilizer consumption was significantly greater in male-headed farms. Scholars have reported that chemical fertilizers, especially N, have a high consumption rate in rice systems (AghaAlikhani *et al*., 2013; Bautista and Minowa, 2010; Bockari-Gevao *et al*., 2005; Esk *et al*., 2011; Pishgar-Komleh *et al*., 2011). The proper usage of N fertilizers is essential in rice agro-ecosystems because of the restricted arable lands available for rice production (Galloway *et al*., 2008). Nitrogen is an important factor that limits yield in most agricultural systems (Clark *et al*., 1999); therefore, sufficient N must be supplied to compensate for crop N removal and N losses (Poudel *et al*., 2001). The high consumption of N fertilizer and its low use efficiency, however, have notable environmental consequences (Ju *et al*., 2009; Zhang *et al*., 2013), such as water/soil pollution and decrease in biodiversity and GHG emissions (Chen *et al*., 2014; Davidson, 2009; Li *et al*., 2007; Van Groenigen *et al*., 2010; Yang *et al*., 2011). There is a significant positive correlation between the usage of N fertilizer and GWP in crop production systems (Nemecek *et al*., 2015). For all crops and farm types, most of the carbon footprint (75%) is caused by the use of N fertilizer (Hillier *et al*., 2009a), because only 30% to 50% of it is absorbed by plants (Tilman *et al*., 2002). Qiao *et al*. (2014) found that the use of P fertilizers and manure with N and K fertilizers reduced GWP when compared with consumption of only N and K fertilizers. Providing sufficient amounts of plant-available P enhanced plant N uptake and reduced N loss. They demonstrated that the application of manure in combination with inorganic fertilizers reduced the GWP compared to the use of merely synthetic fertilizers, because of the additional gain in soil organic carbon (SOC) to offset N_2O emissions. In other words, the manure C (and possibly its quality) sequesters more soil N, leaving it less prone to leaching loss (Clark *et al*., 1998). Haas *et al*. (2007) in Germany and Isaksson (2005) in Sweden reported lower energy and GHGs emission for crop production without N fertilizers than with N fertilizers. Nabavi-Pelesaraei *et al*. (2014) analyzed energy use efficiency and GHG emissions in rice production and stated that the share of N fertilizers in the total GHGs emission was 148.09 kg.CO_2.equivalent.ha^{-1} in the province of Guilan, Iran.

In Iran, Pishgar-Komleh *et al*. (2011) found that the lack of knowledge and fertilizer subsidies were the major reasons for high fertilizer consumption by farmers. Table 4 shows that the majority of Iranian farmers are over 40 years old and have minimal education;

therefore, they do not have precise information about the quantity of fertilizers required in different agro-ecosystems. The lack of education and scientific information has given rise to farmers' opinion that the overuse of fertilizers will increase yield (Chauhan *et al*., 2006). Therefore, better education is one of the most effective factors to promote awareness of sustainable agricultural practices (Tatlidil *et al*., 2009). In general, input management in agro-ecosystems can have a strong effect, especially in female-headed agro-ecosystems, because of their ecologically-friendly attitude and decreased consumption of fertilizers and fuels. Optimizing the usage of fertilizers in crop production systems increases financial gain for farmers due to the decrease in the expenditure of fertilizers (Kazemi *et al*., 2015) and can diminish environmental risks (Chen *et al*., 2011; Zhang *et al*., 2011). The use of synthetic fertilizers can be more efficient due to some driving factors such as crop rotation, the use of a cover crop, the management of crop residues, suitable tillage, and the prudent use of alternative inputs such as manure that increase SOC and N storage (Clark *et al*., 1998; Drinkwater *et al*., 1998; Nabavi-Pelesaraei *et al*., 2014).

The amount of GHGs emission from herbicides, insecticides, and fungicides consumption are provided in Table 5. The total GHGs emission from biocides was 41.44 kg.CO_2.equivalent.ha^{-1} in female-headed farms and 58.14 kg.CO_2.equivalent.ha^{-1} in male-headed farms. Nabavi-Pelesaraei *et al*. (2014) stated that the amounts of GHG emissions from biocides in rice farms with inefficient use of inputs were 188.86 kg.CO_2.equivalent.ha^{-1} and 95.55 kg.CO_2.equivalent.ha^{-1} in rice farms with efficient use of inputs. The GHG emissions from biocides in the findings of Mohammadi *et al*. (2014) were reported 62.4 kg.CO_2.equivalent.ha^{-1} for rice, 22.4 4 kg.CO_2.equivalent.ha^{-1} for soybean, 14.74 kg.CO_2.equivalent.ha^{-1} for wheat, and 12.9 4 kg.CO_2.equivalent.ha^{-1} for canola.

The results demonstrated that women were less reliant on the overuse of biocides for pest control. The total GHG emissions of herbicides (21.53 kg CO_2 equivalent ha^{-1}), insecticides (14.22 kg.CO_2.equivalent.ha^{-1}), and fungicides (5.68 kg.CO_2.equivalent.ha^{-1}) in the female-headed farms were lower than in male-headed farms (27.23 kg CO_2 equivalent $ha^{-}1$, 21.37 kg.CO_2.equivalent.ha^{-1}, and 9.54 kg.CO_2.equivalent.ha^{-1}, respectively). Female farmers employ fewer biocides than male farmers, because biocides usage is known to be expensive. The biocides, sprayers, and all protective equipment must be bought (World Bank, 2009), but the limited access of women to productive resources makes them not have a tendency to purchase agricultural inputs such as biocides to consume in their farms (Doss and Morris, 2000). On the other hand, women and children often have vast participation in mixing biocides, replenishing biocides tanks (Rother, 2000), and doing sorely time-consuming farming activities such as weeding during the peak spraying season, when the residue levels in the farms are high (Mancini *et al*., 2005). These responsibilities increase concerns among women about the environment, health of themselves and their families, risks associated with pesticides, and awareness of alternative pest control approaches which can strongly influence their farming methods (Birah *et al*., 2016).

Sustainability of male-headed and female-headed rice-based farms

The results related to the sustainability of the rice production systems are shown in Table 6. Based on the outcomes, the amount of carbon input was significantly higher in male-headed farms (897.64 kg.C.equivalent.ha^{-1}) than in female-headed farms (799.18 kg.C.equivalent.ha^{-1}; $t = 6.37$; $p < 0.00$). This higher carbon input in male-headed farms was strongly related to the increased use of energy inputs (machinery, fossil fuels, fertilizers, and biocides) by male rice farmers (Table 5). As noted earlier, females often use lower amounts of energy inputs in their farms due to their restricted access to agricultural productive resources (Bisheh *et al*., 2017; Peterman et al., 2014). The total carbon output, however, was not considerably different between female-headed farms (3094.77 kg.C.equivalent.ha^{-1}) and male-headed farms (3223.42 kg.C.equivalent.ha^{-1}; $t = 0.69$; $p < 0.49$) (Table 6). Considering the significant impact of employing high-yield seeds on the improvement of yield per hectare (Thapa, 2008), the tendency of both male and female rice farmers were to plant high-yielding rice varieties. Therefore, no significant differences were noticed between female-headed and male-headed farms with respect to energy output.

Table 6. Carbon input (kg.C.equivalent.ha^{-1}), output (kg.C.equivalent.ha^{-1}), carbon sustainability index and carbon efficiency in female-headed and male-headed rice farms

	Quantity		Student's *t* test	Sig. ($P = 0.05$)
	Female-headed farms	Male-headed farms		
Carbon input (CI) (kg.C.equivalent.ha^{-1})	799.18	897.64	6.37	0.000
Carbon output (CO) (kg.C.equivalent.ha^{-1})	3094.77	3223.42	0.69	0.493
Carbon sustainability index (CSI)	2.88	2.55	1.57	0.118
Carbon efficiency (CE)	3.88	3.55	1.57	0.118

Carbon efficiency (CE) and carbon sustainability (CSI) indices reveal the efficiency of carbon flux in agricultural production systems. High CE and CSI values indicate that these systems have a lower environmental impact and the energy inputs are employed without significant loss. CE and CSI were calculated 3.88 and 2.88 in female-headed farms and 3.55 and 2.55 in male-headed farms, respectively (Table 6). The results of the current study showed that CE and CSI decreased dramatically in the studied agro-ecosystems (both male-headed and female-headed farms) because of the high and inefficient usage of energy inputs such as fuel, machinery, and agrochemicals. CE and Carbon footprints (CF) were dependent on both carbon-based inputs and crop yield (Hillier *et al*., 2009b; Pandey *et al*., 2013). Huang *et al*. (2017) reported that the highest area-scaled CF belonged to rice production due to the highest consumption of inputs in rice agro-ecosystems. Cheng *et al*. (2011) demonstrated that fertilizers consumption contributed to 60% of the total CF in agro-ecosystems. Pratibha *et al*. (2015) studied the impact of conservation agriculture practices on energy use efficiency and GWP in rainfed pigeon-pea castor systems. The tillage treatments in their study were conventional tillage (CT), reduced tillage (RT), and zero tillage (ZT) i.e. direct sowing without tillage. The authors reported that the much lower fuel consumption in RT and ZT than CT produced values of CE and CSI that were highest for RT (11.66, 12.66), followed by ZT (11.47, 12.47) and CT (10.67, 11.67); however, these were statistically similar for pigeon peas. For castor, the CSI and CE values were higher for RT followed by ZT. These values were similar to each other and significantly higher than the CT. In other countries, scholars have indicated that the inputs consumption has a powerful impact on the total CF and CE of crop production, such as in China (Huang *et al*., 2017), India (Dubey and Lal, 2009; Pathak *et al*., 2010), Canada (Ma *et al*., 2012), and Denmark (Ponsioen and Blonk, 2012).

Females were slightly successful to achieve higher amounts of CE and CSI than males because of women's lower tendency to use carbon-based inputs (Table 6). However, rice production systems (both male- and female-headed), like other Iranian agro-ecosystems, were inefficient in terms of carbon-based input consumption. Studies have reported a low level of energy use efficiency in Iranian crop production systems (Kazemi *et al*., 2015; Mohammadi *et al*., 2008; Banaeian and Zangeneh, 2011). Bisheh *et al*. (2017) revealed that regarding the high consumption of carbon-based inputs, the energy use efficiency was not in an acceptable condition in both female- (1.48) and male-headed plots (1.30). Banaeian and Zangeneh (2011) stated that the energy wastage in Iranian corn production systems increased from 8816.26 to 26151.94 MJ.ha^{-1} during 2001-2007 because of the excessive use of energy or shortfalls in the corn yield. Hadi (2006) also reported that the energy-use efficiency in Iranian potato agro-ecosystems was 0.98. Hence, adjustment measures should be taken to reduce CF and improve CE and CSI of crop production in Iran, and also pay enough attention to women's knowledge, responsibilities, and priorities in farming.

Farm size versus GHG emissions

Based on the results (Table 7), there was a significant difference between farmers of both sexes regarding the farm size in the current study ($t = 2.01$; $p < 0.05$). The average size of land ownership for female-headed farms was 0.47 ha and for male-headed farms was 0.78 ha. Rural females are less likely to have lands under their control compared to rural males (Doss *et al*., 2013). The ability of women to own or inherit properties is often shaped and limited by the customary law and social norms. The size of female-headed plots also tends to be smaller than that of male-headed plots. In Benin, for instance, the average size of the land was reported 1 ha for women and 2 ha for men. In Burkina Faso, male-managed farms are on average eight times larger than female-managed farms (World Bank, 2011).

Table 7. The correlation between farm size and GHG emissions in female-headed rice-based farms and male-headed rice-based farms

	Farm size (female)	Farm size (male)	Student's t test
Average (ha)	0.48	0.78	2.01*
GHG per area	0.24*	0.38**	

*Significant at 5 % ** Significant at 1%

Iqbal (2007), and Nassiri and Singh (2009) indicated that small rice farms had the highest energy use efficiency in comparison with other groups. Pishgar-Komleh *et al*. (2011) reported that the largest farms had a higher energy ratio than medium-sized and small farms. The positive relationship between fossil energy consumption and GHG emissions (Ghorbani *et al*., 2011; Tzilivakis *et al*., 2005) indicates that the effect of farm size on GHG emissions from rice production can be considerable in the GWP analysis. Table 7 shows the relationship between farm size and GHGs emission footprints in female- and male-headed farms. The relationship between farm size and GHG emissions in female-headed farms was notable at 5%. On the other hand, the relationship between farm size and GHG emissions in male-headed farms was statistically greater at 1%. In general, an inverse correlation was found between farm size and GHG emissions in the production chain in both female- and male-headed farms. This means that large farms produced fewer GHG emissions than small farms in Mazandaran Province, Iran. This result is in agreement with the findings of Johnson *et al*. (2016) and Sefeedpari *et al*. (2013) who reported that the large farms in Iran had a better energy ratio and lower GHG emissions in comparison with small farms because the type and size of the machinery were better matched to large farming needs.

Conclusion

Although a number of studies have focused on the assessment of GHGs emission and GWP in crop production systems, studies on gender mainstreaming in emissions from agricultural operations in Iran and other countries are lacking. This study explored the effect of agricultural practices on GHGs emission and GWP in the rice production systems of Mazandaran Province from a gender perspective. The findings demonstrated a lower GWP in farms headed by women (2930.31 kg.CO_2.equnivalent.ha^{-1}) than in farms headed by men (3291.35 kg .CO_2.equnivalent.ha^{-1}). There was a significant difference between farms headed by men and those headed by women with respect to GWP.

The largest proportion of GHGs emission was caused by fossil fuels in both female- and male-headed farms. This was attributed to outdated diesel pumps, excessive machinery traffic in agro-ecosystems, incompatibility between the power and performance of the equipment with the requirements of female-headed farms, and the relatively low price of fossil fuel. In line with these results, it can be concluded that resource-use patterns for the establishment, production, harvesting, and transportation in the rice fields are compatible with landscapes and masculine norms. Females, like males, used machinery and tools that consumed large amounts of fossil fuels; however, female-headed farms were smaller and wasted more energy, which in turn increased the level of mitigation.

Because the masculine norm is dominant and reproduces through “normal” everyday acts affecting GCC, the men in charge exclude females from climate decision-making policies (Denton, 2002; Ergasand York, 2012). This also leads to the gender-based inequity in access to

GCC-related education, training, and technology (Kronsell, 2013). As adopted by Kronsell (2013), the current study will propose a transitional approach at three levels, where the first considerable reductions in fossil fuels-related GHG emissions from rice production was considered by:

- omit or reduce summer fallow as a way to weeds control,
- change the conventional plow to a minimum or no-till system,
- replace the tillage implements such as the chisel plow with a traditional moldboard plow,
- and the change of cropland from pastureland to on marginal agricultural lands (Dyer and Desjardins, 2005).

Next, the farmers' shares in GHG emissions from subsistence farming systems on a gender basis was considered (Wamukonya and Skutsch, 2002). Finally, gender-sensitive capacity development programs such as the normative cultural landscape, in which the other two levels are embedded (Grin, 2010), was designed. This reduces the GCC and overcomes the traditional belief that climate change is gender neutral. It is expected that these policies will contribute to the mitigation of GHG emissions and GWP in the rice production systems of Mazandaran Province by optimizing the use of inorganic fertilizers.

There were some limitations in the current study which should be noted in future studies to disclose hidden aspects of the impact of the gender factor on the total GWP of global agro-ecosystems. We could not find a solitary number from gender-sensitive methodologies to quantify GHGs emission from agro-ecosystems in Iran or other countries with rice or other kinds of crops. The studies, which proved the link between women and GCC, especially for the identification of the effect of the GCC on women (Denton, 2002; IPCC, 2007; Dankelman, 2002) and overlooked the impact of the women in GCC. Therefore, all calculations and analyzes applied in the current study were inevitably based on the usual assessment methods of GHG emissions from crop production systems (e.g., Soltani *et al*., 2013; Yousefi *et al*., 2014b; Pishgar-Komleh *et al*., 2012; Mohammadi *et a*l., 2013), this way the notable capacity of women in reducing GWP of agro-ecosystems could not be revealed comprehensively. Another important restriction was that we had to leave the overview of women's all agricultural activities (e.g., livestock, poultries, and other crops, for example, vegetables) that are often managed by women to provide the needs of their household's in our gender-based assessment of GHGs emission. It was not possible to calculate the amount of GHG emissions from all of their agricultural activities since they were usually limited to meet just the livelihood needs of households and the number of inputs in the consumption of these activities was often forgotten by households. By contrast, farmers always knew how much and what inputs were used in their main farms (rice farms). On the other hand, conventional methods of GWP assessment would not be efficient to calculate the GHGs emission of all agricultural activities due to its weakness in the gender-based analysis.

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فصلنامه علوم محیطی، دوره هفدهم، شماره ۱، بهار ۱۳۹۸

۲۱۱-۲۳۸

ارزیابی مقایسه ای انتشارگازهای گلخانه ای از مزارع تحت سرپرستی مردان و زنان در شهر بابل استان مازندران ایران

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تاریخ دریافت: ۱۳۹۶/۰۹/۱۹ تاریخ پذیرش: ۱۳۹۷/۱۰/۰۸

ویسی، ه.، آ. ولی اللهی بیشه، ع.م. مهدوی دامغانی و س. خرم دل. ۱۳۹۸. ارزیابی مقایسه ای انتشارگازهای گلخانه ای از مزارع تحت سرپرستی مردان و زنان در شهر بابل استان مازندران ایران. فصلنامه علوم محیطی. ۱۷(۱): ۲۱۱-۲۳۸.

سابقه و هدف: با توجه به تغییرات گسترده در ترکیب شیمیایی اتمسفر به علت انتشار گازهای گلخانه ای، اجماع جهانی بر این قرار است که اثرات تجمعی عامل انسانی بر انتشار گازهای گلخانه ایی اساسی است. زنان نقش کلیدی در کشاورزی دارند، اما شکاف و خلایی در رابطه با مطالعات با محوریت جنسیت بر روی اثرات معنی دار کشاورزی بر انتشار کربن طی فرایند تولید وجود دارد. لذا تحلیل موشکافانه تر نحوه تاثیر عامل جنسیت بر انتشار گازهای گلخانه ای ضرورت دارد. در این رابطه، مطالعه حاضر اثرات جنسیت کشاورزان را بر پتانسیل انتشار گازهای گلخانه ای در نظام های تولید برنج طی سال های ۲۰۱۴-۲۰۱۵ در شهر بابل در استان مازندران- ایران بررسی کرده است. بدین منظور میزان انتشار از مزارع برنج تحت سرپرستی زنان و مردان با استفاده از شاخص درونداد ($kg.C.equivalent.ha^{-1}$) و برونداد ($kg.C.equivalent.ha^{-1}$)، پایداری و کارایی برآورد گردید.

مواد و روش‌ها: داده ها با استفاده از پرسشنامه و از طریق مصاحبه رو در رو با ۱۲۰ نفر از کشاورزان مرد (۶۰ نفر) و زن (۶۰) جمع آوری شد. از نظر روش شناسی، روش پانل بین دولتی تغیرات اقلیمی برای محاسبه انتشار گازهای گلخانه ای از هر مزرعه به کار گرفته شد. هر گاز گلخانه ای مانند دی اکسید کربن، متان، و اکسید نیترو یک پتانسیل انتشار دارد که بر دی اکسید کربن اثر گرمایشی نسبی دارد. میران انتشارها بر اسا یک گاز مرجع مانند دی اکسید کربن یا معادل آن گزارش می شود. روش به حد و مرز مزرعه محدود بود و داده ها در یک صفحات جداگانه وارد گردید که و مقادیر مرجع CH_4 و N_2O برای هر مزرعه محاسبه گردید. شاخص پایداری از طریق ارزیابی تغییرات موقتی در نسبت درونداد به برونداد کربن برای تعیین سهم اثرات عامل انسانی بر روی انتشار گزارهای گلخانه ای در مزارع تحت سرپرستی زنان و مردان برآورد گردید.

نتایج و بحث: نتایج بیانگر تفاوت قابل ملاحظه بین مزارع مردان و زنان از لحاظ انتشار گازهای گلخانه‌ای می‌باشد (به ترتیب ۲۹۳۰/۳۱ و ۳۲۹۱/۳۵$kg.CO_2.equivalent.ha^{-1}$ به ترتیب برای مزارع زنان و مردان). علت اصلی استفاده بیشتر نهاده دها در مزارع مردان بود. سهم غالب پتانسیل انتشار گازهای گلخانه ای برای مزارع مردان و زنان ناشی از استفاده از سوخت های فسیلی، ماشین آلات و کودهای نیتروژنه

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بود. برای مزارع زنان شاخص کارایی کربن و پایداری کربن به ترتیب ۳/۸۸ و ۲/۸۸ و برای مزارع مردان ۳/۵۵ و ۲/۵۵ بود.

نتیجه‌گیری: بالاترین سهم در انتشار گازهای گلخانه ای به انتشار ناشی از سوخت های فسیلی در هر دوی مزارع مردان و زنان اختصاص داشت. که این موضوع به علت استفاده از پمپ‌های دیزلی قدیمی آب، تردد بیش از حد ماشین آلات در بوم نظام‌های کشاورزی و عدم انطباق بین میزان برق مصرفی با عملکرد آبزاالات و همچنین نیازمندی‌های مزارع زنان و قیمت نسبتا پایین سوخت فسیلی بود. در رابطه با این نتایج، می توان نتیجه گیری کرد که الگوهای استفاده از منابع برای استقرار،تولید، فرآوری و حمل و نقل در مزارع برنج با ویژگی های مردان انطباق دارد. زنان مانند مردان از ماشین آلات و ابزارهایی استفاده می کنند که از سوخت های فسیلی زیاد را مصرف می‌نمایند، هر چند مزارع زنان کوچک تر بود و انرژی بیشتر تلف می‌شد که به نوبه خود سبب افزایش سطح انتشار می گردد. این یافته‌ها نشان می‌دهد که در مزارع زنان گازهای گلخانه‌ای کمتری تولید می شود و با روش‌هایی که بیشتر دوست دار محیط زیست هستند از نهاده ها استفاده می‌گردد. سرانجام بر اساس نتایج، چند بسته سیاستی نرم مانند طراحی برنامه توسعه ظرفیت حساس به جنسیت با هدف نشان دادن سهم کشاورزان در انتشار گازهای گلخانه ای از سیستم های کشاورزی بر اساس جنسیت، پیشنهاد گردید.

واژه‌های کلیدی: جنسیت، گازهای کلخانه، تولید برنج، پتانسیل گرمایش جهانی.