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Flower Farms Environmental Performance Evaluation in Ethiopia

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ARTICLE INFO	ABSTRACT
	Cultivation of cut flowers is a new agricultural sector in Ethiopia, which currently generates a high amount of income for the country's developments. Despite its significant contribution to economic developments; many issues were raised from communities and environmentalists concerning its environmental performance. Based on this issue the study assesses cradle to gate of cut flower production in the Wolmera district. The main objective of the study was environmental performance evaluation of flower farms in Wolmera district, Oromia regional state, Ethiopia related to operational activities throughout entire life cycles of cut flower production. In this study, primary and secondary data were collected using ISO 14031 standard structured with LCA tool methodology. Data were collected by inventory using an on-site data collection system from its sources. Based on data collected GHG (CO_2, N_2O, CH_4 & NH_3) emissions to the atmosphere were evaluated by using an inter-governmental panel on climatic changes (IPCC 2006) for inventory data and eutrophication & acidification estimated from data tested at laboratory levels. Similarly, the study also assesses banned chemicals used in the farms through inventory data assessment, and about 156 chemicals applied in the farms were collected to screen out those banned chemicals used and the two most extremely hazardous chemicals (Impulse & Meltatix) banned by WHO identified in the study. As it understood from a general assessment of all flower farms; all of them haven't EIA document established before construction in the district and production started with having less attention for EHPEA code of conducts in the flower farms which faces the environments for high impacts by emission emitted from flower farms in the district as a whole.

1. Introduction

Ethiopia is the second-most populous country in Sub-Saharan Africa and with a current population growth rate of 2.6%, it made one of the highest populous country in the world [1,2]. As the population growth continues the pressure on existing natural resources and ecosystems increases within time proportionally. Most Ethiopian people depend on consumable and non-renewable resources to obtain the necessities of life; with this rate of population growth can lose the abilities of sustainable life for societies. Even today, evidence of deforestation and desertification, loss of biodiversity, land degradation is the most

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problem in the country [3]. Depletion of potable water and aquatic resources is continuous for agriculture without any recognition for the environmental issues [4]. In Ethiopia, most of the time agricultural productions are based on subsistence food crops production and coffee harvesting for exporting purposes dominantly, but recently agriculture sectors in the country moving from subsistence farming to commercial production which included flower farming for exporting purpose, especially in the central parts of the country which included Wolmera, Sululta, Ziway, Sebeta and others [5]. Among these, the Wolmera district is one of the areas found in the central parts of the country or district which is densely occupied by flower farms. Wolmera district is almost covered by high lands (>1100m a.s.l) that are most preferable for cut flowers or roses cultivation [6-8]. Therefore, this situation makes odd the areas to attract the investors than elsewhere, especially flower farm investors are attracted by this area. Unfortunately, at this moment only about twenty-one flower farms are on the function and the rests are already phased out.

Floriculture can be defined as "a discipline of horticulture concerned with the cultivation of flowering and ornamental plants for gardens and floristry, comprising the floral industry". It can also be defined as The segment of horticulture concerned with commercial production, marketing, and sale of bedding plants, cut flowers, potted flowering plants, foliage plants, flower arrangements, and noncommercial home gardening [9]. The Ethiopian floriculture industry started around 1980 when state farms began to export cut flowers to Europe and within a short period recognized as an international cut flowers business player next to Kenya in Africa. Because, Ethiopia has geographical advantages for floriculture industry developments; i.e. cut flowers grow well at high altitude or above 1100m [10]. As stated by Ethiopia's agroecology facilitate opportunities to produce different varieties of flowers in different ecological zones that used to increase flower industries through time in the country [11]. Cut flower includes all commercially cultivated rose and ornamental plants in the greenhouse or the field, especially in a controlled environment [12]. But, various cut flowers sometimes grow out of the greenhouse in many climatic conditions. The rapid growth of flower farms in Ethiopia in general, due to comfortable climatic conditions and natural resources, excellent governmental supports, good transportation system, and availability of abundant and cheap labor forces. Floriculture is used for luxury with high social value and rarely used for food. The demand for luxury is increased in the international market from time to time recently. The flower farms/industries are one part of the agricultural sectors in Africa just like other continents for economic developments at this moment [13-15].

The objective of this study is the environmental performance evaluation of operating systems within flower farms in Wolmera district, Oromia regional state, Ethiopia. The studied dedicated on water consumption and discharge, solid waste generation and discharge and energy consumption and emission during the flower plantation.

2. Methodology

2.1 Study Methodology

Study methodology is mainly based on selecting LCA tools for assessments and the main purpose of this selection tool study is to express the values of environmental management tools for a realistic case and to analyze. The result generated or aspects of the firms. Production of flower farms in Wolmera district is blamed by a large amount of chemical fertilizer, pesticides, and resource use. These create great problems on the environment through emission, discharges, and disposal to the environment in the district. The reason is to identify the environmental impacts or burdens within the sectors. It is vital to collect the necessary data from its sources. Based on this method to assess the issues in the current study it is best to choose a globally acceptable route (tool) to collect, organize, analyze and decide on the issues following new standard ISO 14031 & ISO 14044. Therefore, by using the new international organization for standard; the fundamental data were aggregated following the LCA method that passes at least four fundamental steps through product life cycles which included goal and scopes, data collection & interpretation [16]. It is easy to understand from schematic diagram overview steps that carried out for the implementation of environmental performance evaluation of cut-flower farms or industries within their operation, shown in Figure 1.
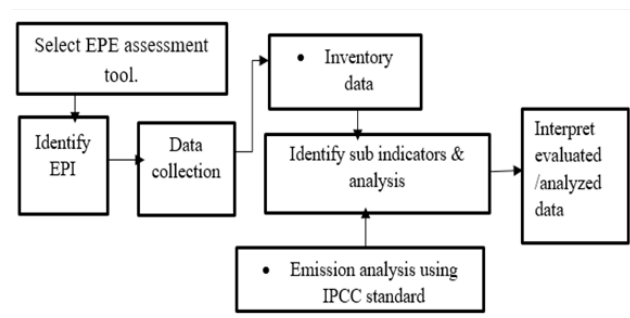

Figure 1. Study methodology schematic diagram.

The system boundary of study identification: The system boundary of any process describes the process's activity and input-output components, which have been engaged into account within a life cycle assessment [17]. For

this study, system boundary starts from land preparation to cut flower products transportation. The process included in the system was water consumption, energy consumption, chemical consumption, products, waste generates, and emission to the environments. Again, in this industry, some processes are excluded from the system boundaries of the current study which involves office activity, chemical container storage, and nursery site, shown in Figure 2.
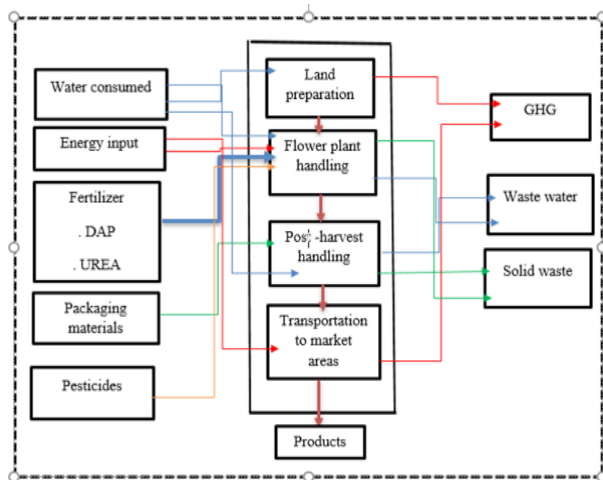

Figure 2. System boundary of the study

2.2 Core Indicators Selection for Study

Fundamental operational indicators are significant for an organization to establish a sustainable civilization and decreasing environmental burden (Jasch 2009). Also, sub-indicators use in combination with the core sets of indicators to measure and follow environmental performance for further accuracy. Indicators can direct types and amount of resources input and output easily to point out quantitatively the material utilized in an organization [18]. The most core indicators used or identified in this study were total energy used, the total amount of water used, total material input, total products, wastewater output, solid waste, and most known GHG as sub-indicators data were evaluated quantitatively using secondary and primary data collection system following ISO 14031 standard. All indicators identified were grouped under EPI which resulted in environmental condition indicators. But, most GHG emissions which included CH_4, CO_2, N_2O, NH_3, and eutrophication & acidification facilitators cannot be collected in the farm process as another type of parameter. Because of this, the amount of GHG, eutrophication & acidification emission from the farms was evaluated using different equations that measure emission emits from the agricultural process as per IPCC,2006, EPA (2003), and FAO from material inputs and outputs [19].

2.3 Inventory Data Collection

Inventory data collected from more than 21 flower farms existed in the district that have about 35 km distances from Finfinnee /Addis Ababa. The study covered more than one year time interval i.e. starting from February 2019 to April 2020. Collected data focused on four stages of cut flower harvesting activity that included land preparation stages which included the amount of energy used, amount of water used as inputs. The second data collection stage was from cut flower plant handlings, which focused on the amount of water, chemical, energy, material used, and products in the cut flower production farms. The third stage is from post-harvesting activities that involve data collection on water, chemical, cardboard paper used, and wasted materials throughout the activities and the fourth stages of flower production included transportation of product and data collection related to power consumption for transportation or fuel used [20]. Data collected at each stage of the flower harvesting activities were focused on selected indicators that are based on the input-output entire life cycle of the production. All necessary data were collected using both primary and secondary data sources by distributing questioner papers, reviewing related documents from various sources that included governmental offices, Private institutions, individual, nongovernmental organizations (NGO), interviewing the workers in floriculture industries, interview farm managers, direct physical site observation and assessing the existing situation of the study areas. All necessary data collected by using all mentioned data collection systems from cut flower farms and other data sources, but impossible to get data about GHG emission resulting from the materials used at four stages of cut flower productions. So, the emission of the firms quantified by using the amount of material used (fertilizer, chemical, fuel), amount of wastes burnt, amount of waste discharged/disposed of, and their emission factors with relating different study paper and IPCC 2006 guidelines for every emitted GHG from input-output indicators in data analysis [21].

2.4 Evaluate Potential Environmental Impacts

Data collected using inventory methods were evaluated and provide the necessary information, but impossible to get quantitative data about GHG emission from fertilizer and pesticides used in the farms, from residual biomass burnt in the farms, and from power energy (diesel fuel, petroleum fuel, and electricity) used for transportation of products and irrigation purpose in the farms. In the same way's eutrophication supporter discharged materials within the wastewater per hectare (NO_3, PO_4, NH_3, SO_4)

require estimation. Therefore, it is obligatory to estimate the emission of material input-output in the flower farms and the most greenhouse gaseous emitted from the farms to environments (atmosphere) identified for estimation (CO_2, N_2O, and CH_4) and were evaluated or analyzed by using different equations which included equation for evaluation of GHG emitted from wastewater, from nitrogen synthetic fertilizer (DAP, UREA), from solid waste biomass burnt in the farms and combustion of energy sources by vehicles released to the environments at the end life cycle of cut flower production or transportation of main products evaluated using emission factors of the material used or disposed of; but the amount of eutrophication and acidification supporter materials calculated using laboratory results and wastewater discharged per hectare of cut flower production [22]. The identified parameters whether core indicators or sub-indicators, it used to point out the environmental problems that occurred by flower farms in the districts analyzed using Excel and evaluation was done based on average materials flow in the farms per hectare of any activities [23].

3. Results and Discussion

Based on the methodology used in the study, all necessary data collected from an onsite data collection system using inventory assessments. This inventory data collection included the fundamental materials input-outputs in the flower farms cradle-gate processing system based on LCA as per ISO14044 which is organized in the following Table 1 (based on the selected functional unit).

Table 1. Input-output inventory results

No	Indicators		Unit	Input	Output	Consumed
1	Solid materials	Leaf and stems	Kg	-	86000	-
		Cut flower wastes	Kg	-	5220	-
		Paper	Kg	1500	20.26	1479.74
		Cardboards	Kg	4100	30.12	4069.88
		Plastic	Kg	3200	20.9	3179.1
2.	Water	Used water	m^3	28800	7200	21600
3.	Chemical	Fertilizer DAP	Kg	650	-	-
		Fertilizer UREA	Kg	450	-	-
		Pesticide All	Kg	50	-	-
4.	Energy	Diesel	Kg	48	-	-
		Petrol	Kg	35	-	-
		Electricity	Kwh	2.55	-	-

Planting media in the flower farms: In flower farms, media is the area that is prepared for the plantation of cut flowers in the greenhouse or open fields of the flower farms within a furrow alignment form. This study assessed primary and secondary data from 21 flower farms that existed in the district. As understood from collected data, the district flower farms have used both soil bed media and hydroponics media. All most all flower farms in Wolmera district have used soil bed as planting media because of its cost-effectiveness, but using soil bed in flower farms environmentally less significant when compared with hydroponic beds because hydroponic bed systems have the recycling probability of wastewater as data obtained from flower farm managers and Environmental protection authority office of the district [24-26].

3.1 Cut Flower Products

Cut flower products are annually produced cut flowers may be measured in stem/tons/kg/bunch that supplied for marketing purposes (export/for local markets). For this study to get the annual production of cut flowers more than twenty questioner papers were distributed to flower farms in the areas and tangible data were collected from its sources. The growth production of cut flower in Wolmera district flower farms was about 85520 kg/ ha production yields were harvested throughout the one-year production life cycle for marketing purposes. This has a great role in the country's economic developments as stated that export earnings further diversifying Ethiopian exports and becoming an important contributor to Ethiopia's economic developments [27]. Despite this, an average nearly 5220 kg of cut flower rejected during packaging process as waste materials and through cut flower development process huge amount of stem and leaves were wasted to the environment which has similar amount with products per year in average as data obtained from the flower farms managers office and EPA of the district. In the same way, no route tries to change these solid wastes to any beneficiary assets in the flower farms [28]. The rejected cut flower wastes, stems & leaves were disposed of and burnt in the firms as agricultural residual biomass. Any agricultural residual biomass burnt in the farms emits emission of GHG (CO_2, N_2O, and CH_4) (IPCC 2006). In this study based on IPCC standards emissions emitted to the atmosphere were calculated using IPCC (2006) guidelines related to agricultural residue biomass burning emission factor standards [29]. Based on this guideline the results of evaluated GHG emission from burnt floricultural residue and biomass aggregated in Table 2.

3.2 Water Consumption and Analysis

The total water consumptions in flower farming are originated from groundwater, surface water, and harvested

water, normally more percentage of demand fulfilled from groundwater. This similar Ethiopia flower farms use more present water from groundwater [30]. It is belonging that flower farms use a high amount of water just like other common horticulture production. But, the use of water in floriculture depending on the farm area, climate change, soil types, and water using mechanism in the activities and flower farms daily water consumption is varying from farm to farms. In the current study, Wolmera district flower farms were used on average 28800 m^3/ha as input to process cut flower production activities and 7200 m^3/ha wastewater was discharged to the environments per year as data organized from flower farms managers (21 in number) and district EPA office. But, even if horticulture production is known by using too many intensive resources like land, water, and chemicals [31]; the amounts of water consumption in Wolmera district flower farms have the highest values when compared with previous articles. This indicated that flower farms in Wolmera district have used too much water which results in GHG emission to the atmosphere & drains the wastewater directly to the field and rivers that supplying nutrients like PO_4, NO_3, and NH_3 which support the process of eutrophication or acidification. This situation restricts the value of water for a different purpose in the communities [32]. This assures that the boundless use of water in flower farms can lead the area to scarcity of groundwater and can cause a high amount of wastewater drain to environments. In general, the wastewater discharged from the flower farms to the fields and rivers could facilitate the eutrophication and acidification in the areas by supplying N, P with their compounds respectively and these all emission to atmosphere, territory and aquatic body quantitatively estimated in the next portion at flower farm emission evaluation parts from per hectare emitted wastewater [33].

3.3 Solid Waste Analysis

The most solid waste observed in the flower farms were plastic wastes, paper wastes, cardboards, flower stems, leaves, and cut flower residues. As data collected from different sources of the district office and flower farms managers (21 in numbers) the total amounts of stems and leave waste disposed of were an average of 86000 kg/ha and cut flower wastes during packaging 5220 kg/ha were wasted from the farms and 20.26 kg/ha paper wastes generated from 1500 kg/ha input papers, 30.12 kg/ha of cardboard wastes from 4100 kg/ha inputs and 20.9 kg/ha of plastic materials wasted from 3200 kg/ha of plastic materials input to the flower farm process were disposed to the environments, which shown in Figure 3. To dispose of the wastes in flower farms, there are different types of

waste disposal mechanisms that including landfill, incineration, anaerobic digestion, and recycling wasted materials [34]. But, in the Wolmera district, all almost all flower farms have used open burn of the farm's residual biomass infield because of fear of the cost to build modern and acceptable disposal mechanism, but a little bit of wastes has burnt in incinerators in some of the flower farms. Open burning of agricultural residues biomass generates GHG emission (IPCC 2006). In the district, all flower farms recycling and changing to the beneficial asset is zero as data obtained (gathered) from Wolmera district environmental protection & climate change authority office and physical observation of the farms at sites except some percent of plastic wastes. The GHG emission emitted from residual biomass burning in farms estimated using equation listed in chapter three that based on IPCC 2006 agricultural residues biomass burning guideline in the emission estimation process and the GHG emission that generated from the farms evaluated and discussed in emission estimation parts [35].
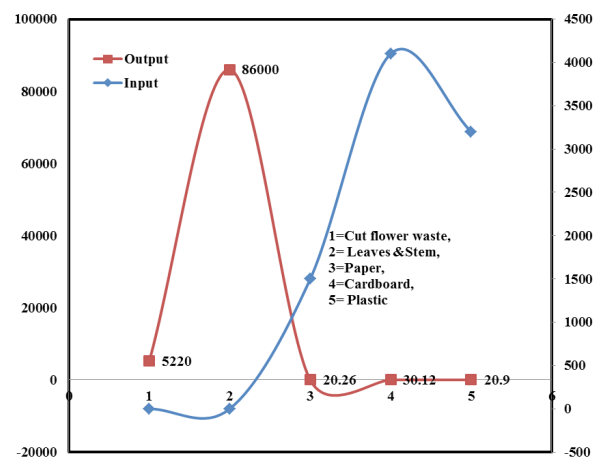

Figure 3. Solid waste types disposed from flower farms

3.4 Chemicals Used in the Farms

Ethiopia's floriculture industries use more than 300 types of chemicals in rose production farms (Kassa 2017). In the same way to get chemical types used in Wolmera district flower farms in this study sufficient questioner papers were distributed to collect the necessary data from the farms. To aggregate, these data about twenty-one questioner papers were distributed and collected the necessary data on chemical type and the number they used at each flower farms. The collected data indicate that about 156 chemical types were applied in the Wolmera district flower farms. These all chemicals are mostly used at nursery sites, cut flower plant handling stages and at packaging rooms for prevention and preservation purposes. Most

chemicals used in flower farms are fertilizer and pesticides that are stated separately [36].

Fertilizer

Flower farms in Ethiopia used more than 30 types of fertilizers to supply sufficient nutrients to the harvesting plants. Also, Wolmera flower farms are used different types of fertilizer which involves ammonium sulfate, potassium sulfate, potassium nitrate, potassium phosphate, ammonium phosphate, and urea, but the current study focused on two main fertilizers were used in the farms with the highest percentage which included DAP & UREA [37]. In this study, as data collected from flower farms office directly at on-site data collection system, an average Wolmera district flower farms use 650 kg DAP and 450 kg UREA per hectare of cut flower production within a year. The farms used much amount of fertilizer that can lead the process to environmental pollution in case of GHG emission, nutrient discharging to the rivers that support the eutrophication or algal developments in river bodies and increase the acidity of the rivers in the areas as evaluated from laboratory analysis. The study mainly focused on estimating both emission types (GHG &nutrient discharged to rivers) emitted to environments from the farms as a whole [38]. The GHG emission was evaluated using a different equation based on the number of materials used/disposed of and emission factors to estimate NH_3, N_2O & CO_2 emitted to air with a correction factor of each gaseous as per IPCC 2006 standards related to synthetic nitrogen fertilizer, but the nutrients discharged to the rivers were estimated from laboratory results related with wastewater discharged per hectare of cut flower productions. The most GHG emissions evaluated in this study from wastewater discharged or emission were N_2O, CO_2, and CH_4; also, NH_3 emission estimated from 8% of applied nitrogen fertilizer in the farms [39].

Pesticides

Ethiopia flower farms used more than 200 types of pesticides to control macro and micro-organism that affect the developments of cut flowers. Based on this statement in the current study more than 156 chemical types were collected to assess the banned chemical used and estimate emission to air in the farms. Wolmera flower farms on average about nearly 45 kg of pesticides used per hectare of cut flower production within a year. The pesticide used in flower farms has the ability of emitting pollutants into an atmosphere that cause climatic changes or pollution [40]. This pesticide emission into the atmosphere was estimated which indicated that 30-50% of pesticide sprayed emitted into the air in case of volatilization and air drafting system which organized in Table 2.

3.5 Energy Consumption Analysis

The most energy sources in Wolmera district flower production farms are electricity, diesel, and petrol to facilitate any activities in the firms. Also, they are mainly depending on non-renewable energy sources rather than supporting renewable energy sources. Energy in the farms was used in the cooling room, in the office, lighting in the compounds, transportation, and for irrigation purposes. But current study focused on energy used for transportation and irrigation water pumping which is included in the system boundary. Total energy consumes per hectare of cut flower production were 3.55 kWh electric power,50 kg of diesel oil, and 35 kg of petrol. The energy used in flower farm production emits GHG to the environment that has great value in environmental pollution. Most GHG emissions caused by these sources of energy used in the farms are CO_2, N_2O & CH_4. These were estimated concerning on heavy-medium duty vehicle emission factor adopted from IPCC 2006 guideline. The result and discussion of the evaluated emission were aggregated in the emission estimated portion is mentioned in Table 2.

Table 2. GHG emission results from different input-output materials.

No	Indicators		Emission	Unit	Values
1.	Fertilizes	DAP	CO_2	Gg/yr	$3.17*10^{-4}$
			N_2O	Gg/yr	$1.02*10^{-6}$
			CH_4	Gg/yr	$1.85*10^{-4}$
			NH_3	Gg/yr	$6.31*10^{-5}$
		Urea	CO_2	Gg/yr	$1.41*10^{-4}$
			N_2O	Gg/yr	$4.56*10^{-7}$
			CH_4	Gg/yr	$3.265*10^{-9}$
			NH_3	Gg/yr	$4.37*10^{-5}$
2.	Residual biomass burn (BB)	Total residues	CO_2	Gg/yr	7.155
			N_2O	Gg/yr	$6.39*10^{-3}$
			CH_4	Gg/y	0.24643
3.	Energy used	Diesel fuel	CO_2	Gg/yr	$4.896*10^{-4}$
			CH_4	Gg/yr	$2.448*10^{-4}$
			N_2O	Gg/yr	$2.304*10^{-4}$
		Petroleum fuel	CO_2	Gg/yr	$1.988*10^{-4}$
			N_2O	Gg/yr	$1.68*10^{-4}$
			CH_4	Gg/yr	$1.785*10^{-4}$
		Electricity	CH_4	Gg/yr	$3.06*10^{-3}$
			N_2O	Gg/yr	$2.55*10^{-5}$
			CO_2	Gg/yr	0.072165
4	Pesticides	Emission	All	Gg/yr	0.00002
5.	Waste water	Effluent	CO_2	Gg/yr	2.85
			CH_4	Gg/yr	0.00288
			N_2O	Gg/yr	0.009

3.6 Evaluation of Emission

Emission is the process of releasing materials (gaseous, liquid & solid substances) to the atmosphere, land, and water bodies that cause great problems in the environments that resulted from a large amount of natural resource consumed by industries [41]. In this study emission of gaseous substances from input and output materials was evaluated based on data collected from its sources. As listed in Table 2 the most known greenhouse gas (GHG) evaluated were CO_2, N_2O, and CH_4 using IPCC (2006) standard and emissive factors (EF) of each GHG. The study mainly focused on the GHG emission from fertilizer used, energy used, and agricultural residue biomass burnt in the farms and wastewater discharged [42]. Agricultural residues are the main sources of GHG emission in the flower farms that emanated from leaves, stems, cut flowers, and decomposable input materials incinerated or burnt in the farms. In the current study, the residual biomass of flower farms burnt in open fields and release GHG to the environments which mostly included CO_2, N_2O, and CH_4 as expressed in Table 2. These GHG emissions were evaluated from residual biomass burnt in the farms as per IPCC (2006). The evaluation expressed that high amount of CO_2 released to the atmosphere among evaluated GHG emitted from other materials in the farms or when compared with N_2O and CH_4 from these sources shown in Figure 4, but N_2O can create GHG about 265 times over CO_2 gases within a hundred years' life spans [43].
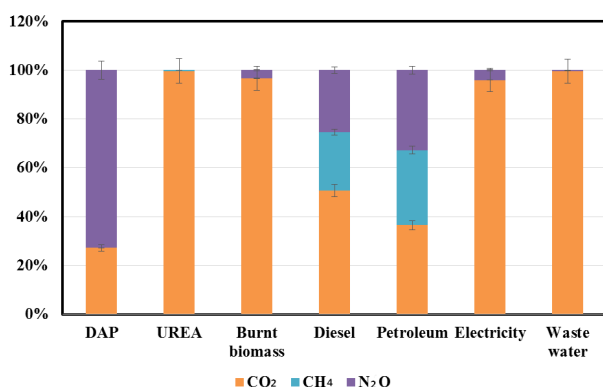

Figure 4. GHG emission from different sources in flower farms

Fertilizer is another type of GHG emission source in agricultural activities and flower farms are one sector of the agricultural system which used a high amount of chemical fertilizers. In this study, only two main nitrogen fertilizers were selected which included DAP and UREA that are used in high percentages in the farms. When these fertilizer types are used in the farms, greenhouse gas is emitted to the atmosphere that can cause global warming by supporting climatic changes (FAO). The basic GHG emitted from both nitrogen fertilizers used in the farms were CO_2, N_2O, CH_4, and NH_4. This GHG emitted from N- fertilizer was also evaluated as per IPCC (2006) standards that included using CO_2, N_2O & NH_3 gaseous from DAP, but for NH_3 using 8% of total nitrogen fertilizer percentages used in the farms as an emissive factor [44]. Also, greenhouse gas emitted from UREA evaluated using the total amount of Urea used to multiply with gaseous emitted emission factors for evaluation of both CO_2, N_2O & CH_4 estimated from global warming potential standards for each GHG emission. NH_3 was evaluated from total urea used per hectare of flower production after decomposition evaluated based on 8% of fertilizer used released to the atmosphere in form of ammonia & 2% release in the form of NOx [45].

$$N_2 + 3H_2 \leftrightarrow 2NH_3$$

$$2NH_3 + CO_2 \leftrightarrow NH_2CONH_2 + H_2O$$
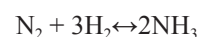
As mentioned in Table 2 and shown in Figure 4 high percentages of CO_2 emanated from urea and high percentages of N_2O from DAP released into the atmosphere when compared with other types of GHG emitted from both types of fertilizers. This can cause atmospheric pollution and climatic changes in the environments. The other types of GHG emission sources in the current study were the gaseous emitted from energy sources used in the farms that included energy for transportation and water pumping systems. Different types of energy sources used in flower farms, but the current study only selected the major energy sources used in the farms which included diesel fuel, petroleum fuel, and electricity power [46]. For all energy sources in the farms major GHG (CO_2, N_2O & CH_4) emitted as fundamental emission from the energy used were evaluated for diesel fuel, petroleum fuel and electricity. The amount of material used and emission factors of each GHG emitted from all energy sources used in flower farms and is based on medium to heavy-duty vehicles for emission factor of each GHG emitted. It can be observed that high percentages of CO_2 released to the atmosphere from diesel fuel and low amount of CO_2 released from petroleum when compared with each other or compare three of them that can bring climatic changes in the areas [47].

Wastewater discharged from flower farms is another type of material output that can cause environmental pollution and emit greenhouse gases to the air. In the current study, the other materials that can cause GHG emissions were wastewater discharged to environments from flower farms. The main greenhouse gas emitted from wastewater included CO_2, N_2O, and CH_4 that evaluated in this study. The CO_2 gas emission in the study estimated using hundred-year time horizon global warming potential (GWP =310 for N_2O and GWP = 21 for CH_4) that collected from IPCC 2006

standards and both N_2O and CH_4 estimated values. Based on evaluated results the amount of GHG emission from wastewater (effluent) to the atmosphere was greater than the other types of GHG emitting sources i.e. wastewater discharged from flower farms has great values to increase global warming by supplying a huge amount of GHG rather than other types of GHG emitting materials. The emission from pesticides in this study evaluated from a total pesticide used per year in the farms based on emissive factor. The reason behind to released on atmosphere and soils which depend on 30-50% of pesticides sprayed emitted to air in case of volatilizations and air drafting that mainly focused. Estimation of pesticide emission most of the time based on air condition, time, application methods, application systems, application skill, and types of pesticides [48]. Using this system, the GHG emitted from these chemicals evaluated totally from pesticide applied in flower farms that highly supports the climatic changes of the environments by inducing about 0.00002 Gg/year [49].

3.7 Emission of Nutrients to the River with Wastewater

The number of nutrients discharged to the river and nearby lands was evaluated from the results of effluent sampled that examined by the laboratory and the amount of wastewater discharged to the environments. As shown in Figure 5 PO_4, NO_3, NH_3 & SO_4 were the main nutrients that were discharged to the environments which support the eutrophication and acidification i.e. N, P, and their compounds are the major causes of eutrophication and acidification respectively [50]. Acidification occurred by NH_3, NO_X, SO_X by releasing H^+ which has the potential to acidify soil and water bodies. In this study, the main supporters of acidification are SOx, NH_3, and NOx and the main eutrophication supporter nutrients are PO_4, NH_3, NO_3.
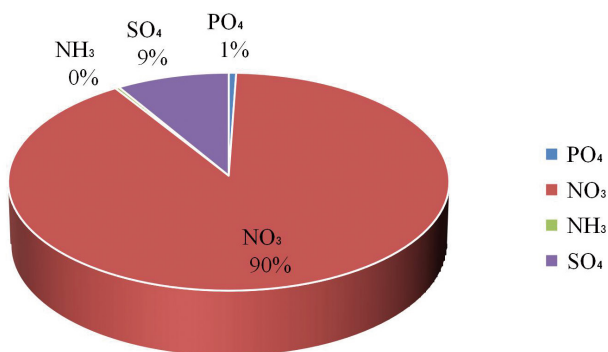

Figure 5. Nutrients support eutrophication and acidification of water bodies

As mentioned in Table 2 Wolmera district flower farms released a high dosage of chemicals that supports eutrophication and acidification into the environments as understood from estimated results. In general, the assessment evaluation involves the most influential emission which focused on GHG emission and wastewater emission to the environments. Both emission types estimated using international standards and laboratory analysis using the emitted discharge to the environments. The fundamental emission of GHG estimated from all input-output materials was CO_2, N_2O, CH_4 & NH_3 which has high potential to increase global warming and emission of wastewater to environments; also used to estimate chemical nutrient (PO_4, NO_3, NH_3, and SO_4) added to the rivers that support the development of eutrophication and increase acidification in the ecosystem after chemical fertilizer and pesticides react with water. In addition to these CO_2 has a great value to add acidification to environments especially in water bodies that included rivers, lakes & oceans [51]. According to this statement, CO_2 released into the air react with water and creates water body acidification that can harm the organisms in water and users of the water resources. Acidification of the water body could occur during atmospheric CO_2 reaction with water as following reaction process and increase H^+ in water bodies (oceans, lakes, rivers) of CO_2 from the air. In general, CO_2, SO_4, like compounds resulted in acidification when they reacted in the atmosphere with water droplets or precipitation [52].

$$CO_2 + H_2O \leftrightarrow H_2CO_3$$

$$H_2CO_3 \leftrightarrow HCO_3^{1-} + H^+$$
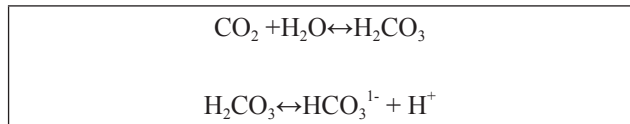
4. Conclusions

Wolmera flower farms consume too many resources and disposed of/discharged a huge amount of wastes to the environments which directly or indirectly influence the environment & its components. In the company, input-output materials were assessed & identified by using inventory and sampling data collection methods that are supported by ISO14031 standard integrated with LCA. An important data was collected from its sources (at the site) and GHG (CO_2, N_2O, CH_4 & NH_3) emission emitted to environments were evaluated from fertilizer (DAP & UREA), floriculture biomass residue burns in farms, energy consumed (diesel fuel & petroleum), pesticide applied and wastewater discharged to an environment using IPCC 2006 from inventory data aggregated. These all GHG emitted to environments can increase global warmings. Similarly, the basic cause of eutrophication

and acidification materials (NO$_3$, PO$_4$, NH$_3$, SO$_4$ from wastewater & N, P from soil) were evaluated from laboratory results. In general, the farms have low operational performances and environmentally less significant. To solve these like challenges in flower farms they must follow internal and external combined or linked environmental performances evaluation. Therefore, this systematic environmental management tool is used to lead the flower farms to evaluate an ability they have to manage impacts of an environment instead of missed EIA documents during construction.

References

[1] Ethiopia, C. (2008). "Summary and statistical report of the 2007 population and housing census." Addis Ababa, Ethiopia: Federal democratic republic of Ethiopia population census commission: 1-10.

[2] Mengistie, B. (2016). Environmental governance of pesticides in Ethiopian vegetable and cut flower production, Wageningen University.

[3] Ariti, A. T., et al. (2018). "Farmers' participation in the development of land use policies for the Central Rift Valley of Ethiopia." Land use policy 71: 129-137.

[4] Minale, A. S. and K. K. Rao (2011). "Hydrological dynamics and human impact on ecosystems of Lake Tana, northwestern Ethiopia." Ethiopian Journal of Environmental Studies and Management 4(1).

[5] Mbow, C., et al. (2014). "Knowledge gaps and research needs concerning agroforestry's contribution to sustainable development goals in Africa." Current Opinion in Environmental Sustainability 6: 162-170.

[6] Getu, M. (2009). "Ethiopian floriculture and its impact on the environment." Mizan law review 3(2): 240-270.

[7] Sahle, A. and J. Potting (2013). "Environmental life cycle assessment of Ethiopian rose cultivation." Science of the total environment 443: 163-172.

[8] Kassa, M. A. (2017). "Review on Environmental Effects of Ethiopian Floriculture Industry." Asian Research Journal of Agriculture: 1-13.

[9] Kuzichev, O.B. and Kuzicheva, N.Y., 2016. Innovative processes in floriculture: current status, problems and prospects. Indian Journal of Science and Technology, 9(16), p.89804.

[10] Hall, T.J., Lopez, R.G., Marshall, M.I. and Dennis, J.H., 2010. Barriers to adopting sustainable floriculture certification. HortScience, 45(5), pp.778-783.

[11] Belwal, R. and M. Chala (2008). "Catalysts and barriers to cut flower export: A case study of Ethiopian floriculture industry." International Journal of Emerging Markets 3(2): 216-235.

[12] Tilahun, A. (2013). Environmental impacts of floriculture industry in Debrezeit Town: A need for strategic environmental assessment, Addis Ababauniversity.

[13] Janko, A.M. and Alemu, G., 2014. Supply and marketing of floriculture in Ethiopia. International of Horticulture and Floriculture, 5(3), pp.254-270.

[14] Mwase, D.E., 2015. Performance of Floriculture Industry in East Africa: What Lessons can Tanzania Learn from Kenya?. Asian Business Review, 5(1), pp.20-27.

[15] Hall, T.J., Dennis, J.H., Lopez, R.G. and Marshall, M.I., 2009. Factors affecting growers' willingness to adopt sustainable floriculture practices. HortScience, 44(5), pp.1346-1351.

[16] Xia, Y. and X. Yan (2011). "Life-cycle evaluation of nitrogen-use in rice-farming systems: implications for economically-optimal nitrogen rates." Biogeosciences 8(11): 3159.

[17] Mengistie, B.T., Mol, A.P. and Oosterveer, P., 2017. Governance of agro-pesticide through private environmental and social standards in the global cut flower chain from Ethiopia. Ambio, 46(7), pp.797-811.

[18] Belwal, R. and Chala, M., 2008. Catalysts and barriers to cut flower export: A case study of Ethiopian floriculture industry. International Journal of Emerging Markets.

[19] Seyoum, A., Gebreyohannes, A., Nega, A., Nida, H., Tadesse, T., Tirfessa, A. and Bejiga, T., 2019. Performance evaluation of sorghum (Sorghum bicolor (L.) Moench) genotypes for grain yield and yield related traits in drought prone areas of Ethiopia. Adv Crop Sci Technol, 7(439), p.2.

[20] Benti, G., Degefa, G., Biri, A. and Tadesse, F., 2017. Performance Evaluation of Tomato (Lycopersicon esculentum Mill.) Varieties Under Supplemental Irrigation at Erer Valley, Babile District, Ethiopia. Journal of Plant Sciences, 5(1), p.1.

[21] Gebreeyesus, M. and Iizuka, M., 2012. Discovery of flower industry in Ethiopia: experimentation and coordination. Journal of Globalization and Development, 2(2).

[22] Semman, U., Eba, B. and Dinkale, T., 2018. Performance evaluation of improved oat varieties/accessions at the highland of Guji Zone, Bore, Ethiopia. Journal of Biology, Agriculture and Healthcare, 8(17).

[23] Staelens, L., Desiere, S., Louche, C. and D'Haese, M., 2018. Predicting job satisfaction and workers' intentions to leave at the bottom of the high value agricultural chain: evidence from the Ethiopian cut

flower industry. The International Journal of Human Resource Management, 29(9), pp.1609-1635.

[24] Gemechu, B., Besufekad, A. and Mekuriaw, A., 2019. Performance evaluation of improved bread wheat (Triticum aestivum L.) varieties and production technologies in Central High Lands of Ethiopia. African Journal of Agricultural Research, 14(7), pp.439-446.

[25] Belay, F. and Meresa, H., 2017. Performance evaluation of sorghum [Sorghum bicolor (L.) Moench] hybrids in the moisture stress conditions of Abergelle District, Northern Ethiopia. Journal of Cereals and Oilseeds, 8(4), pp.26-32.

[26] Geleta, D.H., Alemayehu, M., Asrade, G. and Mekonnen, T.H., 2021. Low levels of knowledge and practice of occupational hazards among flower farm workers in southwest Shewa zone, Ethiopia: a cross-sectional analysis. BMC public health, 21(1), pp.1-12.

[27] Oqubay, A. (2015). Made in Africa: industrial policy in Ethiopia, Oxford University Press, USA.

[28] Suzuki, A., Mano, Y. and Abebe, G., 2018. Earnings, savings, and job satisfaction in a labor-intensive export sector: Evidence from the cut flower industry in Ethiopia. World Development, 110, pp.176-191.

[29] Mengistie, B.T., Mol, A.P., Oosterveer, P. and Simane, B., 2015. Information, motivation and resources: The missing elements in agricultural pesticide policy implementation in Ethiopia. International journal of agricultural sustainability, 13(3), pp.240-256.

[30] Melese, A.T. and AHJ (Bert) Helmsing, 2010. Endogenisation or enclave formation? The development of the Ethiopian cut flower industry. The Journal of Modern African Studies, pp.35-66.

[31] Nigatu, A.W., Bråtveit, M., Deressa, W. and Moen, B.E., 2015. Respiratory symptoms, fractional exhaled nitric oxide & endotoxin exposure among female flower farm workers in Ethiopia. Journal of Occupational Medicine and Toxicology, 10(1), pp.1-8.

[32] Gobie, W., 2019. A seminar review on impact of floriculture industries in Ethiopia. Int. J. Agric. Econ, 4, p.216.

[33] Firew, Y., Mekbib, F. and Asfaw, A., 2016. Performance evaluation and participatory varietal selection of highland Sorghum (Sorghum bicolor (L.) Moench) genotypes in western part of Ethiopia. American-Eurasian Journal of Agricultural & Environmental Sciences, 16(10), pp.1641-1647.

[34] Gezmu, A.B., 2013. The human impacts of flower farm development in the Ethiopian Rift Valley region (Doctoral dissertation, University College Cork).

[35] Amsalu, S., Addisu, G.G.B. and Kebede, M., 2018. Performance Evaluation of Different Crops as an Option for Smallholder farmers producing on the Waterlogged Vertisols of Central Highlands of Ethiopia. Soil Fertility and Plant Nutrient Management.

[36] Nigatu, A.W., 2017. Respiratory Health and Acute pesticide intoxications among workers in the flower farm industry in Ethiopia.

[37] Mitiku, M. and Mesera, T., 2017. Performance Evaluation of Common Bean (PhaseolusVulgaris (L.)) Varieties at Benatsemayworeda of South Omo Zone, SNNPR, Ethiopia. Int J Agric Biosci, 6(6), pp.277-280.

[38] Tizazu Mengistie, B., 2016. Environmental governance of pesticides in Ethiopian vegetable and cut flower production (Doctoral dissertation, Wageningen University).

[39] Staelens, L., Louche, C. and D'Haese, M., 2014. Understanding job satisfaction in a labor intensive sector: Empirical evidence from the Ethiopian cut flower industry (No. 727-2016-50166).

[40] Mano, Y. and Suzuki, A., 2013. Industrial development through takeovers and exits: the case of the cut flower exporters in Ethiopia.

[41] Darkwa, K., Ambachew, D., Mohammed, H., Asfaw, A. and Blair, M.W., 2016. Evaluation of common bean (Phaseolus vulgaris L.) genotypes for drought stress adaptation in Ethiopia. The crop journal, 4(5), pp.367-376.

[42] Abtew, W.G., Lakew, B., Haussmann, B.I. and Schmid, K.J., 2015. Ethiopian barley landraces show higher yield stability and comparable yield to improved varieties in multi-environment field trials. Journal of plant breeding and crop science, 7(8), pp.275-291.

[43] Yemata, G., Fetene, M., Assefa, A. and Tesfaye, K., 2014. Evaluation of the agronomic performance of stay green and farmer preferred sorghum (Sorghum bicolor (L) Moench) varieties at Kobo North Wello zone, Ethiopia. Sky Journal of Agricultural Research, 3, pp.240-248.

[44] Jansen, H.C., Hengsdijk, H., Legesse, D., Ayenew, T., Hellegers, P. and Spliethoff, P.C., 2007. Land and water resources assessment in the Ethiopian Central Rift Valley: Project: Ecosystems for water, food and economic development in the Ethiopian Central Rift Valley (No. 1587). Alterra.

[45] Asfaw, A., Almekinders, C.J., Blair, M.W. and Struik, P.C., 2012. Participatory approach in common bean (Phaseolus vulgaris L.) breeding for drought tolerance for southern Ethiopia. Plant breeding, 131(1), pp.125-134.

[46] Alemu, A., Wodajo, A. and Chuntal, K., 2016. Per-

formance Evaluation of Elite Hot Pepper (Capsicum Annum) Varieties for Yield and Yield Components at Derashea, South-Eastern Ethiopia. International Journal of Research-GRANTHAALAYAH, 4(12), pp.95-100.

[47] Vasanthakumar, K., Bezu, T. and Bekele, A., 2015. Response of varieties and planting dates on growth and flowering of gladiolus (Gladiolus grandiflorus Andrews) under the ecological conditions of Haramaya University, eastern Ethiopia. Journal of Horticulture and Forestry, 7(5), pp.112-117.

[48] Gudeta, D.T., 2012. Socio-economic and Environmental Impact of Floriculture Industry in Ethiopia. Wageningen University (The Netherlands).

[49] Mengistie, B.T., Ethiopia The Environmental Aspects of Policy and Practice in the Ethiopian Floriculture Industry. Environmental Policy and Law, (Preprint), pp.1-18.

[50] Assefal, G., Berhanu, T., Gizachew, L., Dejeniet, M. and Geleti, D., 2006. Major herbaceous forage legumes: Some achievements in species and varietal evaluation in Ethiopia. Food and Forage Legumes of Ethiopia: Progress and Prospects, p.291.

[51] Alemayehu, M. and Alemayehu, G., Performance evaluation of tomato varaieties for irrigation production system in Mecha District of west Gojiam Zone, Amhara Region, Ethiopia-Masho Aklile1.

[52] Engida, T., Alemu, T., Wu, J., Xu, D., Zhou, Q. and Wu, Z., 2020. Analysis of constructed wetlands technology performance efficiency for the treatment of floriculture industry wastewater, in Ethiopia. Journal of Water Process Engineering, 38, p.101586.