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CARBON FOOTPRINT OF FARM INPUTS USED IN AGRICULTURE SECTOR IN ALBANIA

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Abstract

Evaluation and monitoring environmental performance of agriculture idealistically viewed in a life cycle perspective, is crucial for achieving better management of natural resources approaching sustainability, economic and technological development. In this study a simple LCA model approach was used to estimate GHG emission generated from farm inputs (fuel, machinery, agrochemicals) on regional level in Albania. Emissions were estimated by multiplying activity data obtained from national statistics for year 2012 and emission factors through the consultation of literature using Tier 1 IPCC 2006 methodology. The total GHG emissions from farm inputs was estimated $1075.8*10^3$ tonCO_2eq. The results indicated that farm machinery production accounted for 53% of total GHG emission while agrochemicals and fuel for 46% and 1%, respectively. The main emitting regions were Fieri, Vlora and Tirana with 24, 12 and 11% share in total GHG emissions, respectively. The lowest emitting region was found to be Kukesi. Management measures should be developed in an integrated manner for increasing productivity and economic benefits and reducing negative environmental impacts. Practically, Albania need investments in agricultural mechanization, irrigation systems and extension services. Further research and harmonisation of LCA impact assessment models for GHG emission are considered essential toward a sustainable development.

Keywords: *Agricultural production, Green economy, GHG emission, Farm management, LCA*

Introduction

Agriculture plays a major role in the flow of greenhouse gasses - especially carbon dioxide (CO_2), nitrous oxide (N_2O), oxides of nitrogen (NO_x) and methane (CH_4). Emissions of these gases may occur from livestock such as cows, agricultural soils and rice production. Agricultural emission from crop and livestock production increased by 14% from 2000 to 2011 according to FAO estimation. This increase occurred mainly in developing countries due to expansion of total agricultural outputs.

Agriculture is the most important sector in Albania in terms of value added and employment, contributing more than half of Gross Domestic Production (GDP). Hence, increasing agricultural production is vital process not only develop the economy and reduce unemployment, but also to enable the reduction of prices of main products and the country's dependence on imports. According to first national communication to the united nations framework on climate change , Albania's contribution to the global greenhouse gas emissions is relatively low, estimated at 7619.90 Gg in 2000, where main source of CO_2 was energy sector with 44% followed by agriculture with 27.12% of total GHG emissions and Land Use Change & Forestry (21.60%). However, rural exodus, lack of irrigation and drainage systems, low level of technologies in use, weak organization of farmers, low level of development of agro – processing are threatening farms systems and rural communities. Emissions from all regions are expected to grow as increasing of population will drive increased demand for food. If no measures to reduce greenhouse (GHG) emissions are taken, the GHG emissions for Albania will increase in the years to come as agriculture is becoming the backbone of economy. The main objective of this study is quantification of direct and indirect GHG emission from agriculture sector in Albania generated from production and combustion of fossil fuels used in agriculture sector, farm machinery production and agrochemical production, packaging, storage and transportation and use.

Materials and methods

Life Cycle Assessment (LCA) is commonly employed to undertake a complete evaluation of emissions. LCA is an internationally standardized method (ISO 14040, ISO 14044) where the environmental impacts of products and processes are analysed from ‘cradle to grave’, such that both direct and indirect emissions from agricultural practices are included. Emissions were estimated by multiplying activity data with emission factors for each resource. The emissions estimates were computed from official national statistics data for 2012 using Tier 1 IPCC 2006 methodology. Tier 1 approaches provide for simple estimations, based on generalized emission factors and other parameter values that are specified either globally or regionally. In line with international greenhouse accounting practice (IPCC, 2006), emission factors are expressed as carbon dioxide equivalents per unit mass of fertiliser product (eg. kg CO_2eq / kg fertiliser) or element (eg. kgCO_2eq/kg N). To calculate carbon footprint the latest 100-year global warming potential for GHGs published by the IPCC were used.

GHG emissions from manufacturing of farm machinery

GHG emissions from farm machinery includes direct emission arising from combusting diesel fuel in engines and indirect emissions from manufacturing, transport from the plant to a farm, repair of machines and discarding/recycling. A detailed analysis for indirect GHG emissions for every machine is impossible due to the workload and missing data. Hence, in this study the GHGs through the manufacture farm equipment (e.g., tractors) were only considered. On average, approximately 83.7 MJ of energy is required to produce one kg of farm machine (Maraseni et al., 2007). Since 1 KWh = 3.6 MJ, 23.25 KWh are required for each of those machinery kilos. In Table 1 are presented the data about tractors registered in each region in Albania.

Table 3. Number of agricultural machineries registered in Albania

Region	Tractor with Wheels	Minitractor	Sowing Machinery	Mower
Berat	514	240	100	80
Diber	348	103	104	45
Durres	471	305	199	151
Elbasan	870	546	403	154
Fier	2315	947	830	566
Gjirokaster	283	100	99	94
Korce	1226	1065	529	191
Kukes	273	196	162	58
Lezhe	449	274	182	198
Shkoder	892	313	156	287
Tirane	504	427	243	180
Vlore	574	292	285	147
TOTAL	8719	4808	3292	2151

To deal with high range of machines found in market the average weight of different types of tractors was used. The average weight of a tractors and accessory equipments were derived from tractor data. The respective average weights were 4007 kg for tractor with wheels, 1474 kg for minitractors, 310 kg for sowing machineries and 260 kg for mowers. Each kWh of energy consumed produces 0.4365 $kgCO_2eq$. The CO_2 emission factor associated with electricity, heat, and/or steam consumption was obtained from Defra 2012 and is average reference value for Europe.

GHG emissions from the production and use of fossil fuels

Use of fossil fuels in agriculture results in CO_2 emissions from production, transportation and combustion of diesel in farm operations. GHG emission from fuel use for agriculture purposes was calculated as a product of fuel consumed multiplied by the appropriate default emission factors. Emissions factor for diesel combustion and life cycle production were obtained from Defra 2012. Each litre of diesel produces 2.4637 $kgCO_2eq$ during its combustion and 0.522 $kgCO_2eq$ from production. Thus the total GHG emissions during the production and combustion of 1 L of diesel is 2.9857 kg CO_2eq.

GHG Emissions from Production, Packing, Transportation and Application of Agrochemicals

Agrochemicals include fertilisers and chemicals (herbicides, insecticides, fungicides and plant growth regulator), with their production, packaging, storage and transportation requiring energy and thereby contributing to GHG emissions (Maraseni, 2012). Three types of fertilizers (Table 2) commonly used in Albania are Urea, Ammonium Nitrate (AN) and Diammonium Phosphate (DAP). Albania.

Table 4. Use of chemical fertilizers on regional level in Albania (All values are in ton)

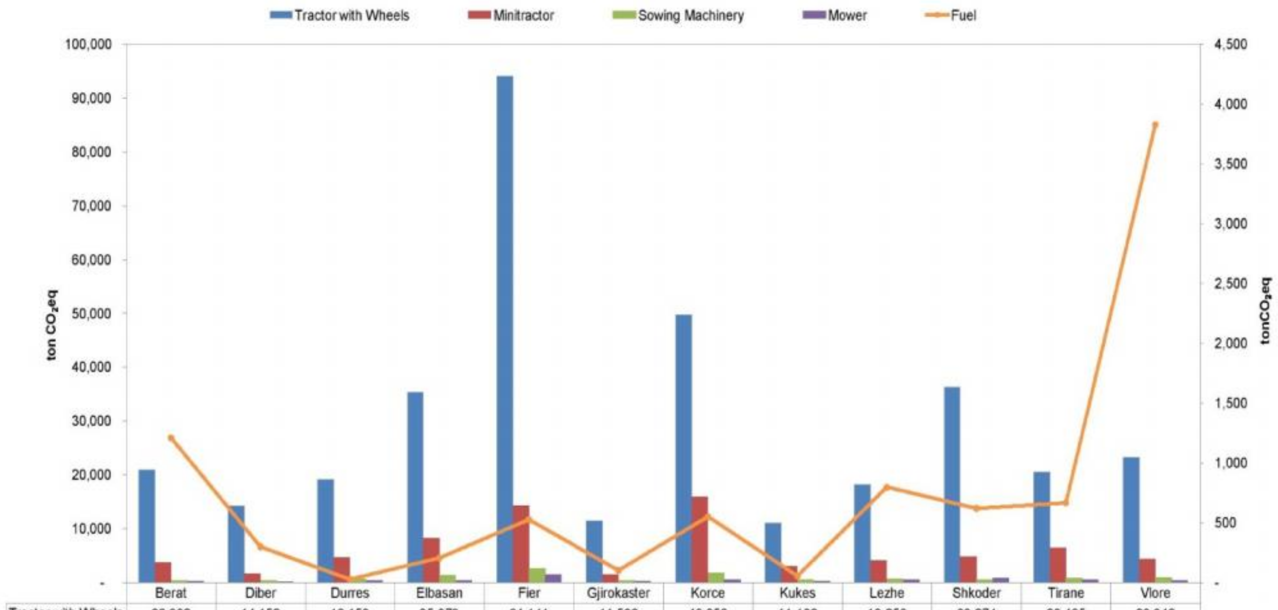
Region	Urea (U)	Ammonium Nitrate (AN)	Di-amonium Phosphate (DAP)	Mean P	Pesticides
Berat	3322	1405	4223	773	44.77
Diber	973	3396	2225	380	3.98
Durres	3481	2695	4021	262	28.13
Elbasan	3722	3996	5299	11	20.17
Fier	10686	5607	12457	1256	93.76
Gjirokaster	497	783	619	316	6.56
Korce	1800	3499	3999	9	31.80
Kukes	287	733	693	19	3.18
Lezhe	2147	2137	1989	50	12.67
Shkoder	2725	3188	2322	101	37.01
Tirane	3848	3444	7303	189	45.30
Vlore	5274	4907	1939	0	9.90
TOTAL	38762	35790	47089	3366	337.217

The proportions major fertiliser elements (such as N, P, K, S) were estimated using their chemical formula and their molecular and atomic weights. The proportions of fertiliser elements (N, P, K, S) are 46-0-0-0 for Urea, 33.5:0:0:0 for Ammonium Nitrate, 18:46:0:0 for Diammond Superphosphate and 0-33.5-0-0 for mean P fertilizer (Wood and Cowie, 2004). Since ammonium nitrate contains 46% phosphoric acid the percent of phosphorus was converted from concentrations of this content. For pesticides was assumed that they are used as herbicides. The common type of herbicide in Albania is Raundup (a.i glyhosphate 36%). Emission factor was converted to kilograms of carbon dioxide equivalent per kilogram of active ingredient (kg CO_2eq/kg a.i.). Active ingredient (in herbicide, insecticide and plant regulators) were obtained from interview with phyto pharmacists. Emission factors for indirect agrochemical emissions were collected from Lal, 2004. Following Lal, 2004 they were converted into CO_2eq by multiplying by 3.67 (molecular weight of CO_2/atomic weight of C = 44/12).

In addition to the GHG emissions associated with the manufacturing and acquirement of N fertilizers, their application results in direct and indirect N_2O emission from agricultural soils. Specifically, N_2O is produced by microbial processes of nitrification and de-nitrification taking place on the addition site (direct emissions), and after volatilization/re-deposition and leaching processes (indirect emissions). The emissions were estimated at Tier 1 following IPCC, 2006: Vol. 4, Ch. 11. The IPCC Guidelines methodology for calculation of direct and indirect nitrous oxide emissions from agricultural soils is based on an emission factor per kg N in the applied nitrogen. Default IPCC methodology uses a default direct emission factor of 1% NO_2-N emissions kg−1 of applied N and 30% for fraction of N lost in leaching and runoff where 0.75% of this N is indirectly emitted as N_2O-N. In addition, it assumes that 10% of the fertilizer and 20% of the manure N applied to agricultural fields is lost through NH_3-N volatilization and NO_x-N emissions, and about 1.0% of this N is later emitted as N_2O-N. Conversion between emission gases was made according to the standard suggested by the IPCC (Eggleston et al., 2006).

Results and discussion

In Figure 2 are presented the machinery-related GHG emissions including emissions from the production of the machinery and those from fuel usage. Machinery manufacturing was the major contributor to emissions, with 53% share on total GHG emission. This is due to high energy used in machine manufacturing. As expected, the highest source for indirect emission from farm machinery manufacturing was Fieri region due to the highest number of machineries. In fact this region has the most intensive agricultural production in Albania. Compared with the European average, Albania obtain 3 times less yield for unit area because only 54% of farm households have the opportunity to use agricultural mechanics, 46% use animal and hand work. From the total of registered tractor, only 60% of tractors (even these very old) are in working condition. Optimal needs are estimated to around 14,000 tractors.

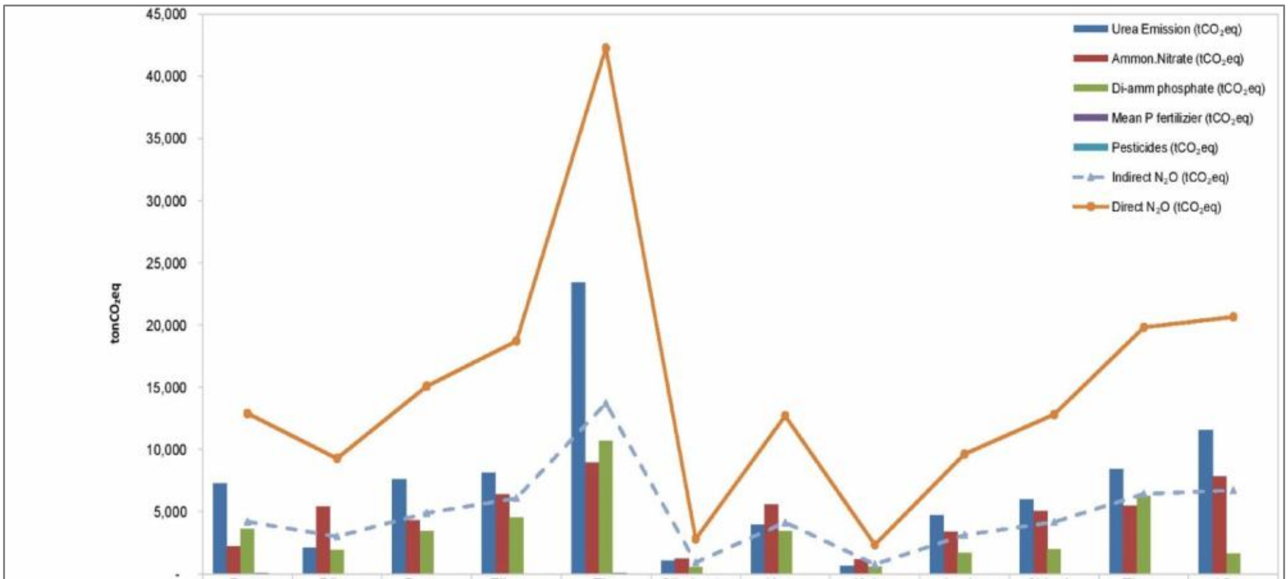


	Berat	Diber	Durres	Elbasan	Fier	Gjirokaster	Korce	Kukes	Lezhe	Shkoder	Tirane	Vlore
Tractor with Wheels	20,902	14,152	19,153	35,379	94,141	11,508	49,856	11,102	18,259	36,274	20,495	23,342
Minitractor	3,589	1,540	4,561	8,165	14,162	1,495	15,927	2,931	4,098	4,681	6,386	4,367
Sowing Machinery	315	327	626	1,268	2,611	311	1,664	510	573	491	764	897
Mower	211	119	398	406	1,493	248	504	153	522	757	475	388
Fuel	1,205.73	295.40	23.29	203.41	523.74	98.84	547.64	52.28	794.53	617.01	662.51	3,828.12

Figure 8. Machinery and fuel consumption related emissions

The total GHG emissions from fuel consumed was estimated at $8.85*10^3$ $tonCO_2eq$ where 83% were produced as direct emission (diesel combustion) and 17% as indirect emission (diesel production). Fuel related emissions ranged from 0.69 $kgCO_2eq/ha$ (Diber) to 99.9 $kgCO_2eq/ha$ (Vlora) with an average of 24.7 $kgCO_2eq/ha$. Agriculture in mountain areas such as Diber and Kukes is dominated by small farms size (average 0.61 ha) and fragmented in the plots which has led to the limitation of agricultural machinery use. In contrast with agriculture machinery emissions, the highest source for fuel related emission was Vlora which has the highest quantity of fuel consumed. This might be explained with the level of farming mechanization needed as the farm size in this region is increased by 43% from year 2000 to 2012. Fuel consumption per unit of work in Albania is much greater than all countries in the region due to the farm zoning, bad fuel quality and obsolescence of agricultural equipment.

Figure 2 presents the agrochemical GHG emissions on regional level. Agrochemical related total GHG emission were estimated as $419.9*10^3$ $tonCO_2eq$. Indirect agrochemical GHG emissions were estimated as $182.5*10^3$ $tonCO_2eq$. The highest relative contribution to total indirect emissions by 46% was attributed to Urea which contains higher amount of N than ammonium nitrate (AN) and diamond phosphate (DAP).



	Berat	Diber	Durres	Elbasan	Fier	Gjirokaster	Korce	Kukes	Lezhe	Shkoder	Tirane	Vlore
Urea Emission (tCO_2eq)	7,284	2,133	7,633	8,161	23,431	1,090	3,947	629	4,708	5,975	8,437	11,564
Ammon.Nitrate (tCO_2eq)	2,244	5,423	4,303	6,381	8,953	1,250	5,587	1,170	3,412	5,091	5,499	7,836
Di-amm phosphate (tCO_2eq)	3,624	1,909	3,450	4,547	10,689	531	3,432	595	1,707	1,993	6,267	1,664
Mean P fertilizier (tCO_2eq)	64	31	22	1	103	26	1	2	4	8	16	-
Pesticides (tCO_2eq)	0.538	0.048	0.338	0.242	1.126	0.079	0.382	0.038	0.152	0.445	0.544	0.119
Indirect N_2O (tCO_2eq)	4,195	3,019	4,908	6,089	13,740	916	4,136	764	3,135	4,165	6,445	6,719
Direct N_2O (tCO_2eq)	12,908	9,290	15,102	18,736	42,277	2,818	12,726	2,350	9,645	12,817	19,830	20,674

Figure 9. Agrochemical related GHG emission

Comparing the regions the highest and lowest indirect emissions was observed for Fieri and Kukesi, respectively. Fieri region is characterized by high amount of Urea used while in Kukes are used more the phosphate fertilizers which has in average 42% lower quantity of nitrogen content. Regarding to emission from fertilizer application the largest source of N_2O was nitrification and denitrification which accounted for 75% of total N_2O emissions. The total direct nitrous oxide emissions (N_2O) from agricultural soils were estimated at 382 ton N_2O or $179.1*10^3$ ton CO_2eq. The total indirect nitrous oxide emissions (N_2O) from agricultural soils were estimated at 124.4 ton N_2O or $58.2*10^3$ tonCO_2eq. Indirect emissions accounted for 69% in leaching and runoff and 31% was produced from volatilization. Thus, the total N_2O emission was estimated 507.8 ton N_2O or $237.4*10^3$ ton CO_2eq. Average FAO estimation of N_2O emission from the application of syntethic fertilisiers in Albania for period 2007-2011 was $205.9*10^3$ ton CO_2eq, which is close to the value estimated in this study. It should be noted that level of emission may vary year to year depending on fertilizers input.

The GHG estimated in this study are associated with uncertainties from activity data. According to IPCC uncertainties in estimation of emission from agriculture (crops and livestock production) range from 10-150 %. In general, emission estimates for agriculture at national level have uncertainties in the range 10-70% . CO_2 emissions from fossil fuels—which represent the majority of anthropogenic emissions—are characterized by a 10-15% estimation uncertainty.

Conclusion

In this study a simple model approach was used to estimate GHG emission generated from farm inputs (fuel, machinery, agrochemicals) on regional level in Albania. This work was developed in order to identify the critical areas and some opportunities for emission reduction through changes to management practices that can simultaneously improve productivity and increase the resilience of production systems in the future. A variety of options exists for mitigation of GHG emission in agriculture. ‘Minimum’ (or ‘reduced’) and ‘zero’ (or ‘no’) tillage practices are currently spreading throughout the world (Soane et al. 2012). In south-western Europe the uptake of no-tillage is currently increasing because of perceived environmental advantages and reduced costs. Conversion to organic pastures and agriculture could mitigate 40 percent of agriculture’s GHG emissions, rising to 65 percent when combined with zero tillage and that organic farming could reduce irrigation needs by 30-50 percent (Niggli et al., 2009). Reduced tillage also save energy by reducing direct energy consumption and CO_2 from fossil fuel combustion (Jane, 2007). However, such practices are frequently combined with periodical tillage, thus making the assessment of the GHG balance highly uncertain.

Improving N use efficiency can reduce N_2O emissions and indirectly reduce GHG emissions from the energy consumed in its manufacture. Improvements in fertilizer efficiency, water and food security through better management, placement and precision application, as well as through slow-release formulations, can reduce N_2O losses from cropping. Nitrous oxide is a byproduct of fuel combustion, so reducing mobile fuel consumption in motor vehicles can reduce emissions. Improving energy efficiency is among the most cost-effective of the many actions needed for achieving green growth and mitigating climate change. Extensive research must be undertaken to examine effective ways to accelerate the adoption of low emission vehicles or to increase vehicle fuel efficiency, looking primarily at the constraints, such as infrastructure requirements and safety. A number of alternative fuels and technologies are already developed that have the potential to significantly reduce CO_2 emissions and local air pollutants. Significant mitigation is possible with improved water management as Albania is still based in traditional irrigation methods. In fact introducing large scale pressurized irrigation systems using electricity could generate significant CO_2 reduction since 90% of electricity in Albania is generated from hydro-energy which generally has low emission factor. Moreover, pressurized irrigation systems can improve nutrient use efficiency since this systems allows precise application of water-soluble fertilizers and other agricultural chemicals. Furthermore, it is worth pointing out that social conditions also play an important role in examining the efficient use of natural resources. The literature reveals many areas where farmer’s education has led to conservation and better use of available water supplies (e.g., Kilpatrick, 2000).

Clearly, there is a big room for improvement for agriculture in Albania, but a wider transition towards a more sustainable agriculture will not occur without some external support and money. Thus, by supporting eco-innovation, regional and national authorities can help to transform the way in which the stakholders interact with local ecosystems and bring value to the local economy.

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