Quest Journals
Journal of Research in Environmental and Earth Sciences
Volume 12 ~ Issue 1 (January 2026) pp: 39-49
ISSN(Online) :2348-2532
www.questjournals.org

Research Paper

Emission Profile in The Rice Life Cycle of The Yagoua Rice Sector, Far North Region of Cameroon

MYGUYRY DAHILE Daniel.[1*], MOUTHE ANOMBOGO Ghislain. Arnaud.[1], GOUDOUM August.[1,2] Author (MYGUYRY DAHILE Daniel.[1*])
Co-author (MOUTHE ANOMBOGO Ghislain. Arnaud.[1], GOUDOUM August.[1,2])
[1*]*Ecole Nationale Supérieure Polytechnique de Maroua, Université de Maroua Cameroun, Département des sciences environnementales*
[1]*Ecole Nationale Supérieure Polytechnique de Maroua, Université de Maroua Cameroun, Département des sciences environnementales*
[1,2]*Ecole Nationale Supérieure Polytechnique de Maroua, Université de Maroua Cameroun, Département d'Agriculture Elevage et Produits Dérivés*

Summary: *Rice farming in the Yagoua sector is a source of development, combats hunger and provides security for the populations of the rice-growing sector and its surroundings. This study of emissions modelling in the rice life cycle in the Yagoua rice sector enabled the life cycle to be inventoried and emissions from rice farming to be analysed. A survey of local stakeholders (rice farmers, rice mills, consumers) produced a detailed inventory of incoming and outgoing material flows in a diagram, which led to the assessment of emissions. The results show that incoming material flows (seeds, chemical fertilisers, pesticides), the product (paddy rice, white rice) and co-products (husks, straw, bran) are the source of effluents (N2O, Glyphosate, NO2, Cypermethrin, P2O5, NH3, K2O, Oxadiazon, CO2, CH4) in the various physical environments (air, water, soil) of the environment. The molecules produced by the carbonisation of rice husks and the use of Roundup, Rizstar, Realstar and Cypercal produce intermediate effects or midpoints, namely: carcinogenic effects at 5.75E+00 CTUh, respiratory effects at 1.29E+01 CTUh, aquatic ecotoxicity at 6.06E+00 CTUe, terrestrial ecotoxicity at 5.71E+00 kg N eq, terrestrial acidification/eutrophication at 1.90E+01 Kg N eq, aquatic eutrophication at 3.06E+01 Kg N eq and climate change effect at 2.58E+01Kg CO2 eq. They therefore explain the origin of damage to human health, natural resources and the ecosystem. N2O, glyphosate and NO2 molecules are the X factors in the magnitude of the impacts. They highlight the urgent need to optimise agricultural practices, particularly the management of chemical inputs and crop residues, while capitalising on the potential for valorising co-products. The study thus provides a scientific basis for the development of sustainable strategies in Cameroonian rice farming, reconciling flows and their impacts on the environment.*

Keywords: *Emissions, Ecotoxicity, Eutrophication, Intermediate effects, Flow inventory, Life cycle, Damage, Rice cultivation, Yagoua sector, ReCiPe method*

*Received 06 Jan., 2026; **R**evised 14 Jan., 2026; **A**ccepted 16 Jan., 2026 © The author(s) 2026.*
P**ublished with open access at **www.questjournas.org

I. INTRODUCTION

Tomorrow's rice farming must respond to a major challenge, which is to reduce various negative environmental impacts and optimise positive environmental impacts for high-quality rice production (Meryem, 2020).

In Cameroon, rice is a staple food for both rural and urban populations (MINEPAT, 2008). This has led to efforts to promote and boost rice production throughout the country by creating three major basins in the West, North-West and Far North regions (MINEPAT, 2008). The Yagoua rice-growing basin in the Far North Region of Cameroon is one of these areas. The Yagoua sector comprises the rice-growing localities of Yagoua, Velé, Kaï.

Rice farming in the Yagoua sector is carried out on soil that is used for continuous cultivation, is depleted of nutrients, and in some places requires external inputs of chemical fertilisers and pesticides (Van der Werf, 2011). The use of chemical inputs causes harm and pollution to both human health and the environment

(Ahmadou, 2016). When added to the soil, they produce chemical reactions that release gaseous molecules (NH_3, N_2O and CH_4) into the atmosphere, thereby altering greenhouse gases. They also contribute to groundwater pollution through the infiltration or absorption of molecules (glyphosate, cypermethrin, P_2O_5, K_2O, etc.) into the soil (Mohamed, 2005).

Given this observation, it is necessary to adopt the right environmental assessment methods to inform decision-makers and enable them to choose between different sustainable production strategies (Ahmadou, 2016). Analytical tools can be used to assess all emissions at different stages of the rice production chain (Nitschelm, 2016). This is where Life Cycle Assessment (LCA) comes in. Developed in industry in 2002, LCA is a method for assessing the environmental impacts of a product or service, and is widely used wherever the need arises (Meryem, 2020). It is a collection of several methods, principles, models and characterisation factors that enable practitioners to study a service or object (Jolliet et al., 2010). In addition, the ReCiPe method, which is part of this framework, is derived from a set of multi-criteria methods specific to the agricultural sector. It enables the identification of critical points, points of comparison and optimisation of technical itineraries for agricultural production. Concurrently, it addresses emissions, including potential damage understood as the final environmental impacts of rice farming (Jolliet et al., 2010).

Therefore, after characterising and classifying the externalities caused by emissions of active molecules from chemical inputs, which cause air pollution, soil contamination and water pollution as a result of chemical reactions in the environment, these can be studied using the ReCiPe method (Dazogbo et al., 2023). How can we define a profile of emissions released by inputs in rice cultivation in the Yagoua sector in light of the flows collected in this study? It is with this in mind that we are studying the modelling of emissions in the rice life cycle in the Yagoua rice sector. More specifically, this study aims to inventory the life cycle in order to highlight the flows in the cycle, then analyse emissions using the ReCiPe method.

II. MATERIAL AND METHODS

MATERIAL

Yagoua rice

The variety of rice grown in the Yagoua sector is IR 46 (Oryza sativa), a starchy grass that is cultivated in wet and marshy areas in warm countries. It combines the hardiness of the African species with the productivity of the Asian species, characterised by: a short cycle of 90 to 100 days and drought tolerance (Khush et al, 2005). The rice plant belongs to the Orizae group (subfamily Pooidaea in the grass family), an annual herbaceous plant characterised by a round stem covered with flat, sessile, blade-shaped leaves, a terminal panicle and primary and secondary roots with absorbent hairs (Lacharme, 2001).

Rice cultivation consists of the following steps: setting up the nursery, preparing the rice field, mudding or puddling with chemical fertiliser. Finally, transplanting is carried out at a depth of between 2.5 and 5 cm, with spacing of 0.20 m x 0.2 m or 0.25 m x 0.25 m and 2 to 3 plants per hole. After transplanting and until harvest, the rice field will be maintained (weeding, fertilisation, irrigation and guarding) and treated with pesticides and chemical fertilisers (Shamie et al., 2014).

Figure 1: Yagoua rice: (A) Paddy, (B) Milled rice Study area: Yagoua rice-growing sector.

Rice cultivation is practised in the localities of Yagoua, Velé, Kaï The functional unit is 1 hectare of irrigated land in the Yagoua sector. Rice farmers produce an average of 6,400 kg of paddy rice per hectare of land, or 80 bags of 80 kg (PCD Yagoua, 2013). Total production in the Yagoua sector in 2020 is estimated at around 1,158.45 tonnes of milled rice. There are two growing seasons per year: one in the rainy season and one in the dry season.

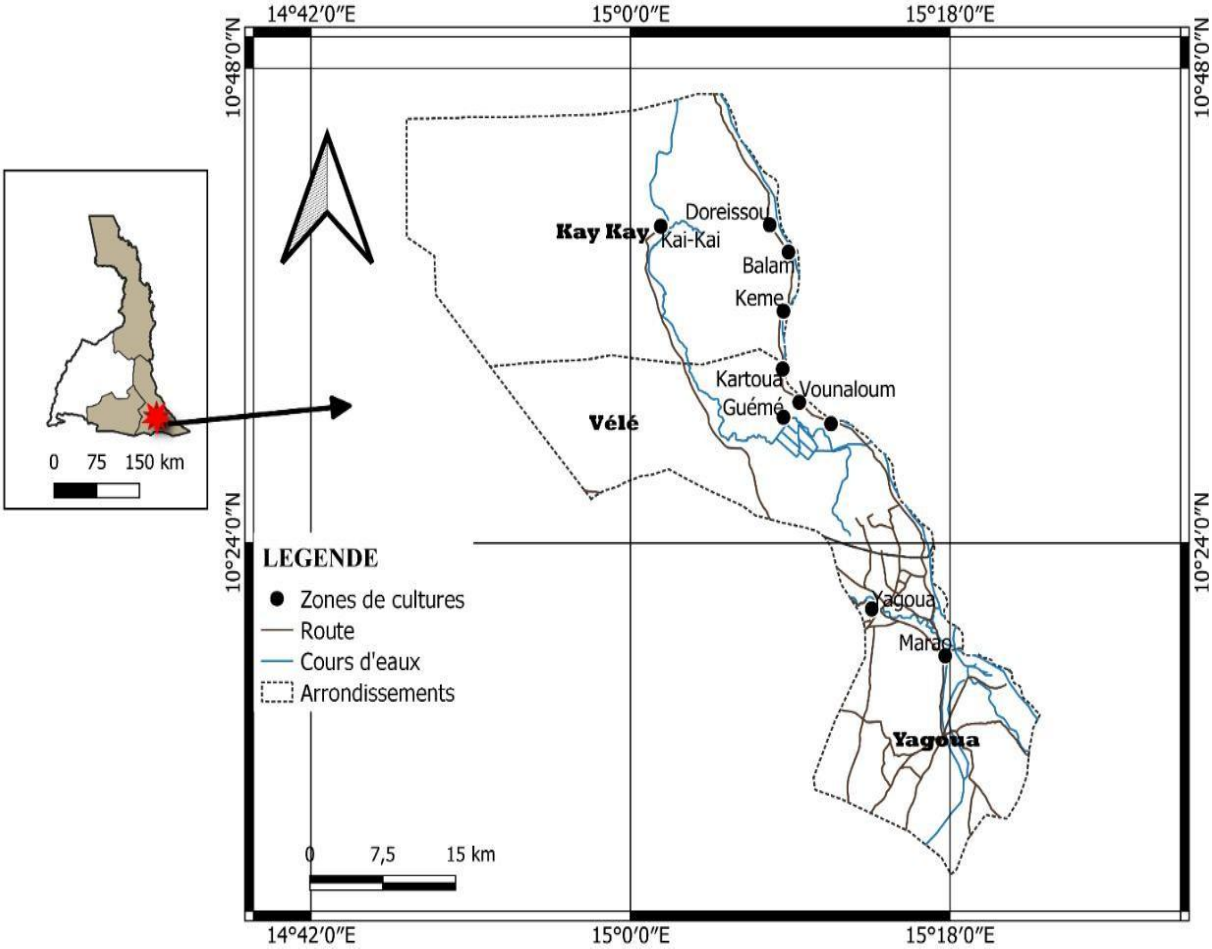

Figure 2: Map of the Yagoua rice-growing area

METHODS

Life Cycle Flow Inventory

The life cycle inventory consists of a quantitative description of the flows of materials and pollutants involved in the predefined system (Figure 3). This approach provides a production vector, consisting of all inputs and direct emissions from the system under study. Incoming and outgoing flows are referenced in the inventory, the intermediate classification and damage, which constitutes a matrix of emissions and extractions (Jolliet et al., 2010).

Figure 3 : Flow tree

ReCiPe method

The ReCiPe method, or "Recipe for Calculating Impact in the Life Cycle," is a recent method that synthesises several previous methods (CML 2002 and Ecoindicator 99). It is widely used to characterise specific impacts in the agricultural and environmental fields in relation to damage (Goedkoop et al., 2008). The classification of impacts (Figure 4) makes it possible to draw up a relevant list of intermediate environmental impact categories relating to specific issues. The emissions and extractions obtained during the inventory are assigned to these categories.

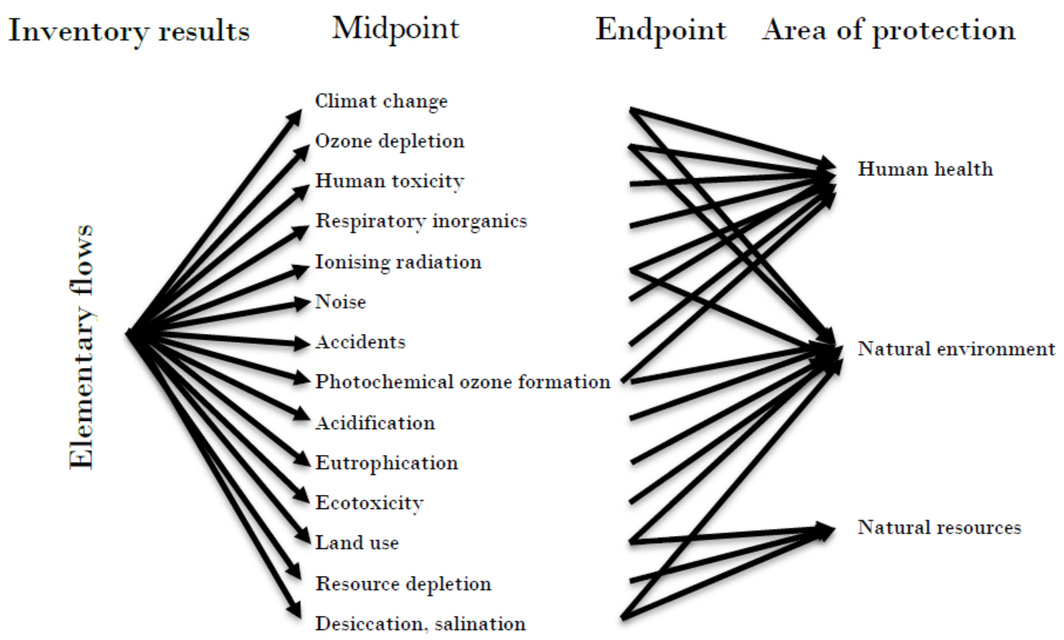

Figure 4: General impact emissions matrix

Calcul des scores Point médian

In concrete terms, the masses of substances emitted and extracted listed in the emissions and extractions inventory will be multiplied by these factors and summed in each of the intermediate categories, thus obtaining the intermediate impact score, expressed in a common unit specific to the category. Emissions are calculated using the following formula:

$$\mathbf{Ei = Ms \ X \ FIs,i}$$

$$\mathbf{SIi = \sum Ei = \sum (FIs,i \ X \ Ms)}$$

Ei : emissions for category i,
SIi : Intermediate characterization score for category i;
FIs,i : Intermediate characterization factor of substance s for a given intermediate impact category **i** **Ms** : Mass of substance emitted or extracted.

The emission levels are calculated by determining the intermediate characterization factors for each molecule. The mass of each element is also determined based on its molecular molar mass and its quantity in solution, and the values of the intermediate characterization factors are shown in Table 1.

Table 1: factors characterization intermediate (FCI)

Actif molecule	FCI
N_2O	265
Glyphosate	31,29
NO_2	310
Cyperméthrine	1
P_2O_5	0,658
NH_3	1,69
K_2O	0,83
Oxadiazon	1
CO_2	1
CH_4	25

III. RESULTS AND DISCUSSION

Rice flows

The process tree in Figure 5 highlights the elements of the input flow (pesticides, chemical and biological fertilizers, seeds, paddy, plastic packaging and twine), the output flow (powder or bran, husks, straw, various types of pollution, plastic packaging and waste, and organic fertilizer) surrounding the basic process (transformation of paddy into consumable rice) to produce packaged, consumable rice. The process tree characterizes the type and nature of flows around the elementary processes. Similarly, Dazogbo et al. (2023) highlighted the inputs and outputs of the life cycle analysis system for grain maize in the cereal sector in Quebec, with a view to reducing greenhouse gas emissions through the circular economy.

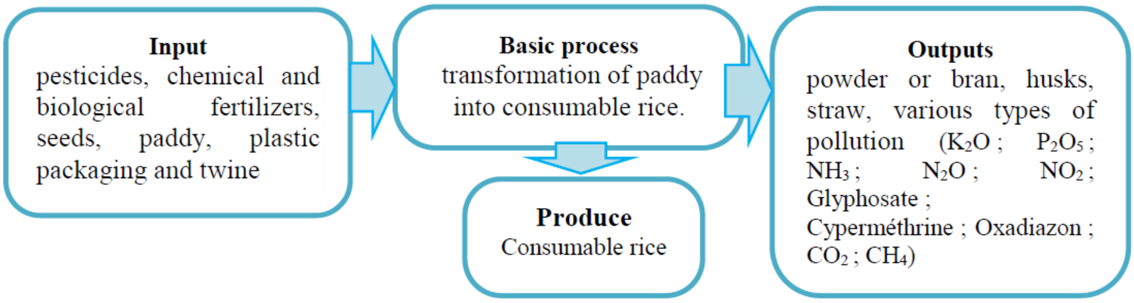

Figure 5: Rice production in the Yagoua sector

Causes of damage

The origin of environmental impacts (emission of chemical compounds, smoke formation, leachate production, soil contamination, ash production, land use, leaching of pesticides and chemical fertilisers, infiltration of chemical compounds, wastewater production) are illustrated in the main figure of the ReCiPe method (Figure 6) and Table 2. They are essential and combine an intermediate classification block of effects that is linked to the damage classification block. It is clear that these changes cause damage to health, the ecosystem and natural resources through the introduction of chemicals into the environment.

The inputs used in the rice sector in Yagoua are the total herbicide Roundup Biosec 680g/kg organophosphate, with glyphosate as the active ingredient, and the selective herbicide Rizstar or Realstar, with oxadiazon as the active ingredient. Not to mention the insecticide Cypercal 12 and 50g/kg, whose active ingredient is cypermethrin.

Table 2: Impacts based on the physical environment and the nature of emissions

Environment	Impacts	Émission	Impact value
Air	Chemical emissions, Smoke formation, Production of ash	L'ammoniac (NH3), Protoxyde d'azote (N2O), dioxyde d'azote (NO2), Méthane (CH4), Dioxyde de carbone (CO2), Glyphosate, cyperméthrine	18,5%
Soil	Soil contamination, Infiltration of chemical compounds, Leachate production	Oxyde de potassium (K2O) Glyphosate, Oxadiazon, cyperméthrine	21,6%
water	Production of wastewater, Leaching of pesticides and chemical fertilisers	Protoxyde de phosphore (P2O5), Glyphosate, Dioxyde de carbone (CO2) cyperméthrine, Oxadiazon, Protoxyde d'azote (N2O),	16,6%

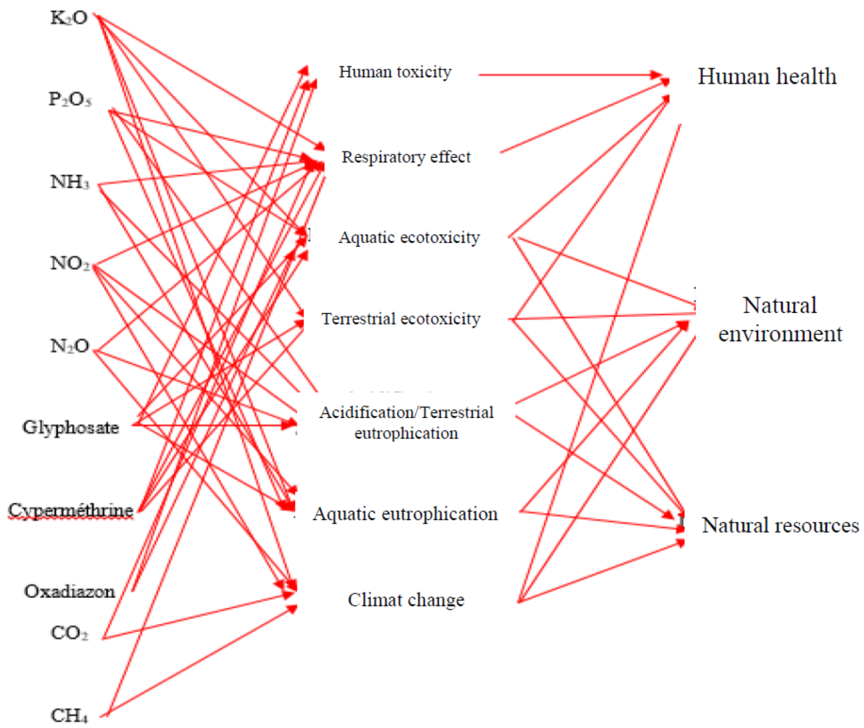

Figure 6 : Causes of environmental damage

Pollutant emissions into the environment
Emissions are obtained after constructing the ReCiPe major figure, which allows us to see the causes of chemical emissions into the environment that cause damage to human health, resources and the ecosystem (Table 3).

Table 3 : Substance weight

Emissions	Moléculaire weight (Kg.mol^{-1})	substance weight (Kg/mol.ha) I=Ep
K2O	0,00831	2,493
P2O5	0,00436	1,308
NH3	0,017	0,017
NO2	0,044	0,044
N2O	0,044	0,044
Glyphosate	0,16909	0,67636
Cyperméthrine	0,4163	0,4163
Oxadiazon	0,34525	0,34525
CO2	0,044	0,044
CH4	0,016	0,016

Carcinogenic effect : In rice cultivation in the Yagoua sector, Roundup and Cypercal are used, which release glyphosate (5.29E+00 CTUh) and cypermethrin (4.16E-01 CTUh) into the environment (Figure 7). These molecules are carcinogenic to human health. However, glyphosate is primarily responsible in rice cultivation in the sector, as it has a carcinogenic effect of 5.75E+00 CTUh, but this is lower than the standard value of 2.66E+05 CTUh set by Sala et al (2017).

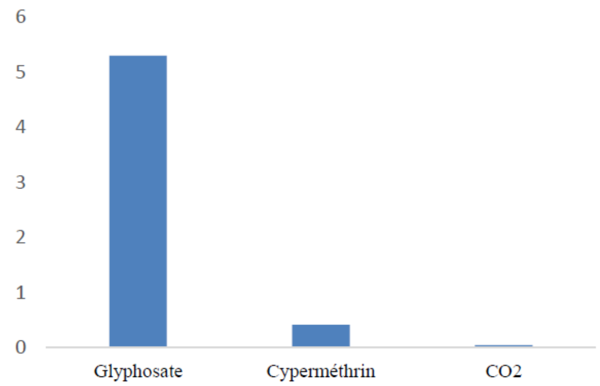

Figure 7 : Distribution of active molecules contributing to carcinogenic effects

***Respiratory effect**: Rice farming in the Yagoua area produces high levels of N_2O (1.17E+01 CTUh) as well as other molecules such as cypermethrin and oxadiazon*, CH_4, CO_2, NH_3, P_2O_5, and K_2O in small quantities compared to N_2O (Figure 8) in the air, causing respiratory problems. The respiratory effect has a value of 1.29E+01 CTUh.

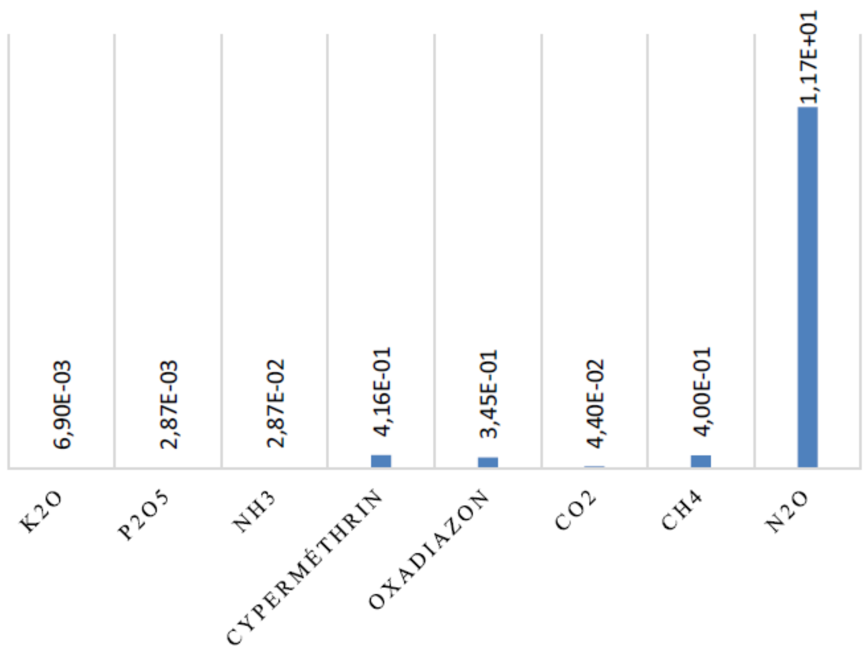

Figure 8 Distribution of active molecules contributing to respiratory problems

Aquatic ecotoxicity: N2O (1.17E+01 CTUe) and glyphosate (5.29E+00 CTUe) are the major molecules, followed by cypermethrin and oxadiazon in small quantities (Figure 9). They contribute to the aquatic ecotoxicity of the rice-growing environment in the Yagoua sector with a value of 6.06E+00 CTUe, well below the standard value of 8.15E+13 CTUe set by Sala et al (2017).

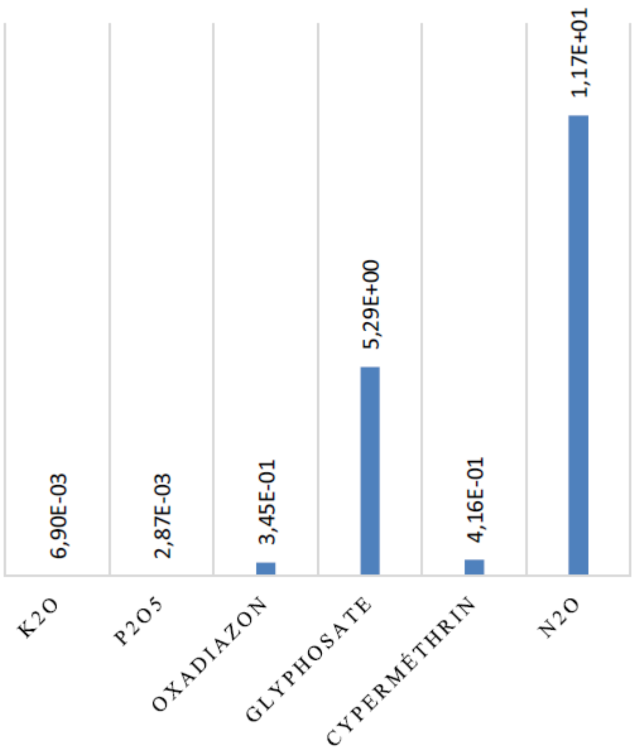

Figure 9 Distribution of active molecules contributing to aquatic ecotoxicity

Terrestrial ecotoxicity: The glyphosate molecule (5.29E+00 kg N eq) is the active ingredient in Roundup that causes terrestrial ecotoxicity, as does cypermethrin (4.16E-01 kg N eq), which is found in small quantities compared to glyphosate in cypercal insecticides (Figure 10). Glyphosate is the major component, with a value of 5.29E+00 kg N eq, of terrestrial ecotoxicity in rice cultivation in the Yagoua sector, which gives terrestrial ecotoxicity a value of 5.71E+00 kg N eq.

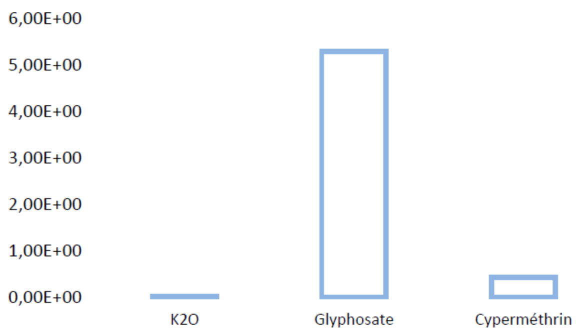

Figure 10: Distribution of active molecules contributing to terrestrial ecotoxicity

Acidification/Terrestrial eutrophication : Soil acidification and terrestrial eutrophication in rice cultivation are caused by the chemical reactions of denitrification and nitrification of nitrogenous chemical fertilizers and organic matter in the soil after water is introduced through irrigation. These reactions are responsible for emissions of NO_2 (1.36E+01kg N eq) followed by glyphosate (5.29E+00 Kg N eq) and small amounts of K_2O, P_2O_5, and NH_3 (Figure 11). Terrestrial acidification/eutrophication has a value of 1.90E+01 kg N eq, which is well below the standard value of 1.60E+12 kg N eq reported by Sala et al. (2017).

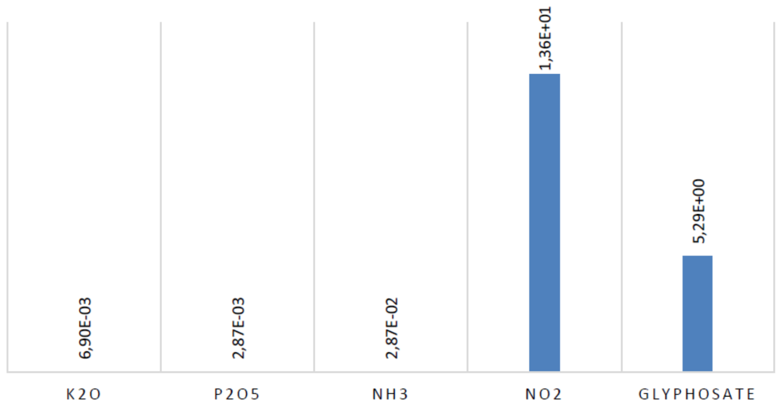

Figure 11: Distribution of active molecules contributing to soil acidification and terrestrial eutrophication

Aquatic eutrophication: The chemical reactions of denitrification and nitrification of nitrogenous chemical fertilizers and organic matter in water are responsible for aquatic eutrophication in rice cultivation, marked by emissions of NO_2 (1.36E+01kg N eq) followed by N_2O (1.17E+01 kg N eq) and glyphosate with other compounds (K_2O, P_2O_5, NH_3) in trace amounts (Figure 12). Eutrophication has a value of 3.06E+01 kg N eq, well below the standard value of Sala et al (2017), which is 1.95E+11 kg N eq.

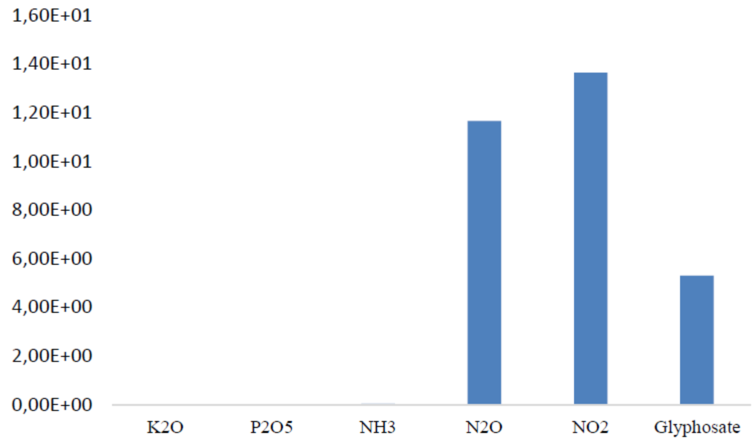

Figure 12 : Distribution of active molecules contributing to aquatic eutrophication

Climate change *:* There are many gases that contribute to climate change, but in the Yagoua area, we have NO_2 (1.36E+01kg N eq) followed by N_2O (1.17E+01 kg N eq) and CH_4 (4.00E-01Kg CO_2 eq), with other elements (CO_2, K_2O) in small quantities (Figure 13). The climate change value is estimated at 2.58E+01 kg CO_2 eq, well below the standard value of Sala et al (2017), which is 5.79E+13 kg CO_2 eq.

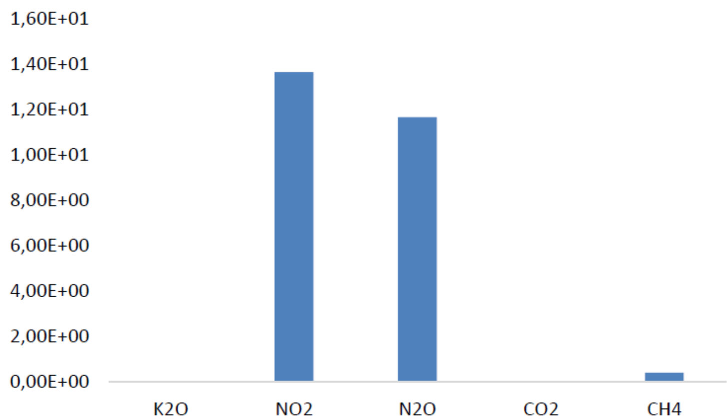

Figure 13 Distribution of active molecules contributing to the climate change effect

In rice farming in the Yagoua sector, chemical reactions occur in the soil, air, and water after the introduction of pesticides and chemical fertilizers, which are responsible for emissions into the environment via intermediate effects (Figure 14). These cause damage to human health, including respiratory disorders, skin cancers, and several other types of cancer. They also affect natural resources and ecosystems, namely aquatic and terrestrial ecotoxicity, soil acidification, terrestrial and aquatic eutrophication, and climate change. However, the damage to human health is low compared to the damage to natural resources and ecosystems. Aquatic ecotoxicity is greater due to the distribution shown in Figure 14. Basset-Mens (2015) also obtains a significant value for the same Midpoint, which can be explained by the reactions in the presence of water during the irrigation of rice fields.

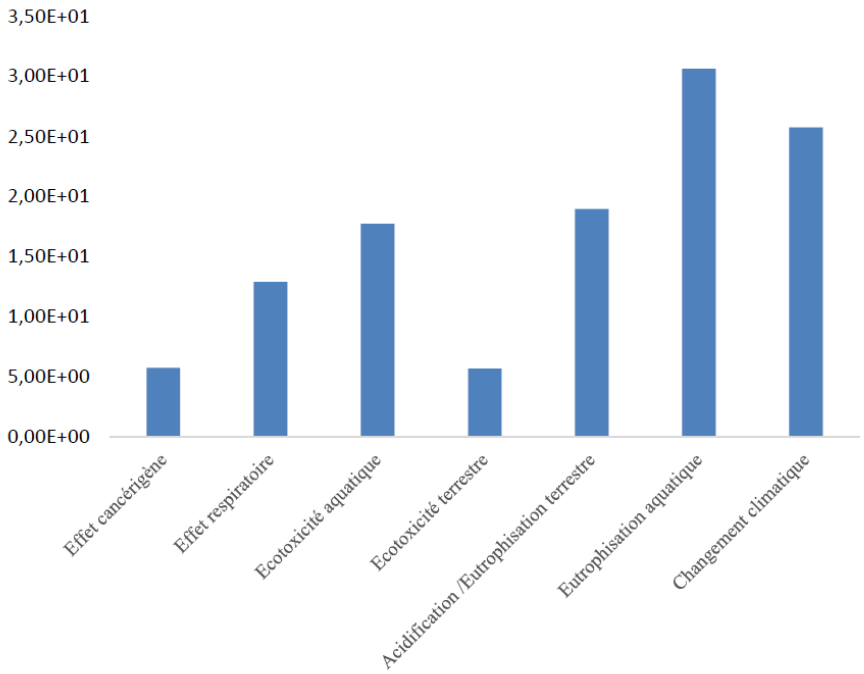

Figure 14: Distribution of effects on the environment

IV. CONCLUSION

The study on modeling emissions in the rice life cycle in the Yagoua rice sector specifically highlighted material flows via inputs (seeds, chemical fertilizers, pesticides), the product (paddy rice, white rice) and co-products (husk, straw, bran), as well as waste, namely plastic packaging and effluents (N_2O, glyphosate, NO_2, cypermethrin, P_2O_5, NH_3, K_2O, oxadiazon, CO_2, CH_4) in different physical environments (air, water, soil). Molecules resulting from the carbonization of rice husks and the use of Roundup, Rizstar, Realstar, and Cypercal produce intermediate effects or midpoints, namely: carcinogenic effects at 5.75E+00 CTUh, respiratory effects at 1.29E+01 CTUh, aquatic ecotoxicity at 6.06E+00 CTUe, terrestrial ecotoxicity at 5.71E+00 kg N eq, terrestrial acidification/eutrophication at 1.90E+01 kg N eq, aquatic eutrophication at 3.06E+01 kg N eq, and climate change effects at 2.58E+01 kg CO_2 eq. The intermediate effects explain the origin of damage to human health, natural resources, and ecosystems and identify N_2O, glyphosate, and NO_2 molecules as factor x in the magnitude of the impacts.

BIBLIOGRAPHICAL REFERENCES

[1]. Ahmadou C, Kouebou D, Malaa S, Bourou J.P, Olina M. Mbiandoun. 2016. Les engrais et les pesticides dans la riziculture périurbaine de la ville de Garoua, au Nord-Cameroun : cas de Nassarao et Boklé, international Journal of Innovation and Applied Studies ISSN 2028-9324 Vol. 18 No, pp. 26-35

[2]. Basset-Mens C, 20215, Evaluation environnementale par l'Analyse de Cycle de Vie des systèmes de production agricole Premiers acquis et perspectives de recherche pour l'évaluation et l'amélioration de la performance environnementale des systèmes horticoles au Sud Université de

[3]. Montpellier II Ecole doctorale « Systèmes Intègres en Biologie, Agronomie, Géosciences, Hydrosciences et Environnement » (SIBAGHE) Unité de recherche Hortsys CIRAD-Persyst. p92 Bockel L, Tinlot Marianne, Gentien A, 2010. Potentiel de Mitigation Climatique de la Filière : Riz Bilan Carbone de Scénarios Stratégiques sur la Filière Riz à Madagascar à l'horizon 2020, Geo Environnement. FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, FAO. p10

[4]. Costedoat S. 2012. L'analyse du cycle de vie (ACV) : outil ou contraintes pour la compétitivité des entreprises. Responsabilité & Environnement. p 66
[5]. Cruz J-F. 2005. Usinage du riz au Burkina Faso, Diagnostic technique des rizeries. Cirad. p25
[6]. Darío R. Gómez, John D. Watterson. Branca B. Americano, Chia Ha, Gregg Marland, Emmanuel Matsika, Lemmy Nenge Namayanga, Balgis Osman-Elasha, John D. Kalenga Saka, et Karen Treanton. 2006. Lignes directrices 2006 du GIEC pour les inventaires nationaux des gaz à effet de serre
[7]. Dazogbo, S., Tirado-Seco, P., M, D., Berthélemy, N. Bulle, C. (2023). L'économie circulaire dans la filière céréalière au Québec pour réduire les émissions de gaz à effet de serre selon une perspective cycle de vie : le cas du maïs-grain. Revue Organisations & territoires, 32(3), 71–103. https://doi.org/10.1522/revueot.v32n3.1677
[8]. Goedkoop M, Spriensma R. 2000. The Eco-indicator 99: A Damage Oriented Method for Life-cycle Impact Assessment: Manual for Designers (éd. 2). Amersfoort, Pays Bas: PRé Consultants
[9]. Jolliet, O., Saadé, M., Crettaz, P. et Shaked, S. 2010. Environmental Lifecycle and Sustainability Assessment, Montpellier Sup Agro Synthese Technique Les méthodes d'évaluation des impacts environnementaux liés aux usages de l'eau,
[10]. Khush GS, Virk PS. 2005. IR varieties and their impact. Los Baños (Philippines): International
[11]. Liboga Oenabaiso B, Litucha Bakokola J, Ngama Boloy F, Balimo Isecha F. 2019 Etude de la qualité physico-chimique et technologique d'une variété locale (Kitombe) et quatre variétés améliorées du riz pluvial cultivées à Kisangani et ses environs, en R. D. Congo journal of Applied Biosciences 139 : 14158-14166. p9
[12]. Merle. T, 2012, Application au programme REBECCA pour l'évaluation environnementale d'une filière canne à usage de combustible. Méthodologie de l'utilisateur de l'Analyse du Cycle de Vie. CIRAD, Note scientifique REBECCA n° 8
[13]. Meryem El Faiz, 2020, Mémoire de l'Analyse du cycle de vie à l'aide du logiciel SimaPro Exemple d'analyse de l'inventaire de cycle de vie : Brame d'acier produit dans une aciérie italienne, Québec, Canad, Université de LAVAL. p118
[14]. Mohamed Dicko, 2005. Analyse du fonctionnement d'une parcelle de riz irrigué sur sol alcalin. Application à la gestion intégrée de la fertilisation azotée et du calendrier cultural dans le delta intérieur du fleuve Niger (Mali). Domain other. Ecole nationale supérieure agronomique de montpellier - AGRO M, Français. ffNNT : ff. fftel-00423469ff
[15]. Nitschelm L. 2016. Développement de la méthode analyse du cycle de vie territoriale spatialisée (ACVTS) appliquée à l'agriculture. Cas d'étude des bassins versants de la lieue de grève, Bretagne, France. Etudes de l'environnement. Agrocampus Ouest. Français. ffNNT : 2016NSARD079ff. fftel-02003360ff
[16]. Plan Communal de Développement (PCD) De Yagoua. 2013. GIC PI-PNVRA Sur Financement du Programme National de Développement Participatif (PNDP). 307p
[17]. Pradel. M, De Gervillier. A. 2015. L'analyse du cycle de vie à l'échelle d'une exploitation agricole : méthode et premiers résultats. Sciences Eaux & Territoires n°04. p39
[18]. Sala S., Crenna E., Secchi M., Pant, R., 2017, *Global normalisation factors for the Environmental Footprint and Life Cycle Assessment*, EUR (28984), Publications Office of the European Union, Luxembourg, ISBN 978-92-79-77213-9, doi:10.2760/88930, JRC109878
[19]. Van der Werf H.M.G.a,b, Kanyarushoki C.c, Corson M.S.a,b, 2011, Innovations Agronomiques, Analyse de Cycle de Vie : un nouveau regard sur les systèmes de production agricole