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An impact study on the variation of parameters for the main sources of CO_2 emission and absorption in a city for the management of it's atmospheric pollution through a multi-agent system

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Abstract In this paper, an impact study has been carried out on the variation of parameters of the sources of CO_2 emission and absorption. The present investigation is intended to be a contribution to the management of the atmospheric pollution of a city through a multi-agent system. It is also an additive value to the struggle of climate and environmental researchers in their attempts to attenuate the important rise of greenhouse gases which could continually increase the global warming for future generations. Only the main sources of CO_2 emission and absorption have been considered and the results obtained have been intensively discussed.

Keywords Modeling, Simulation, Multi-Agent System, Sustainable Development, Urban Pollution, Greenhouse Gas

1. Introduction

Economic progress and employment opportunities in cities are attracting and leading to a major migration phenomenon of rural world. This situation has created growing needs in many domains such as transportation, energy, housing, etc. [1]. These phenomena lead to overconsumption of fossil fuels in order to satisfy the quest for energy, the intensive road and air traffic, an exponential increase in the number of households, a massive production of waste and the development of socio-professional activities in various sectors. All together, these manifestations contribute to increase the urban pollution due to continuous releases of gases that are harmful to health and the environment. The carbone dioxide which is considered to be the main greenhouse gas [2], is one of these gases that are daily released into cities and the accumulation of which would be the cause of climate change [3-4]. In front of this constraining situation, the need to have technological tools to simulate this eventual pollution is necessary [5-6].

Furthermore, the paradigm of multi-agent systems embodies an alternative for solving complex problems. Examples of resolutions by multi-agent systems appear in several sectors: research, industry, economy, health, management of information systems, etc. as evidenced by the works [7-17].

Using a multi-agent system, this work proposes an impact analysis focussed on the variation of parameters of the main sources of CO_2emission and absorption for the management of atmospheric polution in cities.

2. Mathematical modeling and multi-agent simulation for the variation of parameters

The mathematical model representing CO_2 emissions and absorptions has been described by Dan Djari and Naroua [6]. Figure 1 below illustrates the contributions of the different groups of CO_2 emitters and absorbers where ρ, v, PCI, FEa, Activity, Purity represent the density, the volume, the net calorific value, the emission factor for type a fuel, the quantity of urea-based additives, and the mass fraction of urea in urea-based additives.

Only the landing and take-off (LTO) phases are considered for air flights. The absorptions are estimated on the basis of the categories and types of trees where NA_{ij} and C_{ij} are respectively the number of trees and the average annual carbon accumulation.

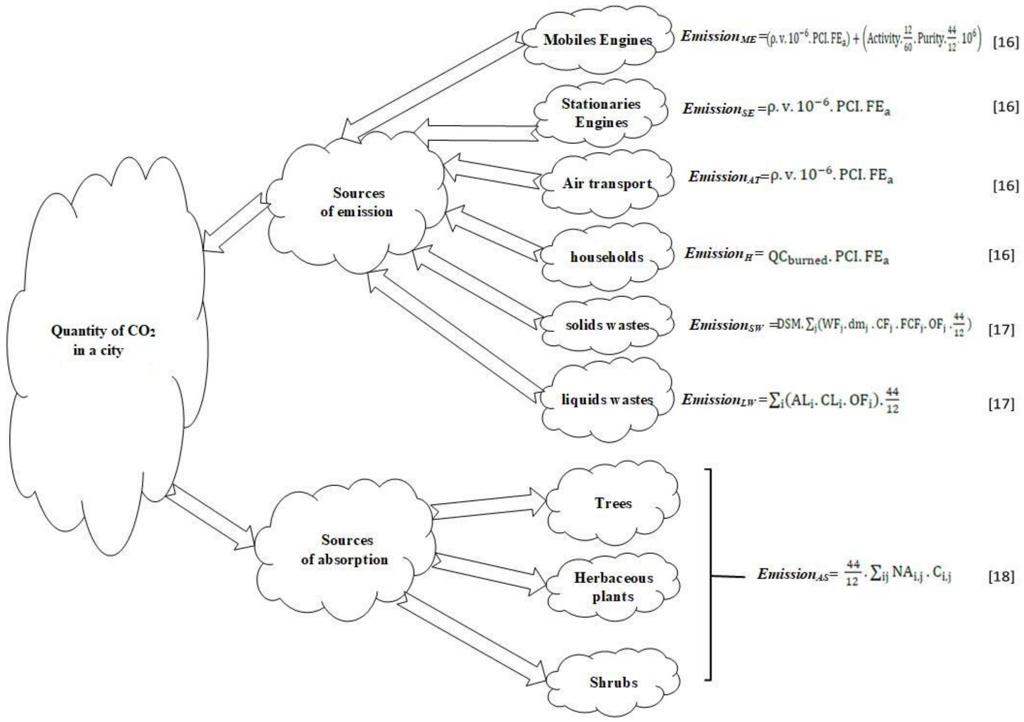

Figure 1: Model of emissions and absorptions of CO_2 in a city

Two types of agents (permanent and temporary) are participating in the coordination protocols with variation of parameters. The permanent agents concerned are the main interface (IPS), the MANAGER, the CONTROLLER, the CONFIGURATOR, and the INTERPRETER. The temporary agents are similar to those used by Dan Djari and Naroua [6] and consist of MEA (mobile engine), HA (household), ATA (air transport), SEA (stationary engine), SWA (solid waste), LWA (liquid waste), and AA (absorber). The following protocols are used for the variation of parameters:

Algorithm 1 : settingsConfiguration ()

input: changeType, Parameters, PerformedChanges: string;
agentsListToModify: array;
totalNumberChanges: integer ;
output: true if the configuration is done, false otherwise
known: temporary agents (MEA, HA, ATA, SEA, SWA, LWA and AA), IPS, MANAGER and CONFIGURATOR.

begin

totalNumberChanges ← 0;
parameters ← "";
agentsListToModify ← null;
performedChanges ← "";
IPS displays the main interface to USER;
USER specifies the type of modification to IPS;
IPS reads changeType of USER;
IPS sends changeType to CONFIGURATOR;
IPS closes the main interface to USER
CONFIGURATOR receives changeType of IPS;
CONFIGURATOR analyzes the context of changeType;

```
CONFIGURATOR displays the appropriate interface to USER;
        while (invalid parameters or invalid agentsListToModify)
            USER enters parameters and agentsListToModify;
            if ( USER cancels the change configuration) then
                CONFIGURATOR sends the configuration cancellation to IPS;
                CONFIGURATOR closes the change configuration form;
                CONFIGURATOR terminates the USER change process;
                IPS receives the modification cancellation from CONFIGURATOR;
                IPS displays the main interface to USER;
            else
                CONFIGURATOR reads parameters, agentsListToModify;
                CONFIGURATOR validates parameters, agentsListToModify;
            endIf
endWhile
        CONFIGURATOR sends changeType, Parameters, agentsListToModify to MANAGER;
MANAGER receives (changeType, parameters, agentsListToModify );
MANAGER prepares a modification request with parameters;
MANAGER sends the prepared request to all agents of agentsListToModify list;
MANAGER sends size (agentsListToModify) to CONFIGURATOR ;
        CONFIGURATOR receives size (agentsListToModify) and initiates totalNumberChanges to size
                    (agentsListToModify);
        For each temporary agent in agentsListToModify
                receive the request of the MANAGER;
                update its arguments associated to the received parameters;
                send the modification result to CONFIGURATOR;
        endfor
        while (totalNumberChanges > 0)
   if (CONFIGURATOR receives a change response) then
         CONFIGURATOR updates performedChanges;
         CONFIGURATORdecrements totalNumberChanges;
   endIf
        endWhile
        CONFIGURATOR sends performedChanges to IPS;
        CONFIGURATOR closes the modification interface to USER;
        IPS receives performedChanges from CONFIGURATOR;
        IPS diagnoses the content of performedChanges;
        IPS displays the main interface to USER;
        IPS displays the result of the changes to USER;
end
```

Algorithm 2 : periodicSimulationCO2 ()

```
input:  city : string ;
        Globalvalue, MEAvalue, HAvalue, ATAvalue, SEAvalue, LWAvalue, SWAvalue, AAvalue: real ;
        startDate, endDate, currentDate: date ;
        agentsList: array ;
        totalNumberReceptions, duration: integer ;
        ctrlDisplay : boolean ;
        output:Globalvalue, MEAvalue, HAvalue, ATAvalue, SEAvalue, LWAvalue, SWAvalue, AAvalue.
        known: Emission and Absorption factors, contentInit, temporary agents (MEA, HA, ATA,
                SEA, SWA, LWA and AA), IPS, CONTROLLER, and INTERPRETER
begin
```

```
ctrlDisplay ← false;
totalNumberReceptions ← 0;
duration ← 0;
IPS displays the main interface to USER;
USER launches the forecast;
IPS displays the input interface for forcasting parameters to USER;
while ( invalid startDate or invalid endDate or startDate > endDate)
        USER enters the dates (startDate, endDate);
        IPS validates the dates (startDate, endDate) of USER;
endWhile
IPS calculates duration ← number of days between startDate and endDate;
IPS sends (duration, startDate, endDate) to CONFIGURATOR;
CONFIGURATOR receives (duration, startDate, endDate);
CONFIGURATOR determines agentList ← list of all temporary agents;
if (size (agentsList) = 0) then
        CONFIGURATOR sends a notification to IPS;
        IPS displays "No agents deployed in the platform" to the USER;
else
        CONFIGURATOR initializes all temporary agents;
        CONFIGURATOR updates its forecast settings;
                CONFIGURATOR sends (agentsList, contentInit, duration, startDate, endDate) to
        CONTROLLER;
endIf
for ( each temporary agent in agentsList )
        receive the initialization request;
        get initialized;
        calculate the quantity of CO2 to emit or absorb;
endfor
CONTROLLER receives (agentsList, contentInit, duration, startDate, endDate);
CONTROLLER updates its forecast parameters;
CONTROLLER sends (contentInit, duration, startDate, endDate) to INTERPRETER
INTERPRETER receives (contentInit, duration, startDate, endDate);
INTERPRETER updates its forecasting parameters;
INTERPRETER sends the confirmation of receipt of the parameters to IPS;
IPS receives confirmation of receipt of parameters;
while (duration≥0)
        IPS sends the control authorization to CONTROLLER;
        CONTROLLER receives the authorization of control;
        CONTROLLER sends size (agentsList) to INTERPRETER;
        CONTROLLER sends authorization to each temporary agent of agentsList;
        CONTROLLER sends the end notification to INTERPRETER;
        INTERPRETER receives size (agentsList) and updates totalNumberReceptions;
for (each temporary agent in agentsList)
                receive the authorization of emission or absorption;
                calculate the quantity of CO2 to emit or absorb;
                send the quantity of CO2 to INTERPRETER;
        endfor
        INTERPRETER receives notification of end of authorization and changes
                ctrlDisplay to true;
        while (totalNumberReceptions > 0)
```

```
                if (INTERPRETER receives an emission or an absorption) then
                                INTERPRETER processes quantity of CO2;
                                INTERPRETER  decrements totalNumberReceptions;
                        endIf
                endWhile
                if (ctrlDisplay = true and totalNumberReceptions = 0) then
                        INTERPRETER sends (Globalvalue, MEAvalue, HAvalue, ATAvalue, SEAvalue,
                            LWAvalue, SWAvalue, AAvalue, currentDate) as a display notification to IPS;
                        currentDate ← currentDate +1 (one day);
                        duration ← duration - 1;
                        ctrlDisplay ← false;
                endIf
                if (duration <0) then
                        INTERPRETER sends the end of the forecast to IPS;
                endIf
                if (IPS receives the display notification) then
                        IPS saves all emissions and absorptions with currentDate;
                endIf
                if (IPS receives the end of the forecast) then
                        IPS displays "Forecast Complete" to USER;
              endIf
      endWhile
  end
```

The sequence diagrams (Figures 2 and 3) below describe the exchanges of the two coordination protocols.
To study the impact of the variation of parameters, daily CO_2 emissions and absorptions were considered. Figure 4 illustrates the results of the basic simulation using the initial settings. The analysis was carried out on the basis of the elements that determine the type of combustion of temporary agents. The results of the simulations are shown in Figure 5 and we observe that:

- The number of agents is determinant on the overall quantity of CO_2 ;
- The variations of parameters of emitters and absorbers yield different in pacts on the global quantity of CO_2 ;
- For mobile engines and stationary engines, the type of fuel used has a remarkable influence on the overall quantity of CO_2 rejected;
- For the same quantity of fuel consumed by a mobile engine or a stationary engine, the rejection of CO_2 is more important for diesel than for gasoline, which confirms the results of Helmers et al. [27] ;
- For mobile engines, non-combustive emissions do not have a major influence on the global rejection;
- For the same quantity of fuel consumed by a household, the rejection of $CO_2$is more important for butane than for charcoal and wood. An insignificant change has been observed for charcoal and wood;
- For air transport, the type of fuel used yields to an insignificant impact on the global CO_2 emissions;
- The fraction of the population that burns solid waste, the quantity of waste produced per habitant and the rate of incineration or open-air burning per habitant, significantly increase the overall quantity of CO_2;
- For emissions from liquid wastes, the carbon content and the oxidation factor significantly increase the overall quantity of CO_2;

The absorption varies insignificantly according to tree species and contributes to the reduction of the quantity of CO_2 but, its influence remains low when compared to global emissions. This result is in agreement with several works such as Lerman and al. [28] and Privitera et al. [29], which suggest planting and maintaining trees as a powerful means of reducing emissions of CO_2 in urban environments.

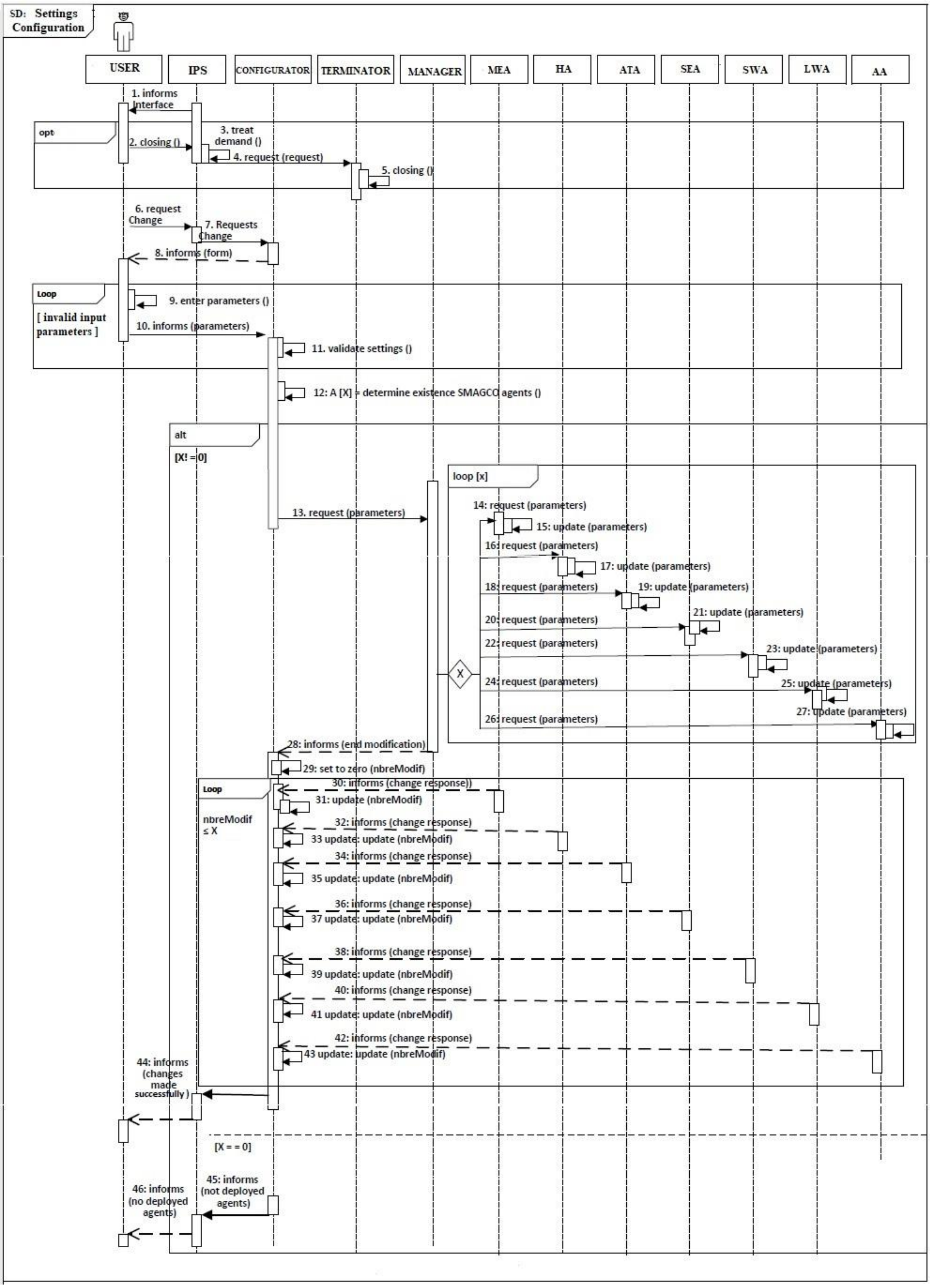

Figure 2: Sequence diagram of parameters settings

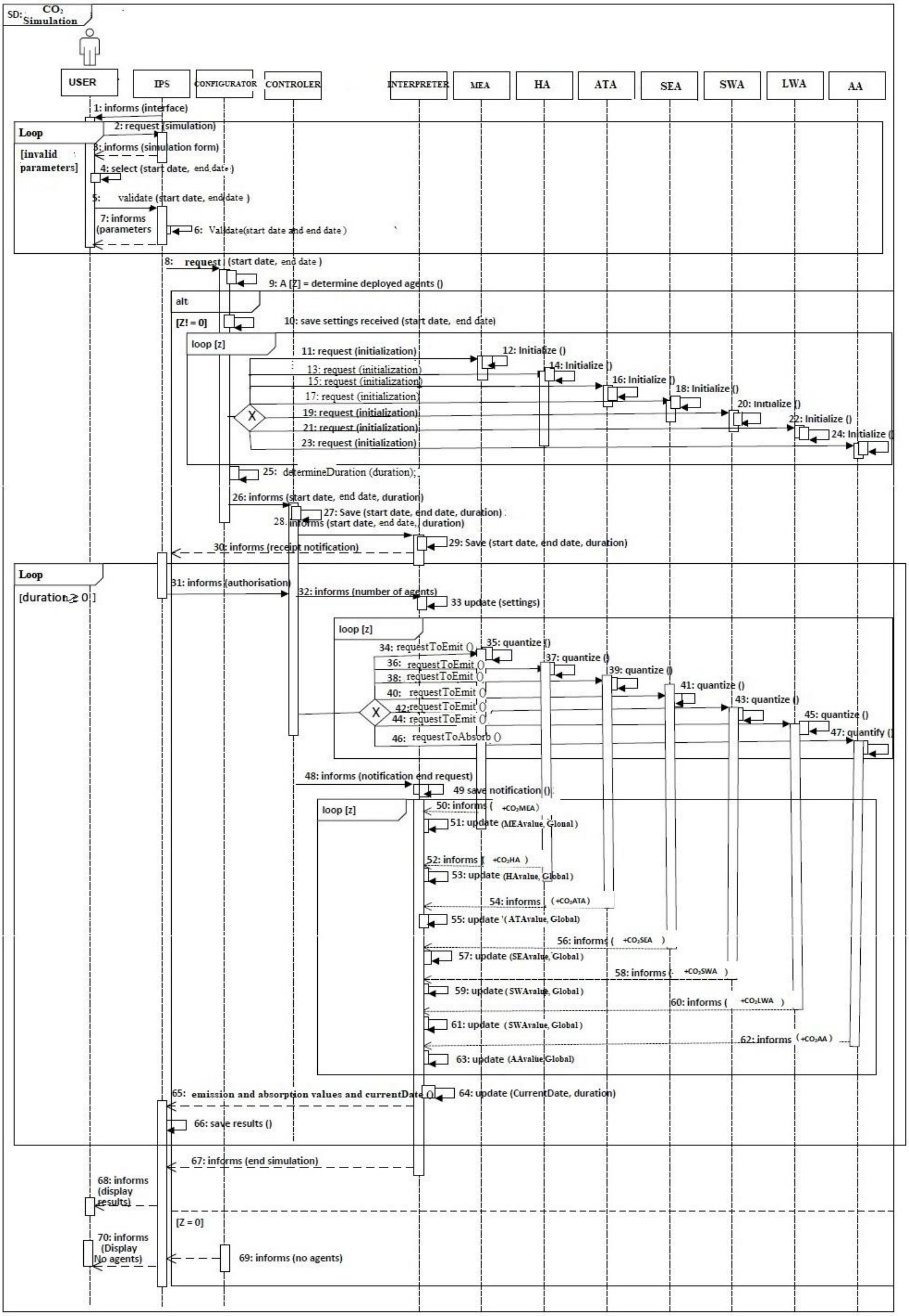

Figure 3: Sequence diagram of simulation

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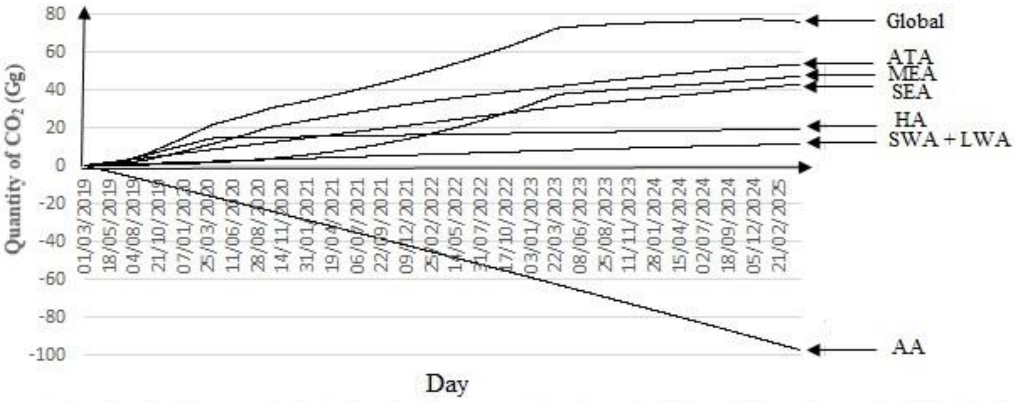
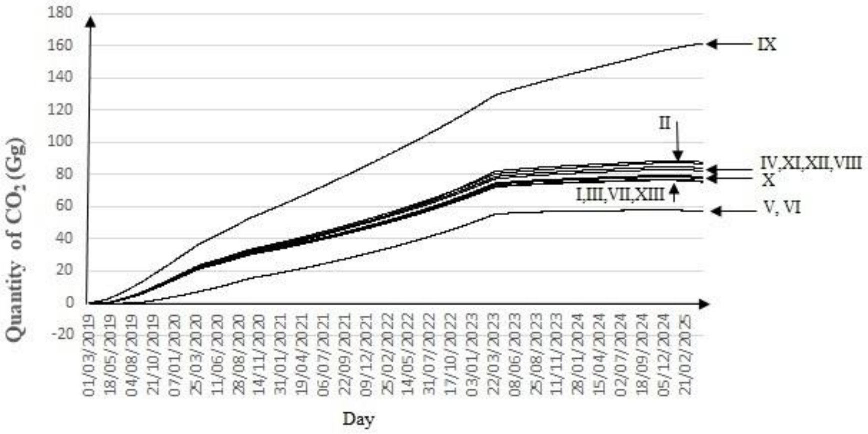


Agents	Quantity	Parameters that have the same values for all deployed agents	Intitial value
MEA	10 000	Fuel used, Activity	gasoline
SEA	1 000	Fuel used,	gasoline
HA	200	Fuel used,	butane
ATA	1 000	Fuel used,	gasoline airplane
SWA	500	Burnning waste fraction, Waste volume/habitant/day, Burned waste voulme /habitant/day	0.25, 0.25, 0.4
LWA	1 000	Carbon content, Oxidation factor	0.35, 0.45
AA	8 000 000	Species	neem

Figure 4: Basic simulation results



Series	MEA	SEA	ATA	HA	SWA	LWA	AA	Modified Paramter	Old value	New value	Concerned Agents
I	10 0000	1 000	200	1 000	500	1 000	8 000 000	Initial	Initial	Initial	Initial
II	10 0000	1 000	200	1 000	500	1 000	8 000 000	Fuel used	gasoline	diesel	MEA
III	10 0000	1 000	200	1 000	500	1 000	8 000 000	Activity	2.5E-10	2.5E-5	MEA
IV	10 0000	1 000	200	1 000	500	1 000	8 000 000	Fuel used	gasoline	diesel	SEA
V	10 0000	1 000	200	1 000	500	1 000	8 000 000	Fuel used	butane	Charcoal	HA
VI	10 0000	1 000	200	1 000	500	1 000	8 000 000	Fuel used	butane	wood	HA
VII	10 0000	1 000	200	1 000	500	1 000	8 000 000	Fuel used	gasoline airplane	kerosene	ATA
VIII	10 0000	1 000	200	1 000	500	1 000	8 000 000	BWF	0.25	0.8	SWA
IX	10 0000	1 000	200	1 000	500	1 000	8 000 000	WVHD	0.25	2.0	SWA
X	10 0000	1 000	200	1 000	500	1 000	8 000 000	BWVDH	0.4	0.9	SWA
XI	10 0000	1 000	200	1 000	500	1 000	8 000 000	CC	0.35	0.85	LWA
XII	10 0000	1 000	200	1 000	500	1 000	8 000 000	OF	0.45	0.95	LWA
XIII	10 0000	1 000	200	1 000	500	1 000	8 000 000	species	neem	boabab	AA

BWF:Burning Waste Fraction; **WVHD** : Waste Volume / Habitant / Day; **BWVHD** : Burned Waste Volume / Habitant / Day
CC : Carbon Content; **OF** : Oxidation Factor; **Initial:** initial values of parameters from Figure 4

Figure 5: Simulation results for varying parameters of agents

3. Conclusion

In this paper, investigations have been conducted on the impact of the variation of parameters of CO_2 emitting and absorbing sources using a multi-agent system in order to manage the atmospheric pollution of a city. The analysis shows that the parameters of the major emitters greatly influence the magnitude of the overall quantity of CO_2. Though their absorption is low, the analysis shows that trees are a great potential to help mitigate the exponential and temporal rise of CO_2 in urban centers. It was concluded that multi-agent systems are important tools in the struggle of scientists to counteract the greenhouse effect for sustainable development.

References

[1]. Benoit, Conti. (2017). La mobilité pendulaire des interurbains et leurs impacts sur les émissions de CO_2, un enjeu d'aménagement Région et Développement. L'Harmattan, <hal-01731360>, https://hal.archives-ouvertes.fr/hal-01731360.

[2]. Marie-Pier P., Leandro, C. (2017). Facteurs et méthodes de calcul de gaz à effet de serre. Faculté des sciences de l'Université Laval, FSA-2017-001.

[3]. Ciais, P., Sabine, C., Bala, G., et al. (2014). Carbon and other biogeochemical cycles. In: Climate change 2013: the physical science basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, 465-574.

[4]. Stocker, F., Qin, D., Plattner, K., Ignore, M., Allen, K., Boschung, J., Midgley, M. (2013). Climate Change 2013: the Physical Science Basis. Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change 2013, Cambridge, Cambridge university Press, URL https://www.google.com/books.

[5]. Dan Djari, H., Naroua, H. (2019). Modeling and multi-agent simulation of CO_2 management in an urban center. ARPN Journal of Engineering and Applied Sciences, 14(3): 686-693.

[6]. Dan Djari, H., Naroua H. (2019). A simulative and multi-agent study for balancing the quantity of CO_2 in an urban area by fixing the sources of emissions and absorptions. Journal of Scientific and Engineering Research, 6(3): 128-139.

[7]. Merizig, A. (2018). Approche de composition de services web dans le Cloud Computing basée sur la coopération des agents Intelligence artificielle, Université Mohamed Khider, Biskra (Algérie), Thèse.

[8]. Nicolas, P. (2018). Simuler la science: un modèle multi-agents de l'évolution des idées scientifiques, Université du Québec à Montréal (Canada), Thèse, Philosophie.

[9]. Benhajji, N. (2017). Système multi-agents de pilotage réactif des parcours patients au sein des systèmes hospitaliers, Université de Lorraine (France), Thèse, Mention automatique, traitement du signal et des images, génie informatique.

[10]. Meriyem, C. (2017). Conception et Réalisation d'une Plateforme de Gouvernance des Systèmes d'Information à base des Workflows inter-organisations, du Web sémantique et des Systèmes Multi Agents, Université Hassan II, Casablanca (Maroc), Thèse, Génie Informatique .

[11]. Buron C. (2018). Un Système Multi-Agents pour une place de marché de factures,Sorbonne Université (France), Thèse, Informatique.

[12]. Ferber J. (1997). Les systèmes multi-agents: un aperçu général, Technique et Science Informatiques, 16 (8): 979-1012.

[13]. Ghazi, S., Dugdale J. and Khadir T. (2018). A Multi-Agent based Approach for Simulating the Impact of Human Behaviours on Air Pollution, Informatica, 42 (2):199-209.

[14]. Gao, Y., Liu G., Casazza, M., Hao, Y., Zhang, Y. and Giannetti, B. F. (2018). Economy-pollution nexus model of cities at river basin scale based on multi-agent simulation: A conceptual framework, Ecological Modeling, 379: 22-38.

[15]. Fareh, M. (2018). Une plateforme e-commerce basée agent pour les entreprises réparties géographiquement. International Journal of Innovative Technical and Applied Sciences, 2(2): 014-020.

[16]. Nicolas, P. (2018). Simuler la science: un modèle multi-agents de l'évolution des idées scientifiques, Université du Québec à Montréal (Canada), Thèse, Philosophie.

[17]. Fethi, M., Kamel Z., Khaled, G. et Pierre, B. (2012). Modélisation d'un Système Multi-Agent pour la résolution d'un Problème de Tournées de Véhicule dans une situation d'urgence, 9th International Conference on Modeling, Optimization Simulation, MOSIM 12, Bordeaux, France.
[18]. Eggleston, H., Buendia, L., Miwa, K., Ngara, T. andTanabe, K. (2006). Lignes directrices 2006 du GIEC pour les inventaires nationaux de gaz à effet de serre, préparé par le programme pour les inventaires nationaux de gaz à effet de serre Energie, GIEC, Japon, 2.
[19]. Eggleston, H., Buendia, L., Miwa, K., Ngara, T. and Tanabe, K. (2006). Lignes directrices 2006 du GIEC pour les inventaires nationaux de gaz à effet de serre, préparé par le programme pour les inventaires nationaux de gaz à effet de serre, Edition IGES, Japon, 5.
[20]. Eggleston, H., Buendia, L., Miwa, K., Ngara T. andTanabe, K. (2006). Lignes directrices 2006 du GIEC pour les inventaires nationaux des gaz à effet de serre, préparé par le programme pour les inventaires nationaux des gaz à effet de serre. Groupe d'experts intergouvernemental sur l'évolution du climat, Edition IGES, Japon, 4.
[21]. Vergriete, Y., et Labrecque, M. (2007). Rôles des arbres et des plantes grimpantes en milieu urbain: Rapport d'étape destiné au conseil régional de l'environnement de Montréal, Institut de recherche en biologie végétale, Université de Montréal, Canada.
[22]. Dubé, A., Saint-laurent D. et Senecal G. (2006). Penser le renouvellement des politiques de conservation de la forêt urbaine à l'ère du réchauffement climatique, Institut national de la recherche scientifique, Urbanisation. Culture et Société : 50-51.
[23]. Brack, C., (2002). Pollution mitigation and carbon sequestration by an urbanforest. Environmental pollution, 116: 195-200.
[24]. Myeong S., Nowak, D. and Duggin M. (2006). A temporal analysis of urban forest carbon storage using remote sensing. Remote Sensing of Environment, 2 (101): 277-282.
[25]. Nowak D., (2002). Carbon storage and sequestration by urban trees in the USA. Environmental Pollution, 3(116): 381-389.
[26]. Meas, M. (2016). La séquestration naturelle de carbone en milieu urbain: un outil de lutte contre les changements climatiques à promouvoir, Université de Sherbrooke, Mémoire.
[27]. Helmers, E., Leitão, J., Tietge, U., and Butler, T. (2019). CO_2-equivalent emissions from European passenger vehicles in the years 1995–2015 based on real-world use: Assessing the climate benefit of the European "diesel boom. Atmospheric environment, 198: 122-132.
[28]. Lerman, B. and Contosta R. (2019). Lawn mowing frequency and its effects on biogenic and anthropogenic carbon dioxide emissions. Landscape and Urban Planning, 182: 114-123.
[29]. Privitera, R., Palermo, V., Martinico, F., Fichera, A., and La Rosa, D. (2018). Towards lower carbon cities: urban morphology contribution in climate change adaptation strategies. European Planning Studies, 26(4): 812-837.