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Climate Change and the Law: Cushioning the Effects of Climate Change- in Niger Delta

By Dr. C. T. Emejuru & Mrs. M. O. Izzi
University of Science and Technology, Nigeria

Introduction- Climate change has been defined as any natural or induced change in climate, either globally or in a particular area. However, the United Nations Framework Convention on Climate Change gives its own definition as a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. This definition is holistic as it includes the causative elements of climate change. There is consensus that climate change is a critical issue for Africa and indeed, its greatest challenge in the 21st century, along with poverty. There is a speculation that climate change in no specified measure is likely to affect the continent's development trajectory, as most African countries are characterized by undiversified economic structures, poor infrastructure, fragile structures and institutions, poor human development and most importantly, the heavy reliance on agriculture for the majority of the population. The reason for climate change is that "Mother Earth – our only home – is under pressure…".

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CLIMATECHANGEANDTHELAWCUSHIONINGTHEEFFECTSOFCLIMATECHANGEINNIGERDELTA

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Climate Change and the Law: Cushioning the Effects of Climate Change- in Niger Delta

Dr. C. T. Emejuru [α] & Mrs. M. O. Izzi [σ]

I. Introduction

Climate change has been defined as any natural or induced change in climate, either globally or in a particular area[1]. However, the United Nations Framework Convention on Climate Change gives its own definition as a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods[2]. This definition is holistic as it includes the causative elements of climate change. There is consensus that climate change is a critical issue for Africa and indeed, its greatest challenge in the 21st century, along with poverty[3]. There is a speculation that climate change in no specified measure is likely to affect the continent's development trajectory, as most African countries are characterized by undiversified economic structures, poor infrastructure, fragile structures and institutions, poor human development and most importantly, the heavy reliance on agriculture for the majority of the population[4]. The reason for climate change is that "Mother Earth – our only home – is under pressure…[5]".

The role played by petroleum or oil to Nigeria's economy is no longer an issue for debate as it has come to stay as the mainstream of the country's wealth. It is not however without its devastating consequences or effects. The production of petroleum has damaged the environment and economy of many nations. Petroleum damaged rather than benefited Venezuela[6].

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The constant flaring of gas in the Niger Delta is a human rights, environmental and economic monstrosity. Nowhere else in the world have communities been subjected to it on such a scale[7]. Gas flaring contributes significantly to climate change, thus affecting communities all over the world[8]. Climate change, for example, is extremely complex environmentally, and tackling it has enormous economic and social implications[9]. Although a number of gases contribute to climate change, carbon dioxide is the major culprit and addressing reliance on carbon, particularly fossil fuels, implicates an extraordinary range of industrial, agricultural, transport and consumption activities[10]. This notwithstanding, it is the global responsibility "to promote harmony with nature and the earth to achieve a just balance among the economic, social and environmental needs of present and future generations of humanity[11]." In the climate change arena, binding targets agreed under international conventions have been incorporated not only in national policy documents but also, some into draft legislation in the form of the *Climate Change Bill*[12]. The thrust of this paper is to explore the legal policy and initiative made to effectively tackle the problem of climate change and its application to the environmental damage of Niger Delta.

II. The Problem of Climate Change

Climate change presents as the archetypal environmental problem[13]. As the world's climate continues to change at unprecedented rate, the impacts of climate change are likely to be considerable in Niger Delta in Africa as well as other tropical developing regions[14]. The importance of climate change is underscored by the fact that problems associated with it are essentially global in both their causes and effects,

[1] Chris Park, Oxford Dictionary of Environment and Conservation (Oxford University Press 2007) 82.
[2] United Nations Framework Convention on Climate Change (Rio, 1992) 31 ILM 849
[3] Seventh African Development Forum, Acting on Climate Change for Sustainable Development in Africa: Climate Change, Economic Growth and Poverty Reduction in Africa, Issues Paper #12, ADF VII. 10-15 October 2010 United Nations Conference Centre. Addis Ababa, Ethiopia.
[4] *Ibid*
[5] Environment, http://thp.org/issues/environment/6-10-2014.
[6] Jehwo Yalaju, Impact of the Oil Industry on the Niger Delta Environment, Environmental and Planning Law Review, Vol. 1 No.1, October – December 2004, 1.
[7] Gas Flaring in Nigeria: A Human Rights, Environmental and Economic Monstrosity, ERA Action, Port Harcourt, 5.
[8] *Ibid*
[9] Jane Holder and Maria Lee, *Environmental Protection, Law and Policy* (2nd Edition Cambridge University Press, 2007) 419.
[10] *Ibid*
[11] Environment, http://thp.org/issues/environemnt, 6-10-2014.
[12] Yusuf, Olaolu Ali, Legal Progress and Climate Change.
[13] Dr. Nicola Purrant, LWNXXX select issues in climate change law, currant---1Wnxxx—select-issues-in- climate-change-law-2011-final.
[14] Sometimes the answer to the question 'why'? Can come first from answeringthequestion'where?'http://www.ilri.org/ilrinews/index.php/archieves/437.

and they respect no national boundaries[15]. Although legitimate and important areas of uncertainty still exist with respect to the ultimate impacts of climate change, the range of uncertainty is narrowing over time[16]. Perhaps most important, a global consensus now exists among the international scientific community that the world is witnessing discernible impacts on our climate and natural systems due to human activities[17]. The acceptance that anthropogenic climate change was a problem more or less coincided with the arrival of new regulatory instruments in the mainstream[18]. Global climate change driven largely by anthropogenic activities is a growing threat to human well-being in developing and industrialized nations alike leading to a conclusion that significant harm from climate change is already occurring, and further damages are likely[19]. In short, our use of fossil fuels is unlocking and releasing carbon dioxide taken out of the atmosphere in prehistoric times[20]. Carbon dioxide and Nitrogen oxide (NO_x) remain in the atmosphere and contribute to greenhouse effect for many decades to centuries[21]. The earth's climate has changed over the past century, because of the increase in atmospheric concentration of greenhouse gases[22]. The constant increase in greenhouse gas has led to its twin issue of global warming[23]. The global increases in CO_2 concentration are due primarily to fossil fuel use and land use, while those of CH_4 and N_20 are primarily due to agriculture[24]. The scientific reports of the intergovernmental panel on climate change state that the stabilization of emission in the atmosphere, to avoid the adverse impacts of climate change, requires significant and rapid reductions in 'business as usual' global greenhouse gas emissions[25].

III. Effects of Climate Change

Climate change is among the most pressing challenges that the world faces today[26]. With the present huge atmospheric concentrations of greenhouse gases (GHGs), the world is already committed to significant warming[27]. This concentration of greenhouse gases (GHGs), poses a grave challenge, given the wide range of expected climate impacts on natural systems as well as on human societies[28]. It was this challenge to the global impact of the disastrous effects of atmospheric concentration of greenhouse gases that prompted the International Convention (World Summit) on Climate Change, which was held in Rio-de-Janeiro (Brazil) in 2012, where more than 170 member nations ratified or signed the Rio declaration of 2012 with a commitment to decrease the CO_2 emissions to minimize greenhouse effect[29]. However, it is apposite to state that greenhouse gases are not completely worthless. The useful effect is that they provide the warmth in the climate, which prevents the earth from freezing[30]. Oxygen and carbondioxide derivable therefrom are the atmospheric components that absorb ultraviolet radiation[31]. The over accumulation of greenhouse gases in the atmosphere could result in an unprecedented atmospheric warming at a global scale to such an extent that human beings and other living things will not be able to tolerate the heat[32].

Gas flaring contributes to climate change, which has enormous implications for both Nigeria and the entire global system[33]. The burning of fossil fuel, mainly coal, oil and gas – greenhouse gas, has led to warming up the global system[34]. This, has led to some scientific problems. It affects human health, for instance it has led to deficiency in human immune system, the skin and eyes[35]. Just as it does to humans, it also affects the animals. There is also the problem of acid rain. Climate change is not merely an environmental, scientific, or economic issue; it has become a humanitarian issue too[36]. The effects of climate change will most likely have a major impact on population movement and settlement, whether within countries or across borders[37].

[15] Yusuf Olaolu Ali, Legal Profession and Climate Change in Nigeria – check website.
[16] David Hunter; James, Salman and Durwood Zaelke, International Environmental law (Foundation Press, 2002) 590
[17] *Ibid*
[18] Jane Holder and Maria Lee, Environmental Protection Law and Policy, *op cit.*
[19] Raheem Usman Adebimpe, Climate Change Related Disasters and Vulnerability: An Appraisal of the Nigerian Policy Environment, http.www.medwelljournals.com/fulltext/?doi=erj.2011.97.103
[20] David Hunter, James Salzman and Durwood Zaelke, International Environmental Law, *op cit,* 592.
[21] *Ibid* 593
[22] *Ibid*
[23] Raheem Usman Adebimpe, Climate Change Related Disasters and Vulnerability: An Appraisal of the Nigerian Policy Environment, *op. cit.*
[24] Ann Ogbo, Ndubuisi Ebele Lauretta and Wilfred Ukpere, Risk management and Challenges of climate Change in Nigeria, JHUM ECOL, 41(3): 22-235.
[25] Dr. Nicola Durrant, LWNXXX select issues in climate change law, *op. cit.*
[26] Daniel Hoornweg, Mila Freire, Marcus J.Lee, Perinaz Bhada – Tata, and Belinda Yuen, Cities and Climate change: Responding to Urgent and Urgent Agenda (The World Bank), 1
[27] *Ibid*
[28] *Ibid*
[29] Dr. Vinay N. Paranjape, *Environmental Law*, Central Law Agency, Allahabad, 2013, 19.
[30] Ajuzie C. Osunda, *Our Common Environment: Understanding the Environment, Law and Policy*, University of Lagos Press, 69.
[31] Gundling, L., International Environmental law: Atmosphere, Freshwater and Soil, UNITAL, Geneva, Switzerland, 1998, 57; See Ajuzie C. Osundu, Our Common Environment: Understanding the Environment, Law and Policy, op cit.
[32] Gas Flaring in Nigeria: A Human Right, Environmental and Economic Monstrosity, ERA Action, Port Harcourt, 19.
[33] *Ibid*
[34] Ajuzie C. Osundu, *op cit* 70-71
[35] Toni Pfanner, Humanitarian Debate: Law, Policy, Action, Environment, International Review of the Red Cross, Volume 92 Number 879 September, 2010, 541.
[36] *Ibid*
[37] *Ibid*

The scale of potential humanitarian challenge that climate change may present is indeed staggering[38]. It is now recognized that not only does the nature and extent of climate change hamper human development, it also forms a major threat to human security and political stability[39]. This raises the fundamental issue whether a fossil fuel-based economy should be continued or whether a radical transition to a low carbon economy should be pursued[40]. This raises the issue of time as to how long it would take to reconfigure energy systems based on fossil fuels (oil, natural gas and coal)[41].

Not only is time an issue regarding of how long it would take to reconfigure energy systems based on fossil fuels (oil, natural gas and coal), but the constraints of resources as to when oil and natural gas reserves, will be exhausted remains critical issue in like manner as to when the impacts of Climate Change are to be felt[42]. This raises the fundamental issue as to whether there is need for continuation of fossil fuel-based economies and their associated growth regions or whether a new and radical transition to a low carbon economy is envisaged[43]. Carbon dioxide emissions can be reduced either by using less energy or by using alternative energy sources (such as wind, photovoltaics, or hydro) that produce no carbon dioxide[44]. Another possible strategy involves encouraging activities that allow more carbon to be absorbed by trees or soils[45].

The problems of damaging Climate Change and the loss of plant and animal biodiversity are issues of common concern to the whole of mankind[46]. They have the potential to affect all countries, wherever they are situated, either in a geographical sense or in terms of their relative level of socio-economic development[47]. Therefore, any action taken to moderate Climate Change provides a global public good[48]. Even if Climate Change turns out to be less serious than we may think presently, any possible solutions have other positive benefits in the future[49]. Turning from the use of fossil fuels to renewable energy sources such as solar or wind power, for example, would make us be free from dependence on oil and improve air quality[50].

IV. Legal Framework for Climate Change

While in 1990, the International Panel on Climate Change (IPCC) was set up, in 1992, the Rio Earth summit agreed on a Legal Framework Convention on Climate Change[51]. It was this very Convention that recognized that only a legally binding international framework can ensure that actions will be taken to reduce emissions and to protect the most vulnerable from the potentially catastrophic impacts of climate change. Not minding this recognition, it cannot be underplayed that possible legal solutions to climate change problems are complex and difficult to classify as they encompass a wide range of international and national law[52].

The ultimate object as resolved in the International Convention (World Summit) on Climate Change held in Rio de Jaheiro (Brazil) in 2012 had as its prime attention the need to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the Climate Change[53]. This is with a view to obviating the disastrous effects of atmospheric concentrations of greenhouse gases and the consequential problem. In order to achieve this, there was a commitment to decrease CO_2 emissions to minimize greenhouse effects. The 1992 United Nations Framework Convention on Climate Change had already recognized the principle of global cost-effectiveness of emission reduction and this opened the way for flexibility[54]. However, a binding emission target for any country was not fixed, and so the need to invest in emission reduction either at home or abroad was not a pressing issue[55].

Article 3 of the Climate Change Convention of 1992 has as its basic principles the need for parties to

[38] Seventh African Development Forum, Acting on Climate Change for Sustainable Development in Africa: Climate Change, Economic Growth, and Poverty Reduction in Africa, Issues Paper #12, ADF VII. 10-15 October 2010, United National Conference Centre, Addis Ababa,

[39] Mike Hodson and Simon Marvia, *World Cities and Climate Change*, (McGraw Hill Open University Press 2010), 31.

[40] Ibid 30

[41] Jack Rostron, *Environmental Law for the Built Environment*, (Cavendish Publishing Limited 2001), 107.

[42] Mike Hodson and Simon Marvin, World *Cities and Climate Change: Producing Urban Ecological Security*, McGraw Hill, Open University Press, 2010, 30.

[43] *Ibid*, 31

[44] Tom Tietenberg, *Environmental Natural Resources Economics,* Pearson, 2006, 410.

[45] *Ibid,* 411

[46] Maurice Sunkin, David M.ong and Robert Wight, *Source Book on Environmental Law*, Cavendish Publishing Limited, 2002, 95.

[47] *Ibid*

[48] Tom Tietenberg, *Environmental Natural Resources Economics,* op cit, 410.

[49] William P. Cunningham, Mary Ann Cunningham and Barbara Woodworth Saigo, *Environmental Science: A Global Concern,* McGraw Hill Higher Education, 2007, 340.

[50] *Ibid*

[51] *Ibid* 3

[52] Dr. Vinay N. Paranjape, Environmental Law, (Central Law Agency 2013) 19.

[53] Ibid

[54] Tom Tietenberg, *Environmental Natural Resource Economics,* Pearson, 2006, 412.

[55] *Ibid*

protect the climate system for the benefit of present and future generations of mankind, on the basis of equity. The principle also emphasizes the need to give full consideration to those that are particularly vulnerable to the adverse effects of climate change and would bear a disproportionate or abnormal burden under the Convention[56]. No other region in Nigeria better falls within the context of the provision of the principles than the Niger Delta where fossil fuel (oil and gas) is being exploited with its unabated and unmitigated consequences to the environment and poverty striken people of the region. The author takes the view that in line with the principle of the Convention in Article 3, the government of Nigeria should take special precautionary measures to anticipate, prevent or minimize gas flaring in Niger Delta which is the basic cause of the climate change and its adverse effects in the region. No effort is been made by the government to stop gas flaring by the Multinational Oil Corporations.

Since this effort is lacking, it may not be possible to achieve the content of Article 2 which aims at stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. It would also be impossible to promote sustainable development and develop policies and measures that would protect the climate system against human induced change[57].

Article 4 enjoins all parties to take into account climate change to the extent possible, in their social, economic and environmental policies; to promote and co-operate in research and systematic observation[58]. Article 4 further provides for the promotion of sustainable development, and cooperation in the conservation and enhancement of appropriate sinks and reservoirs of all greenhouse gases not controlled by the Montreal Protocol, including biomass, forests and oceans, as well as terrestrial, coastal and marine ecosystems. In view of the adverse effects of Climate Change, the Article 4 goes further to enjoin parties to take Climate Change considerations into account, to the extent feasible, in their relevant social, economic and environmental policies and actions, and employ appropriate methods, for example impact assessments, formulated and determined nationally, with a view to minimizing adverse effects on the economy, on public health and on the quality of the environment, of projects or measures undertaken by them to mitigate or adapt to Climate Change. Whether or not multinational oil corporations and the Nigerian government have complied with the minimum requirement prescribed for Environmental Impact Assessment is a question of degree[59]. In Nigeria, a major problem with Environmental Impact Assessment is that it is most times used to serve a function of justifying a decision (usually to develop) which has been made and are concerned only with remedial measures[60]. However, in a sincere Environmental Impact Assessment regime, where it is judged that the environment or local communities may be affected by oil and gas activities, it is necessary to address potential impacts through the application of appropriate prevention, mitigation, control and management measures[61]. This is hardly applicable to the operation of multinational oil corporations in Nigeria.

However, it has been held in *City of Los Angeles V. National Highway Traffic Safety Administration*[62] that where climate change is sufficiently serious and causally connected to a project, climate change impact should be discussed in the Environmental Impact Assessment[63]. The Environmental Impact Assessment law can arguably be used in a climate change context where projects have an impact on the climate. It is possible that a proposed oil and gas project which is projected to have a substantial impact on greenhouse gas emission would be considered as having a significant impact on the environment and thus would require the submission of an Environmental Impact Assessment that considers different alternatives to the proposed plan including the zero alternative[64]. The Environmental Impact Assessment must look at the environmental impact of a project. Where it can be demonstrated that climate change should be considered as a predicted effect of a given project, a description of the climate change that an investment may cause should be integral part of an Environmental Impact Assessment report[65]. In America, several leading decisions have invalidated Environmental Impact Assessment reviews for failing to consider climate change[66]. In *Massachusetts V. EPA*[67], the U.S. Supreme Court held that the Commonwealth of

[57] Article 4(1) – (f) – (i); Philippe Sands, Jacqueline Peel, Adriana Fabra and Ruth Mackenzie, Principles of International Environmental Law, (Cambridge University Press, 2012) 278 – 279.
[58] Article 4(1)(f) United Nations Convention on Climate Change, 1992.

[59] Olanrewaju Fagbohun, *The Law of Oil Pollution and Environmental Restoration: A Comparative Review,* Odade Publishers, 2010, 296.
[60] Ibid 310
[61] IPIECA, The Oil and Gas Industry: Operating in Sensitive Environments, International Petroleum Industry Environmental Conservation Association www.ipieca.org 20-9-2012.
[62] 912 F. 2d 478 (D.C. Cir. 1990).
[63] See Center for Biological Diversity v. National Highway Traffic Safety Administration, 508 F.3d 508, 550 (9th cir. 2007) where it was held that the impact of greenhouse gas emissions is precisely the kind of cumulative impacts analysis that NEPA requires agents to conduct.
[64] Richard Lord, Silke Goldberg, Lavanya Rajamani and Jutta Brunnee, Climate Change Liability: Transnational Law and Practice, Cambridge University Press, 2012, 282-283.
[65] Ibid 426
[66] See Center for Biological Diversity v. National Highway Traffic Safety Administration, 538 F.3d 1172; Mid States Coalition for progress v. surface transportation board, 345 F. 3d at 520.
[67] Massachusetts V. E.P.A., 549 U.S. 497, 521 (2007).

Massachusetts had standing to challenge the EPA's failure to regulate greenhouse gas emissions from vehicles, while it also acknowledged that the harm associated with climate change are serious and well recognized. But so far in Nigeria, there is no case related to climate change neither does Environmental Impact Assessments put into consideration in their exercise the issue of climate change. While the NEPA guarantees the issue of climate change, it does seem that this is lacking in Nigeria's Environmental Impact Assessment Act. That notwithstanding, whether existing Environmental Impact Assessment regime is sufficient to ensure a meaningful consideration of climate change remains an issue to be resolved.

V. Climate Change and Adaptation in the Niger Delta

Adaptation is a change in the structure of habit of an organism that makes it better adjusted to its surroundings[68], while adaptive management is an approach to the management of national resources that is based on learning by doing, and on making decisions as part of an on-going process of monitoring, review, and adaption[69]. To prepare for and respond effectively to the impacts of climate change, adaptation is the key.

Article 4(1)(e) provides that parties to the Convention shall cooperate in preparing for adaption to the impacts of climate change. While it may not be possible to stop climate change, it is apposite to state that established mechanisms should be comprehensive and well articulated to recognize the varying needs and vulnerabilities of all sections of the society[70]. Its targets should be focused on both short and long-term sustainable responses.

A major issue when considering climate change adaptation, especially in developing countries like Nigeria, is to ensure adequate focus on the poor[71]. Climate change is a serious risk to poverty reduction and threatens to undo decades of development efforts[72]. Climate change is very likely to increase the frequency and magnitude of extreme weather events such as droughts, flood, and storms. Although it is uncertain to project the exact magnitude, rate, and regional patterns of climate change, its consequences will change the fate of many generations to come and particularly impact on the poor if no appropriate measures are taken[73]. Evidence abound that the number of people affected by disasters is on the rise, and most disaster – related injuries and deaths occur among low-income groups[74].

Moser and Satterwaite showed in their work that the main cause of the increase in loss of life is poverty, which hinders individual and household investments, and exclusion, which restricts access to public services[75]. In this wise therefore, climate change does not only aggravate the existing vulnerabilities of the poor, but it also creates new risks as more areas are exposed to climate-related hazards.

The impacts of climate change, and the vulnerability of the poor communities, particularly in the Niger Delta, to climate change, vary greatly, but generally, climate change is superimposed on existing vulnerabilities[76]. The effects of climate change is already taking its toll on the Niger Delta poverty stricken population. There is the problem of access to drinking water and the access to food security. There is also the problem of decrease in crop yields, which threatens famine.

The need for adaptation measure is prompted by the following reasons:

a) It is a priority for ensuring the long-term effectiveness of investment in poverty eradication and sustainable development.
b) If pursued in the sustainable framework, it can diminish the damage from future climate change and climate change variability.

However, it has been argued that while climate change is only one of the many factors influencing poverty, immediate action should be taken to adapt to climate change impacts. It is not an easy task for a developing nation like Nigeria to adapt and cope with climate change, particularly in the Niger Delta where the economic base of the country lies. The ability to adapt and cope with weather hazards depends on economic resources, infrastructure, technology, and social safety nets. Another issue germane to adaptation to climate change is that of pressure on population growth, rapid urbanization and resource depletion, making them vulnerable to the further challenges thrown up by climate change.

[68] Chris Park, Oxford Dictionary of Environment and Conservation, Oxford University Press 2007, 7.
[69] *Ibid*
[70] BNRCC, National Adaptation Strategy and Plan of Action on Climate Change for Nigeria (NASPA – CCN), prepared for the Federal Ministry of Environment Special Climate Change Unit, prepared by Building Nigeria's Response to Climate Change (ENRCC) Projects, 2011, 5.
[71] Daniel Hoornweg et al .10
[72] Poverty and climate change: Reducing the vulnerability of the poor through adaption, prepared by United Nations environment programme, IX.
[73] *Ibid*
[74] Daniel Hoornweg et al, II
[75] Moser, C., and D. Satterthwaite, "Towards Pro-Poor Adaptation to Climate Change in the Urban of Law and Middle – Income Countries", Human Settlements Working Paper Series Climate Change and Cities 3, International Institute for Environment and Development, Global Urban Research Centre, London, 2008.
[76] Poverty and Climate Change: Reducing the Vulnerability of the Poor through Adaptation, prepared by United Nations Environment Programme.

Climate change is a serious and complex problem that cannot be managed by one-off all approach[77]. It is also doubtful if any time win-win solutions exists, and climate change adaptation will come with trade-offs that will need to be carefully managed. However, it is becoming increasingly evident that well-intentioned climate change responses present a considerable risk, and to manage this risk all adaptation actions should be based on sound science and robust legal framework.[78] However, there is no established legal framework holistically to tackle the problem of climate change in the Nigeria's Niger Delta. That notwithstanding, the establishment of legal frameworks is only part of the solution.[79] There are of course multiple layers of organizational interest and appropriate legal framework will need to provide adaptation principles and goals, but ultimately it is through the implementation process that adaptation occurs[80]. This can only be achieved if decision makers at all levels understand how their decisions affect or are affected by climate change. The need to effect national policy changes, mainstreaming climate change risks into legislative frameworks, policies, plans – is an important approach in sustaining innovative climate-resilient development[81]. Thus, adaptation measures to combat climate change and its effects are essential in decreasing the Niger Delta vulnerability to climate change related threats[82]. Nigeria should create a national climate change policy which will provide a platform for coordination among sectors as well as guidance on national positions and priorities regarding climate change mitigation adaptation, not only in the Niger Delta, but in the whole of the country.

Another possible dimension to adaptation is taking a human rights approach. There are many human rights that are affected by climate change. Such rights include the right to life, the right to take part in cultural life, the right to use and enjoy property, the right to an adequate standard of living, the right to food, the right to water, the right to sanitation, the right to development, the right to adequate housing, and the right to the highest attainable standard of physical and mental health[83], etc. The invocation of such international human rights instruments as the International Covenant on Civil and Political Rights (ICCPR), and the International Covenant on Economic, Social and Cultural Rights (ICESCR). The ICESCR rights in particular that fall within the context of climate change are: the right to an adequate standard of living, including adequate food, clothing and housing; the right to freedom from hunger; the right to enjoyment of the highest attainable standard of physical and mental health; and the right to take part in cultural life[84]. Rights-based claim relating to adaptation may fare better. In the case of adaptation, since core human rights are implicated, rather than the right to environment, which is subject to limits, claims may prove more successful[85]. A claim may lie for instance where the government is not taking the necessary action to adapt to predicted climate change in particularly vulnerable areas such as the Niger Delta, and the resulting climate impacts breach the claimant's protected rights to life, health, water etc[86]. The foreign policy of Nigeria which is provided for in Section 19(d) enjoins respect for international law and treaty obligations. Nigeria is a signatory to such core human rights instruments as ICCPR and ICESCR. The core human rights threatened by climate impacts are protected under the international legal instruments and they are of binding obligation which must be given effect to in good faith[87]. Nigeria is also a party to the Framework Convention on climate change and its Kyoto protocol. The Nigeria's treaty obligations could be thus interpreted by the Supreme Court to enlarge the meaning and content' of constitutional guarantees, *inter alia* to life, health and water[88].

Melanie O'Brien has warned that caution must be exercised to ensure that climate change mitigation measures do not violate human rights[89]. Such violations may include the displacement of peoples from their traditional land for the purposes of reforestation, the pricing out of forest dwelling communities from using their own communities, or the prohibition of people from use of forested areas for traditional means of survival[90].

[77] Donovan Burton, Climate change and the law: The context and the emergence of cascading risks, in Baker-Jones, M., Burton, DL., Bell, J., Chang Seng, D., 2013 climate change adaptation: Guided by the law DLA Piper, Brisbane, 13.

[78] *Ibid*

[79] The establishment of a firm legal framework will to no avail solve the problem without enforcement and implementation. Lack of enforcement and implementation are the bane to the effectiveness of any existing legal framework.

[80] Statement Credited to Esala Nayasi of the Political and Treaties Division of Fijian Government Ministry of Foreign Affairs in a Workshop held in Suva, Fiji and Apia, Samoa, August 2013.

[81] Peniamina D Leavai, Case Study: PACC project, Kosrae state, federated states of Micronesia – Sector: Coastal Management, in Baker-Jones, M., Burton, DL., Bell, J., Chang Seng, D., 2013 climate Change Adaptation: Guided by the law DLA Piper Brisbane, 17.

[82] Jacqueline Hughes, Fiji and Climate Change, in Baker-Jones, M., Burton, DL., Bell, J., Chang Seng, D., Ibid 7, 28.

[83] Dr. Melanie O' Brien, Climate Change and Human Rights in the Pacific, in Baker-Jones, M., Burton, DL., Bell J., and Chang Seng, D., 2013 Climate Change Adaption: Guided by the Law DLA Piper, Brisbane, P. 19 available and www.dlapiper.com.

[84] *Ibid*

[85] Lavanya Rajamani and Shibani Ghosh, National Law: India, in Richard Lord, Silke Goldberg, Lavanya Rajamani and Jutta Bunnee, Climate Change Liability: Transnational Law and Practice.

[86] *Ibid*

[87] *Ibid*

[88] *Ibid*

[89] Lavanya Rajamani and Shibani Ghosh, *op cit.*

[90] *Ibid*

She further asserts that any legal responses that take climate change into account, such as those considering regulations for new or existing developments, the relocation of residents to low-risk areas, or climate change mitigation measures, should take a rights-based approach, which will result in a more holistic outcome with long-term benefits[91]. She went on further to say that a right-based approach should be integrated into natural disaster management, in order to ensure that essential rights are protected and provided for in situations of natural disasters. Such disaster risk management law, policies and regulations must take into account the need for protection of housing, infrastructure, and facilities that will be needed in the aftermath of natural disaster (e.g. sanitary facilities, food, water, clothing, medical treatment facilities)[92].

VI. Climate Change Litigation

Because of the lackluster attitude of the Nigerian courts towards environmental activism, the courts do not fully acknowledge the importance of climate protection, much so, as there seem to be little or no case to actually enhance the obligations to reduce emissions. Possible legal solutions to climate change problems are no doubt complex and difficult to classify as they cover wide range of international and national law. The law exists to serve society, and has according evolved to meet the changing needs and challenges of society. If it is accepted that the purposes of the law include serving society, reflecting its attitudes and providing redress for justices, then there is the need for climate change litigation and adjudication in the country. This will enhance the application of existing legal concepts, including some ancient doctrines generally seen as dormant if not extinct, to new factual issues, and the development of new legal concepts. It will further engender accretion of matrix of rights and obligations: legal rights and obligations, political and moral rights and obligations owed by and to individuals, corporations and states, and in some cases to future generations.

The problem which climate change litigation will certainly have in Nigeria is that of *locus standi*. Standing has traditionally been a major hurdle for all actions whether that of environmental rights or not. But this problem can be averted by the use of public interest jurisdiction or litigation such as in *S. P. Gupta V. Union of India*[93] which relaxed the rule of *locus standi* and opened up the doors of the Supreme Court to public-spirited citizens which includes those wishing to pursue the cause of the poor and oppressed (representative standing) and those wishing to enforce performance of public duties (citizens standing)[94].

The Constitution of Nigeria 1999 provides in its Section 20 that

"The state shall protect and improve the environment and safeguard the water, air and land, forest and wild life of Nigeria".

This constitutionally protected environmental right can be alluded to as the right to: 'environmental protection and conservation of natural resources[95]; live in a healthy environment with minimal disturbance of ecological balance[96]; a decent environemnt[97]; and a living atmosphere congenial to human existence. In the words of Rajamani and Ghosh[98], these formulations leave ample scope for value judgments and judicial discretion, and hence admit the possibility of protecting against threats to the climate. The effects of climate change will certainly disturb the ecological balance and render the atmosphere less congenial to human existence. Those living in the Niger Delta who are at the frontline of climate change, can testify to this.

While it may be uncertain that the Supreme Court of Nigeria will give favourable judgment with regard to climate protection, it will be a welcome development if it can take an approach that applies a human rights optic to climate impacts. This is because a host of rights to life, health and water, among others, will be at risk from climate impacts[99]. However, it is worthy of note that Section 20 of the Constitution of Nigeria 1999 is not intended to be enforceable by any court, they are however, nevertheless 'fundamental in the governance of the country' and it is the duty of the state to apply these principles in making laws.

The possible approach out of this quagmire is for the Nigerian Supreme Court to follow the Indian Supreme Court example by integrating into the Nigerian environmental jurisprudence numerous principles of international environmental law, such as in principles 3, 4, 15 and 16, of Rio Declaration on Environment and Development, 1992[100]. These principles include the polluter pays principle[101], the principle of inter-generational equity[102], the principle of sustainable

[91] *Ibid*
[92] *Ibid*
[93] S.P. Gupta V. Union of India, Lasi Supp SCC 87, at 233
[94] *Ibid*
[95] *Intellectual Forum, Tirupathi V. State of AP* (2006) 3 SCC 549
[96] *Rural litigation and entitlement Kendra V. State of UP* (1985)2 SCC 431 at para. 12.
[97] *Shantistar Builders V. Nayayan Khimala Totame and Ors* (1990)1 SCC 520, at para. 9.
[98] *Virender Gaur & Ors. V. State of Haryana & Ors* (1995) 2SCC 577 at para. 6.
[99] Lavanya Rajamani and Shibani Ghosh, National Laws: India, in Richard Lord, Siike Goldberg, Lavanya and Jutt Brunnee, Climate Change Liability: Transnational Law and Practice, Cambridge University Press, p.148.
[100] *Ibid*
[101] *Ibid*
[102] See principles 3, 4, 15 and 16, *Rio Declaration on Environment and Development*, 1992.

development[103] and the notion of the state as a trustee of all natural resources[104]. The Indian Supreme Court in its epoch making decision in *Vellore Citizens Welfare Forum V. Union of India* held these principles to be 'essential features of sustainable development[105], imperative for preserving ecology[106] and part of environmental law of India[107]. The Nigerian constitutionally protected environmental right in Section 20, complemented by these principles of international environmental law provides a fertile breeding ground for ambitious rights – based claims.

If these principles in particular, of precaution, public trust and inter-generational equity, as interpreted by the India Supreme Court are being adopted by the Nigerian Supreme Court, they will prove useful to prospective rights-based climate impact claims. In precautionary principle, state are enjoyed to take early actions and measures to anticipate, prevent and attack environmental degradation at source. The problem of climate change obviously falls within the ambit of threats that it would be wise to take early action on. Rajamani and Ghosh correctly suggested that this principle could be used to argue the case for ambitious mitigation and adaptation intervention, and to challenge state action that falls short.

The Doctrine of public trust on its part places a duty on the state as a trustee of certain public resources to protect resources like air, sea, water and the forests for the enjoyment of the general public[108]. Reasonably, issue of climate change could well engage the duty of a state as trustee to protect the atmosphere from indiscriminate green house gas emission[109]. The use of the principle of inter-generational equity may also help in climate change claim. In the context of forest resources, the principle of inter-generational equity holds that "the present generation has no right to deplete all the existing forests and leave nothing for the next and future generations[110]. The problem of future generation, intergenerational. This is because, the present generation inherited the problem of climate change while the present generation is exacerbating it, and that will certainly leave a legacy that imposes severe burdens of protection and sacrifice on future generations.

VII. Conclusion

Climate change is a universal phenomenon with far reaching effects on people and the Niger Delta area of Nigeria is particularly vulnerable to the impact of climate change in many fronts putting into consideration its geographical location, climate, vegetation, population, settlement, fossil fuel production and agricultural activities. Manifest events like sea level rise, erosion, flood and excessive heat are some of the effects of climate change which are already experienced in the area. The impacts of this unavoidable climate change need to be counteracted with appropriate legal measures to adapting to the climate change impact. The inclusion of climate change impact should be seen as a matter of topmost priority to the conduct of environmental impact assessment. All adaptation actions should be based on sound science and robust legal frameworks. There is also a need for guidelines to provide protocols and procedures that developers' decision makers at all levels can follow when making decisions about climate change, or decisions that are affected by climate change. This procedures and protocols will take into consideration the direct and indirect impacts of climate change and inform the decision maker as to how the developer's legal liability will be affected by the decision. In substance, the guidelines will take into consideration the statutory powers pursuant to which decisions are made, the results sought to be achieved in making the decisions, the effects any projected climate change impacts will have on the decisions and any consequent exposure to legal liability arising from the decisions.

[103] *Indian Council for Enviro-Legal Action V. Union of India* (Bichri case) (1996)3 SCC 212; *M. C. Mehta V. Kamal Nath* (2000)6 SCC 213, at 220.
[104] *Vellore Citizens Welfare Forum V. Union of India* (1996) 5 SCC 647; *Narmada Bachao Andolan V, Union of India* (2000) 10 SCC 664, at 727.
[105] *State of Himachal Pradesh V. Ganesh Wood Products* (1995) 6 SCC 363; *Indian Court for Enviro-Legal Action V. Union of India* (CRZ Notification Case) (1992) 5 SCC 281.
[106] *M. C. Mehta V. Union of India* (Taj Trapezium case) (1997) 2 SCC 353, at 381; *Narmada Bachao Andolan V. Union of India* (2000) 10 SCC 664, at 727.
[107] M. C. Mehta V. Kamal Nath (1997)1 SCC 388
[108] Vellore *Citizens' Welfare Forum V. Union of India* (1996) 5 SCC 647, at para. 11.
[109] *Karnataka Industrial Areas Development Board V. C. Kenchappa and Ors* (2006) 6 SCC 371, at para. 32.
[110] *Research Foundation for Science Technology and National Resource Policy V. Union of India and Anor* (2005) 13 SCC 186, at para. 24.

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Correlations between a New Daily Global Indicator of Human Behavior, Threshold Seismicity, and Solar Activity: Congruence of Energy and Implications

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Abstract- We correlated the daily average energy per earthquake for global seismicity within successive 1 M increments (<1.0 to >6.0 M), solar activity as defined by Solar Flux Units (SFU) and a new indices for Reports of Human Conflict Behavior for the years 2009 through 2013 (1,826 days). Events associated with intent (e.g. mobilization) and preparation for confrontation were positively correlated only with the average energy per event for 0.01 to 1 M seismic events and negatively correlated with SFU. The statistical significance of this seismic-behavior correlation was no longer significant statistically if the shared variance with solar activity was first removed. Actual events of force and confrontation displayed the opposite relation (positive correlation with SFU and negative correlation with only earthquake energies in this magnitude range). The shared variance between the behavioural categories and geophysical variables ranged between 4% to 10%. Lag/lead correlations indicated that the daily concordance expanded to about three days before or after the behavioural events. In particular average earthquake energies peaked ~3 days before the behaviors associated with intent for conflict.

Keywords: *GDELT project, earthquakes, solar flux units, human conflict behaviour.*

GJHSS-B Classification : *FOR Code: 850506*

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David A. E.Vares [α] & Michael A. Persinger [σ]

Abstract- We correlated the daily average energy per earthquake for global seismicity within successive 1 M increments (<1.0 to >6.0 M), solar activity as defined by Solar Flux Units (SFU) and a new indices for Reports of Human Conflict Behavior for the years 2009 through 2013 (1,826 days). Events associated with intent (e.g. mobilization) and preparation for confrontation were positively correlated only with the average energy per event for 0.01 to 1 M seismic events and negatively correlated with SFU. The statistical significance of this seismic-behavior correlation was no longer significant statistically if the shared variance with solar activity was first removed. Actual events of force and confrontation displayed the opposite relation (positive correlation with SFU and negative correlation with only earthquake energies in this magnitude range). The shared variance between the behavioural categories and geophysical variables ranged between 4% to 10%. Lag/lead correlations indicated that the daily concordance expanded to about three days before or after the behavioural events. In particular average earthquake energies peaked ~3 days before the behaviors associated with intent for conflict. The total seismic energies from the 0.01 to 1 M events when distributed over the surface area of the earth and the fluctuations in SFU are within the intensity range of energies associated with the type of neuronal activity coupled to human cognition. Implications for this convergence are discussed.

Keywords: GDELT project, earthquakes, solar flux units, human conflict behaviour.

I. Introduction

Although the direct impact of releases of large magnitudes of seismic energy upon human behaviour have been obvious historically and cross-culturally, the influences of more subtle releases of seismic energy upon human cognition have not been systematically explored. Persinger (1999) employed techniques of multiple regression to show an intermediate strength association between yearly estimates of global mortality from "social expenditures" (wars and armed conflicts) and the lagged values for variations in the global release of seismic energy in conjunction with geomagnetic indices. The research was inspired by the original thinking by A. L. Tchijevky from the early 20th century (Mikulecky, 2007) who reported the strong association between peaks in solar activity and major conflicts and the persistent yet infrequently investigated moderate strength between solar activity and global seismicity (Jakubcova and Pick, 1986; Odinstov et al, 2007). Recently, Anagnostopolous et al (2013) reported a positive correlation between *daily* numbers of admissions to psychiatric facilities and the numbers of small (M<3) earthquakes within the region of Crete, Greece. More specifically abrupt increases in the numbers of small earthquakes were followed within two days by increased admissions.

A direct real-time coupling between the physical substrates within the human brain that support and generate cognition and environmental events, particularly very low magnitude earthquakes and solar flux density has not been fully considered. Yet the physical potential is feasible. For example the energy associated with the smallest magnitude of earthquakes, 0.01 to 1 M, is in the order of 10^6 to 10^7 J (Joules) per day. For comparison the energy available from the metabolism of 1 Mole of glucose is about 2 x 10^6 J and the average human being utilizes about 2 to 3 M of glucose per day. The brain, as an organ, utilizes about 20 $J \cdot s^{-1}$ (Watts) or 1.7 x 10^5 J per day. However the total amount of energy associated with one estimate of the *electromagnetic* substrate of cognition (rather than the supportive cell metabolism) is more likely to be in the order of 10^{-13} J per second. This is based upon the assumption that an action potential involves units of energy of ~10^{-20} J (Persinger, 2010) and that approximately 10^7 neurons are involved with networks associated with "cognition" and awareness.

When 10^{-13} J per second is divided by the average cross-sectional area of the human cerebral cortices (~10^{-2} m^2) the radiant flux density would be about 10^{-11} $W \cdot m^{-2}$ which has been measured as photon emissions in several experimental sittings (Dotta et al, 2012). Similar flux densities of photons have been

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measured from hippocampal slices (Isojima et al, 1995) and were correlated with the strength of theta (4-7 Hz) activity. During years 2009 and 2013 the daily average numbers of M 0.01 to 1.0 quakes was ~108 per day with a total release of $\sim 8 \cdot 10^{7}$ J per day. This is equivalent to 10^{5} J·s^{-1} (on average). If the power was distributed equally over the surface of the earth the flux density would be 10^{-10} W·m^{-2} which is well within the range of the value associated with photon emission coupled with cognition. Although this does not prove coupling exists between cerebral energies of all human beings and the temporally and spatially heterogeneous release of seismic energies actually occurs, the coincidence requires at least cursory empirical assessment.

Our research group has found that relatively subtle changes in environmental stimuli, such as geomagnetic activity, are positively correlated with discrete and intensity-dependent $\mu V^{2} \cdot Hz^{-1}$ shifts in quantitative electroencephalographic activity for more than 250 subjects sampled over three years (Saroka et al, 2014). Similar intensity-dependent shifts above a threshold of ~20 nT for global geomagnetic activity as measured by the aa (average antipodal) index for subjective experiences in a controlled, quiet experimental setting was reported almost two decades ago (Persinger and Richards, 1995). The magnetic energy induced within the cerebral volume from these global geomagnetic fluctuations (0.6 x 10^{-12} J) approached the quantities associated with cognition. The effect primarily involves the right hemisphere of the human cerebrum and can facilitate the intercalation between the two hemispheres at the level of the temporal lobes (Mulligan et al, 2010). The "geomagnetic" effect has been reproduced experimentally in the laboratory by whole body exposure of volunteers to magnetic field configurations whose intensities and frequencies simulate natural conditions (Mulligan and Persinger, 2013).

We reasoned that if the human brain is sensitive to the environmental energies even crude or indirect estimates of group human behaviour over the planet should be associated with global incidence of the small magnitude earthquakes that approach energies generated by the human brain and body. At this level there should be a contribution from solar activity within the GHz range. For example the average daily solar output is $\sim 10^{-20}$ W·m^{-2}·Hz^{-1} (kg·s^{-2}). When multiplied by the potential range of 10^{9} Hz (s^{-1}) the potential flux density near the earth's surface could approach 10^{-11} W·m^{-2}. Although accommodations for impedance must still be verified, this is within the range associated with photon emission from the right hemisphere while subjects sat in hyper-dark settings and imagined white light rather than mundane events (Dotta et al, 2012). The variations in flux density were strongly correlated (0.9) with beta activity within the left prefrontal region. This region of the brain when activated is associated with self-monitoring and organization behaviors. During period of hypometabolism, the most frequent correlate is severe clinical depression.

We (Vares and Persinger, 2014) have recently shown a clear inverse correlation between daily solar flux units and the radiated energy for an earthquake of 0.01 to 1 M for the five years 2009 through 2013. We found that for every SFU unit decrease the average energy increase *per event* between 0.01 and 1 M quake over the surface of the planet would have been about 3.1 x 10^{-12} J·m^{-2}. The change in energy per event within this range rather than the numbers of events was the critical variable. The energy within the soma of a neuron with a cross sectional area of 10^{-10} m^{2} discharging at an intermediate frequency of about 40 Hz (the primary frequency range associated with consciousness, Llinas and Ribary, 1993) would have been ~1 x 10^{-20} J·s^{-1}, the energy equivalent to a single action potential (Persinger, 2010). Recently two separate groups of researchers have shown experimentally that stimulation of a *single neuron* affects behavioural responses (Houwelling and Brecht, 2007) and can shift the activity of the entire cerebral cortices (Li et al, 2009). Here we present evidence for the supposition that daily changes in global human behaviours according to a new integrated WEB-based system, small magnitude seismic events and solar activity are correlated and may reveal some degree of temporal connection with implications for future causal connection.

II. Data Bases

Access to one of the world's largest event dataset was made publicly available on May 29th, 2014. The Global Database of Events, Language, and Tone (GDELT) Project website (http://gdeltproject.org/) monitors world news media and compiles hundreds of categories of "events" as used by the DARPA-funded Integrated Conflict Early Warning System (ICEWS) project. Events including riots, protests, and diplomatic exchanges have been utilized for comparative study of political violence (Hammond & Weidmann, 2014). The events are recorded with details, including the physical location, direction of political intention and comprise the more than a quarter-billion events database, dating back to 1979. As confirmed by the avowal of the database creator (Leetaru & Schrodt, 2013), the data are considered as a global 'signal' providing insights into changes on the ground. The GDELT Event Database is available in Google's Big Query Developers Console. The cloud-based analytical database service is designed for large datasets. Fast SQL queries against multi-terabyte datasets can be accomplished in seconds, and real-time insights about global human society is accessible. Conflict and Mediation Event Observation (CAMEO) Event Root Codes label events with a key word, (i.e. 'Event Root Code 02' = 'Appeal)

and are accessible from the GDELT website http://data.gdeltproject.org/documentation/CAMEO.Manual.1.1b3.pdf. GDELT was accessed by Big Query for six (6) Event Root Codes and extracted for dates from January 1, 2009 until December 31, 2013 for a total number of days N = 1826. To normalize and to compensate for the exponential increase in the availability of global news material over time, the percentage of CAMEO Event Root Codes were calculated from the total number of events reported in the GDELT Event Database, across all event types, and broken down by day. The following table displays the Event Root Codes average daily percentages and standard deviations.

Table 1 : Means and standard deviations (SD) per day for various codes of behaviour classification as measured by the GDELT Event Database

Code	Description	Mean	SD
15	Exhibit Force Posture (alert/mobilize/police/military)	.33	.10
16	Reduce Relations (halt/withdraw/assistance/aid)	.87	.23
17	Coerce (confiscate/impose/freedoms)	4.96	.56
18	Assault (abduct/kill/bombing/assassinate)	1.65	.30
19	Fight (occupy/fight/territory/arms/aerial)	6.73	1.09
20	Conventional Mass Violence (mass/ethnic/chemical/bio/nuclear)	.03	.02

Earthquakes were queried from the Advanced National Seismic System (ANSS) global composite earthquake catalogue of the U.S. Geological Survey (USGS) for the same N = 1826 dates from 2009 – 2013. The total number of recorded Earthquakes and average Earthquake radiated energy were calculated per day for each order of magnitude (0.01-1M, 1.01-2M, etc.). The following table (Table 2) depicts the average daily seismic activity with standard deviations in parentheses.

Table 2 : Total numbers of events per day for each interval of magnitude of global earthquake events, the numbers of days involving these events, and the average energy in Joules per event

Magnitude	Days	Total Number	Average Energy (J)
0.01 – 1.00	1826	108.73 (33.24)	7.04E5 (9.01E4)
1.01 – 2.00	1826	100.07 (41.69)	1.44E7 (2.05E6)
2.01 – 3.00	1826	35.65 (33.50)	4.38E8 (1.12E8)
3.01 – 4.00	1819	8.70 (10.04)	2.21E10 (1.14E10)
4.01 – 5.00	1826	26.72 (22.22)	5.57E11 (1.30E11)
5.01 – 6.00	1725	3.85 (6.01)	1.05E13 (8.00E12)
≥ 6.01	487	0.36 (1.02)	2.50E15 (1.33E16)

Daily solar flux units (10^{-22} W·m^{-2}·Hz^{-1}) were queried from the NOAA Penticton F10.7cm index as measured at local noon (2000 UT). The peak measurement was 2.8 GHz with a 100 MHz band width. For the analysis period the mean and standard deviation were 101.4 and 27.4, respectively. All statistical analyses involved SPSS PC 16 and 17. Spearman rho (non-parametric) and Pearson product moment (parametric) coefficients were obtained and compared to minimize the probability that any effect was due to outliers.

III. Results

The analyses of the correlations between each of the integer magnitude levels of global earthquakes and the different classes of reports of human behaviour demonstrated that only the strength of the association with the average earthquake energy for the magnitude

0.01 to 1.0 seismic events were statistically significant ($p < .002$) and consistent. The results of the correlational analyses between solar and the low magnitude seismic activity with the different classes of reports of social behaviour as defined by the GDELT CAMEO Event Root codes are shown in Figure 1.

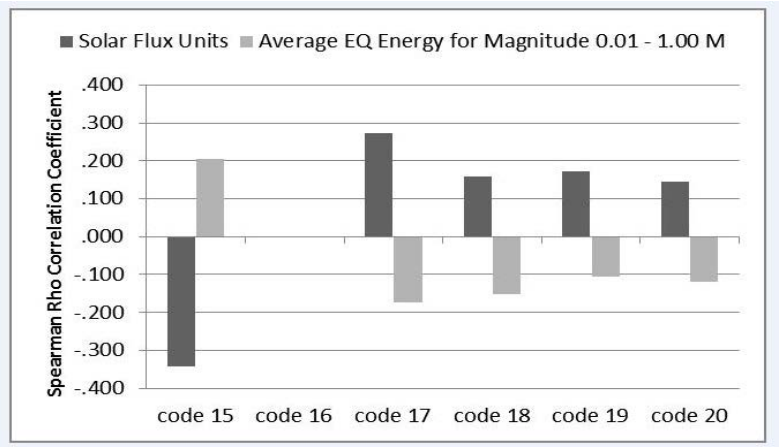

Figure 1 : Spearman Rho correlations between the daily incidence of each of the behavioural categories and the average energy from 0.01 to 1 M earthquakes and solar activity SFU.

All of the classes actually associated with active behaviour, particularly aggressive behaviour were positively and significantly correlated with the inference of solar power (SFU) for the same day. The class (code15) associated with intention, such as mobilization, was associated with increased average energy for the seismic events but decreased association with solar activity. The relationship between the daily incidence of code17 through code20, all involving actual behaviours and earthquake energy or solar flux units was opposite to that associated with intention. It is relevant that episodes of reports of simply policy changes were not significantly correlated with either solar flux units or seismic energy within the 0.01 to 1 M interval.

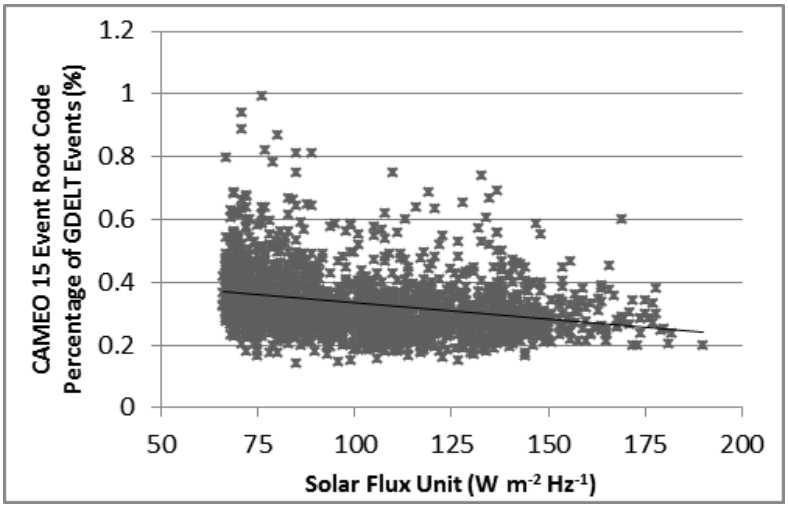

Figure 2 : Scattergram between the indices for CAMEO Event Root Code 15 class of events (exhibitions of force or posturing) and the daily SFU values

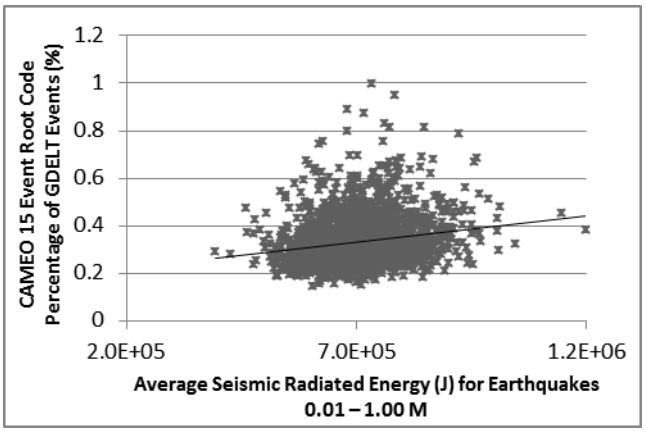

Figure 3 : Scattergram of the association between daily radiated seismic energy per event of very small magnitude earthquakes and the indices for exhibitions of force or posturing

In order to discern if there was shared variance between the three key variables, partial correlation analyses were completed with the parametric (Pearson r) values. The results are shown in Table 3 for the strongest association (Code15, intent and mobilization).

The elimination of the statistically significant association between the seismic energies and this category of reports of human behavior once the shared variance with daily SFUs was removed indicates that the original association was due to their shared variance with SFUs.

Table 3 : Zero-order and partial correlation analyses for pairs of variables after the shared variance (with the remaining variable) was removed for solar activity (SFU), average energy per earthquake within the 0.01 to 1 M range and category of reports associated with intent, e.g., alerts, mobilizations of police or military)

Correlation Variables	R	Control Variable	Partial	ΔR
SFU + EQ	-.472	Code15	-.443	.029
EQ + Code15	.194	SFU	.074	.120
SFU + Code15	-.279	EQ	-.217	.062

Lag, lead analyses were completed for the SFU and average energy per seismic event for each of the five days before and after the key day (day of report) for the various CAMEO Code categories. The most conspicuous pattern is shown in Figure 4 for CAMEO Code 15 reports and our seismic index. The average energy for individual events within the "intent" category increased about 3 days before the behavioral (or reported) occurrence. However a direct test of the difference between the two correlation coefficients if they were treated as parametric values was $z = 1.5$ ($z < 1.96$) and was not significant statistically ($p < .05$). In order to be statistically significant, the sample size (assuming the same effect size) would require a collection of about 10 years of daily data.

The "temporal distribution" of the major category associated with SFU fluctuations per day are shown in Figure 5. In this instance the slow increase in strength of association, although very minute, occurred about 2 days after the day of the reports of coerced episodes. Again the apparent difference between -1 and +2 days for this attractive pattern was not statistically significant, that is there are no significant differences between the correlation coefficients (difference about 1% of the variance). However the shared variance between this category per day and SFUs was about 7%.

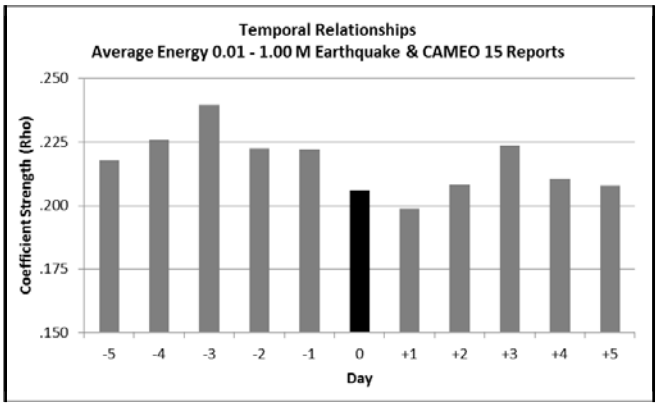

Figure 4 : Strength of association (rho) between numbers of CAMEO Code 15 reports (intentions) and average energy per unit seismic event in the 0.01 to 1.0 M range as a function of lag/lead or days energy release for each of 5 days before and after the days of the reports (0)

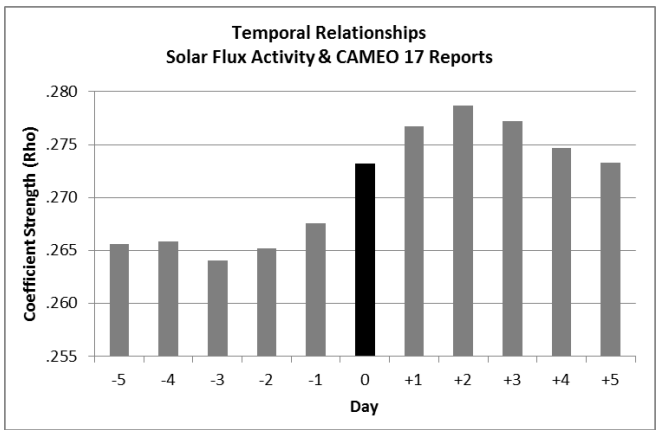

Figure 5 : Strength of association between solar flux units (SFU) and numbers of CAMEO Code 17 Reports (aggression) and for daily SFU values lagged for each of 5 days before and 5 days the days of the reports

IV. Discussion

Most biological scientists would concur with the concept that living systems developed interactively on this planet and that ultimately the majority of the energy from which these systems were constructed originated from the Sun. Some researchers who have developed the concept of quantum biology (Popp, 1979) have suggested that the photon emissions between cells within living systems may actually involve direct communication of information (Dotta et al, 2014) and that these photons are still virtual representations of the original solar source. If even partially accurate, the implications concerning the direct influence of fluctuations in minute power densities on the earth's surface from the sun may require careful reconsideration.

A shared variance of between 4% and 10% between the geophysical variables and the behavioural categories may appear minuscule. However, even when controlling for the qualitative nature of the data base and the issues of sampling and ordinal scaling, such shared variance could have significant implications for large populations. Many relevant sociological effects accommodate less than 10% of the effect size for group or "treatment" differences. The effect sizes (amount of variance explained) for changes in weather (Persinger, 1987) are in the order of 10% with respect to fluctuation in daily estimates of mood. When applied to populations of millions of people, this effect can potentially determine the direction of popular opinion, such as votes, and affect economic productivity. The latter phenomenon, including the multiplier effects noted in many large economic systems, often operates for proportions of variability that are less than 10% of the central tendency. The strength of the periodic 10 year cycle in the correlation between cerebral indicators of hemispheric dominance and birth year coupled to solar activity (Volcheck, 1995) is within this range.

The caveat to any interpretation from these data is that it may reflect the factors responsible for the reporting of the different categories rather than the behaviours themselves. However if this were totally responsible for the correlations one would not have expected the reversal of directions with respect to solar activity and seismic energy for the different categories that effectively differ by intent vs action. In addition, the numbers of CAMEO Code 16 reports which were related

to neither intent nor behaviour at the time but a simple report of changes in policy were not significantly correlated in any direction with either the solar or seismic fluctuations.

The contribution from changes in GHz output from solar activity upon brain function does not appear to have been considered as a direct influence even though the quantitative solutions are congruent. During the five year period involved with this study the average daily SFU units was 101 SFU with a standard deviation of about 27 units, equivalent to 10^{-20} $W \cdot m^{-2} \cdot Hz^{-1}$. If the central band frequency, 2.8 x 10^9 Hz, were applied, the effective flux density is approximately 2.8 x 10^{-11} $W \cdot m^{-2}$. Although there is no evidence, primarily because of absence of systematic experiments, to discern the neutral hydrogen frequency in the human cerebrum and its coupling to physical processes, demonstration of this effect would diminish the argument that such small solar variations cannot be cerebrally effective.

The association between the increased SFU and increased numbers of reports of human actions associated with intent or planning whereas the actual execution of aggressive behaviors were negatively correlated with increased solar activity suggests that cognitions or some aspect of aggregate of anticipatory (social) behaviour is related to solar perturbations. The mechanisms are clearly not evident at this time and could involve a third factor through which both are related rather than direct causality. From the context of the emerging discipline of quantum biology and the seminal concepts of Popp (1979) and the very original thinkers Hu and Wu (2006), the presence of excess correlation between photon interactions within the human brain and the entangled photons originating from the sun would require the consideration of non-locality. That this can occur experimentally at macroscopic and non-traditional distances had been shown by Dotta and Persinger (2012).

The potential for energies associated with seismic energy release within the 0.01 to 1 M range is consistent with the concept that systems that exhibit similar magnitudes of unit energy can potential interact directly or by resonance. For example in computer systems voltages within ±5 V are potentially influential and can alter the type of information or its direction within the system. Voltages that are lower or higher are either not effective or destructive to the system's constituents. The total energy from the seismic events per day within the 0.01 to 1 M value would have been in the range of 7 x 10^7 J per day or about 8 x 10^2 $J \cdot s^{-1}$ and when distributed over the earth (assuming some distribution around homogeneity) would be 1.6 x 10^{-12} $W \cdot m^{-2}$.

This is the same order of magnitude as our measurements of background photon emissions from the earth (Persinger et al, 2012) and the magnitudes of changes from the right hemisphere of human volunteers sitting in hyper-dark settings and engaging in imagination (Dotta et al, 2012). That the latter are not artefacts of metabolism is indicated by the strong positive (0.9) correlation with the photon flux density variations of the photon output from the right hemisphere and the power density of electroencephalographic activity within the beta range over the left prefrontal regions. This region of the human brain is a major locus of neurocognitive processes associated with self-monitoring, planning, and the feeling of intent.

Previously we (Vares and Persinger, 2014) found a quantitative relationship between daily SFU variations during the same five year period and energy release from 0.01 to 1 M seismic events. The slope for the application of the energy over the earth's surface was such that for every 1 unit decrease in SFU, the seismic energy from this magnitude interval increased by 3.1 x 10^{-12} $J \cdot m^{-2}$. This is an important value because when applied to the cross-sectional area of an average neuronal soma (10^{-10} m^2) the energy is 3 x 10^{-22} J. If this fluctuation was around 40 Hz (s^{-1}), the band of cerebral cortical activity associated with consciousness and cognition, the power would be about 1.2 x 10^{-20} $J \cdot s^{-1}$. This equivalent to energy associated with one action potential per second. That a single neuron can affect the state of the entire cerebral cortices has been shown experimentally (Li et al, 2009).

There is still the possibility that the actual stimuli, similar to that found by Anagnostopolous et al (2014), were connected to increased seismic events occurring during the days preceding the aggressive events. Those researchers included a wider range (M < 3) of seismic events. The decrease in average seismic event energy on days associated with day of reports of increased actual expressions of aggressive events, if both are partially caused by solar variations in the GHz range, would suggest that the energy is distributed to the processes that ultimately result in either the smallest earthquakes or the cerebral conditions that contribute to aggressive behaviors as measured by the global index. In other words as one class of phenomenon becomes more frequent the incidence of the other diminishes. The observation that the strong correlations occurred with the average energy per seismic event rather than the numbers of events, per se, suggest that there may be an analogue of a "vesicular" or "quantum" of energy coupled so the solar-terrestrial influence that is common to both seismic and cognitive processes.

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Comparative Study of Methods for Estimating Evapotranspiration Reference in Paranaíba City, Brazil

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Abstract- This study aimed to was evaluating the performance of 30 methods to estimate reference evapotranspiration (ET0) to the city of Paranaíba, Brazil. The meteorological data was removed from National Institute of Meteorology, on the period of six year (March 2008 to February 2014). The method taken as standard was Penman-Monteith-FAO56 and the comparison of results was by the coefficients of determination (r^2), coefficients "a" and "b" of the linear regressions, estimate of standard-error, Willmott's index of agreement (d), Pearson correlation coefficient (r), and reliable coefficient (c). The better methods to ET0 estimate was: Penman-Original, Stephens-Stewart, Priestley-Taylor, Hicks-Hess, Turc, Liquid-Radiation, Thornthwaite-Modified, Temperature-Radiation, Penman-FAO24, Abtew and Camargo. The Camargo method should be preferred when only air temperatures data have. The methods Blaney-Criddle-FAO24 and Hamon should receive calibration for be utilized on the estimate of ET0 in Paranaíba city.

Keywords: agrometeorology. ET0. evapotranspiration. penman-monteith-FAO56.

GJHSS-B Classification : FOR Code: 960301

COMPARATIVESTUDYOFMETHODSFORESTIMATINGEVAPOTRANSPIRATIONREFERENCEINPARANABACITYBRAZIL

Strictly as per the compliance and regulations of:

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Fernando França da Cunha [α], Thiago Ramos da Silva [σ], Arthur Ribeiro Ximenes [ρ] & Rafael Oliveira Batista [ω]

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I. Introduction

The evapotranspiration is the term used to define the loss of water vapor to the atmosphere by the effect combined of the process of evaporation of water of superficies of soil and the plant and, of transpiration of water by the plant (OLIVEIRA et al., 2011). The study of evapotranspiration is important to the agricultural planning, being increasingly higher the requirement of information about the water requirement of crop to the regional planning and preliminary project. This study becomes more important in regions characterized by the spatial and temporal irregularity of rainfall (MOURA et al., 2013).

There are many methods to the determination of evapotranspiration, whether direct or indirect. The Penman-Monteith method (ALLEN et al., 1998) was recommended by FAO as standard to calculate the reference evapotranspiration (ET0) and has been utilized in all world. This method requires many input parameters like air temperature, relative humidity, solar radiation and wind speed. However, there are a limited number of meteorological stations to the monitoring of this variable of time. This lack of meteorological data leads to the development of simpler approaches to estimate ET0 that requiring only a few input parameters. In this context, various methods have been reported in the literature for this purpose.

Although there a lot models to estimate of ET0, these, however, are utilized in climate and agronomics conditions very different from those that were originally designed and, therefore, is utmost importance evaluate the degree of accuracy of these models before using them to new condition. Several of work comparing the various models of ET0 estimate are found on literature to different regions (BARROS et al., 2009; KISI, 2009; CAVALCANTE Jr. et al., 2011; OLIVEIRA et al., 2011; KISI et al., 2012; SAHOO et al., 2012; CUNHA et al., 2013; MOURA et al., 2013).

Given the above, the aim of this work was to evaluate the performance of 30 methods for ET0 estimate, comparing them with the standard method of Penman-Monteith-FAO56, for the Paranaíba city, Brazil.

II. Material and Methods

The meteorological data required for execution of this study were taken from the National Institute of Meteorology (INMET) for the automatic meteorological station in the Paranaíba city, of Mato Grosso do Sul state, Brazil (Latitude 19° 24' 51"S, Longitude 51° 06' 19" W, Altitude 424 m) for six years, from March 2008 to February 2014. The meteorological data used in the research were: average temperature, maximum and minimum (°C); average relative humidity, maximum and minimum (%); average dew point temperature, maximum and minimum (°C); average pressure, maximum and minimum (hPa) wind speed at 10 m height (m s^{-1}) and global radiation (kJ m^{-2}). Data were obtained from a meteorological station that consists of the equipment WAWS 301 (Automatic Weather Station) of the Brand VAISALA, whose composition is described as follows: (1) Pyranometer CM6B; (2) Pressure Sensor PMT16A; (3) Thermometer QMH102; (4) Hygrometer

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QMH102; (5) Pluviometer QMR102 and (6) Anemometer WAA151. The hourly meteorological data were converted to daily data. In order to make the meteorological variables data more homogeneous, verification was made and, subsequently, the information considered discrepant or inconsistent was eliminated, aiming to obtain more representative data groupings. The methodologies used in this research to estimate the daily reference evapotranspiration (ET0) are presented in Table 1.

Table 1 : Methodologies and their respective equations to estimate the daily reference evapotranspiration (ET0) used in the research

Methodology	Equation
Penman-Monteith-FAO56	$ET0 = \frac{0.408\,\Delta\,(Rn-G) + \gamma\,\frac{900}{t+273}\,U_2\,\frac{(e_s-e)}{10}}{\Delta+\gamma\,(1+0.34\,U_2)}$
Penman-Original	$ET0 = \frac{\Delta}{\Delta+\gamma}0.408\,(Rn-G) + \frac{\gamma}{\Delta+\gamma}0.26\left(1+\frac{U_2}{160}\right)(e_s-e)$
Penman-FAO24	$ET\,0 = c\left[\frac{\Delta}{\Delta+\gamma}0.408\,Rn + \frac{\gamma}{\Delta+\gamma}0.27\,(1+0.864\,U_2)(e_s-e)\right]$
Blaney-Criddle-FAO24	$ET\,0 = k\;p\;(0.457\;t+8.13)$
Radiation-FAO24	$ET\,0 = -0.3 + k\left(\frac{\Delta}{\Delta+\gamma}\,R_{SE}\right)$
Makkink	$ET\,0 = R_{SE}\left(\frac{\Delta}{\Delta+\gamma}\right) + 0.12$
Hargreaves-Samani	$ET\,0 = 0.0023\;\;Ra_E\;(t_{max}-t_{min})^{0.5}\;(t+17.8)$
Hargreaves-Original	$ET\,0 = 0.135\;\frac{R_S}{\lambda}\;(t+17.8)$
Priestley-Taylor	$ET\,0 = 0.5143\;\;\frac{\Delta}{\Delta+\gamma}\;(Rn-G)$
Jensen-Haise	$ET\,0 = R_{SE}\;\;(0.025\;t+0.08)$
Camargo	$ET\,0 = 0.01\;\;Ra_E\;\;t$
Linacre	$ET\,0 = \frac{500\;\;(t+0.006z)}{100-\phi} + 15\;(t-t_d)\Big/(80-t)$
Hamon	$ET\;0 = 0.55\left(\frac{N}{12}\right)^2\left(\frac{4.95\;\;\exp^{\;0.062\;t}}{100}\right)\;25.4$
Ivanov	$ET\,0 = 0.006\;(25+t)^2\;\;\left(1-\frac{RH}{100}\right)$
Kharrufa	$ET\;0 = 0.34\;\;p\;t^{1.3}$
Garcia-Lopez	$ET\,0 = 1.21\;\;10^{\left(\frac{7.45\,t}{243.7+t}\right)}\;(1-0.01\;\;RH\;) + 0.21\;t - 2.30$
Blaney-Morin	$ET\;0 = p\;\;(0.457\;\;t+8.13\;)\,(1.14\;-0.01\;\;RH\;)$
Turc	$ET\;0 = \frac{0.013\;\;t}{t+15}(23.9\;\;R_s+50)$
McCloud	$ET\;\;0 = 0.254\;\;\;\;1.07^{\,(1.8\,t)}$
McGuiness-Bordne	$ET\,0 = \frac{Ra}{\lambda}\;\;\frac{t+5}{68}$
Romanenko	$ET\,0 = 4.5\left(1+\frac{t}{25}\right)^2\left(1-\frac{e}{e_s}\right)$
Lungeon	$ET\,0 = 0.2985\;\;(e_s-e)\left(\frac{273+t}{273}\right)\left(\frac{760}{P-e_s}\right)$
Abtew	$ET\;0 = \frac{0.53}{\lambda}\;\;R_s\;\;(1-\alpha)$

Hicks-Hess	$ET\,0 = \frac{1}{\lambda}\left(\frac{\Delta}{0.90\ \Delta + 0.63\ \gamma}\right) Rn$
Global-Radiation	$ET\,0 = 0.9 + 0.115\ R_s$
Liquid-Radiation	$ET\,0 = 0.86\ \frac{Rn}{\lambda}$
Temperature-Radiation	$ET\,0 = \frac{1}{\lambda}\left(\frac{R_S\ t_{max}}{56}\right)$
Stephens-Stewart	$ET\,0 = 0.4047\ R_S\ [(0.01476\ t) + 0.0724]$
Tanner-Pelton	$ET\,0 = 0.457\ Rn - 0.11$
Thornthwaite-Modified	$ET\,0 = \frac{16}{30}\left(10\ \frac{0.36\ (3\ t_{max} - t_{min})}{I}\right)^a \frac{N}{12}$
Thornthwaite	$ET\,0 = \frac{16}{30}\left(10\ \frac{t_i}{I}\right)^a \frac{N}{12}$

ET0 = reference evapotranspiration (mm day); Δ = slope vapour pressure curve (kPa °C^{-1}); Rn = net radiation at the crop surface (MJ m^{-2} day^{-1}); G = soil heat flux (MJ m^{-2} day^{-1}); γ = psychrometric constant (kPa °C^{-1}); t = mean daily air temperature at 2 m height (°C); U_2 = wind speed at 2 m height (m s^{-1}); e_s = saturation vapor pressure (hPa); e = actual vapour pressure (hPa); c = adjustment coefficient (adm); k = local coefficient (adm); p = annual percentage of light (%); RH = relative humidity (%), R_{SE} = solar or shortwave radiation (mm day^{-1}); Ra_E = extraterrestrial radiation (mm day^{-1}); t_{max} = maximum temperature (°C); t_{min} = minimum temperature (°C); λ = latent heat of vaporization (MJ kg^{-1}); z = local altitude (m); φ = local latitude (degrees); t_d = dew point temperature (°C); N = photoperiod (h); R_S = solar or shortwave radiation (MJ m^{-2} day^{-1}); Ra = extraterrestrial radiation (MJ m^{-2} day^{-1}); P = atmospheric pressure (hPa); α = albedo or canopy reflection coefficient (dimensionless); a = local constant (adm); I = annual heat index (adm); and t_i = monthly temperature (°C).

The wind speed was corrected to a height of 2 m (Equation 1).

$$U_2 = \frac{4.868}{\ln\left(67.75\ z - 5.42\right)} U_z \qquad (1)$$

where: U_2 = wind speed at 2 m height (m s^{-1}); U_z = wind speed at "z" m above ground surface (m s^{-1}); and z = height of wind measurements (m).

The net radiation was estimated according to the following equations:

$$Rn = Rns + Rnl \qquad (2)$$

$$Rns = R_S\ (1 - \alpha) \qquad (3)$$

$$Rnl = 4.8989\ 10^{-9}\ T^4 \left(0.09\ \sqrt{0.75\ e} - 0.56\right)\left(1.35\ \frac{R_S}{(a+b)\ Ra} - 0.35\right) \qquad (4)$$

where: Rn = net radiation at the crop surface (MJ m^{-2} day^{-1}); Rns = net solar or shortwave radiation (MJ m^{-2} day^{-1}); Rnl = net longwave radiation (MJ m^{-2} day^{-1}); R_S = solar or shortwave radiation (MJ m^{-2} day^{-1}); α = albedo or canopy reflection coefficient (dimensionless); T = average daily temperature of the air (K [K = °C + 273.16]); e = actual vapour pressure (kPa); a e b = fraction of extraterrestrial radiation reaching the earth on clear days (dimensionless); and Ra = extraterrestrial radiation (MJ m^{-2} day^{-1}).

After obtaining the daily ET0 through different methodologies it was conducted a regression analysis that correlated the ET0 values estimated by empirical equations with the Penman-Monteith-FAO56 method (ALLEN et al., 1998). It was considered the coefficients "a" and "b" of the respective linear regressions and the

coefficient of determination (r^2). The best alternative was the one that showed regression coefficient "a" near to zero, coefficient "b" near the unity and higher coefficient of determination, more than 0.60. The precision was measured through the coefficient of determination, which indicates the degree to which the regression explains the sum of the total squared.

The models performance analysis was performed by comparing the daily ET0 values obtained by empirical methods such as the Penman-Monteith-FAO56 (ALLEN et al., 1998). The methodology adopted for comparison of results was proposed by Allen et al. (1989), and is based on the estimate of standard-error (ESE), calculated by Equation 5. The best method to estimate ET0 was the one that presented the lowest ESE.

$$ESE = \left[\frac{\sum_{i=1}^{n} (X_i - Y_i)^2}{n-1} \right]^{1/2} \quad (5)$$

where: ESE = estimate of standard-error (mm day^{-1}); X_i = reference evapotranspiration estimated by the standard method (mm day^{-1}); Y_i = reference evapotranspiration obtained through the tested method (mm day^{-1}); and n = number of observations.

The approximation of ET0 values estimated by the method studied, in relation to the values obtained using the standard method, was obtained by an index called concordance, represented by the letter "d" where its values range from zero, where there is no concordance, to 1, for the perfect concordance. The concordance index (d) was calculated using the Equation 6. To validate the model, it was also obtained the Pearson's correlation coefficient (r) through Equation 7 and the reliable coefficient or performance (c) through Equation 8.

$$d = 1 - \frac{\sum_{i=1}^{n} (X_i - Y_i)^2}{\sum_{i=1}^{n} \left[\left(X_i - \overline{X} \right) + \left(Y_i - \overline{X} \right) \right]^2} \quad (6)$$

$$r = \frac{\sum_{i=1}^{n} \left[\left(X_i - \overline{X} \right) \left(Y_i - \overline{Y} \right) \right]}{\sqrt{\sum_{i=1}^{n} \left(X_i - \overline{X} \right)^2} \sqrt{\sum_{i=1}^{n} \left(Y_i - \overline{Y} \right)^2}} \quad (7)$$

$$c = r\, d \quad (8)$$

where: d = Willmott's concordance index; X_i = reference evapotranspiration estimated through the standard method (mm day^{-1}); Y_i = reference evapotranspiration obtained through the method tested (mm day^{-1}); $\overline{Y}$ = average values of reference evapotranspiration obtained through the method tested (mm day^{-1}); $\overline{X}$ = average values of reference evapotranspiration obtained through standard method (mm day^{-1}); n = number of observations; r = Pearson's correlation coefficient; and c = reliable coefficient or performance.

According to Cohen (1988), the correlation coefficient (r) can be classified as: "very low" ($r < 0.1$), "low" ($0.1 < r < 0.3$), "moderate" ($0.3 < r < 0.5$); "high" ($0.5 < r < 0.7$); "very high" ($0.7 < r < 0.9$); and "almost perfect" ($r > 0.9$).

The reliable coefficient or performance, proposed by Camargoe Sentelhas (1997), is interpreted in accordance with authors such as: "great" ($c > 0.85$); "very good" ($0.76 < c < 0.85$); "good" ($0.66 < c < 0.75$), "average" ($0.61 < c < 0.65$), "badly" ($0.51 < c < 0.60$), "not good" ($0.41 < c < 0.50$) and "terrible" ($c < 0.40$).

III. Results and Discussion

On Figures 1 and 2 are shown the graphs and the resulting linear regression models considering the methods to estimates of reference evapotranspiration (ET0) utilized on the analysis having the Penman-Monteith method standardized by FAO as standard. It is observed, based on regression straight, that Blaney-Criddle-FAO24 method underestimated the ET0 values only when the Penman-Monteith-FAO56 method was accused estimates exceeding 4.5 mm day^{-1}. The Camargo, Hamon, Abtew and Global-Radiation methods underestimated ET0 when the values of Penman-Monteith-FAO56 were accused estimates above 3.0 mm day^{-1} and Blaney-Morin above 1.5 mm dia^{-1}. The methods of Penman-Original, Priestley-Taylor, Hicks-Hess, Lungeon, Turc, Liquid-Radiation, Stephens-Stewart e Thornthwaite-Modified accused good estimate of ET0, presenting curves of regression near relation of 1:1. Of these, the first four methods deserve spotlight, because presented the regression coefficients "a" next to zero and the coefficient "b" near to unit. Have other methods, independent of evapotranspirometrical demand, presenting higher regressions coefficients and overestimated the values of ET0 in relation to standard method.

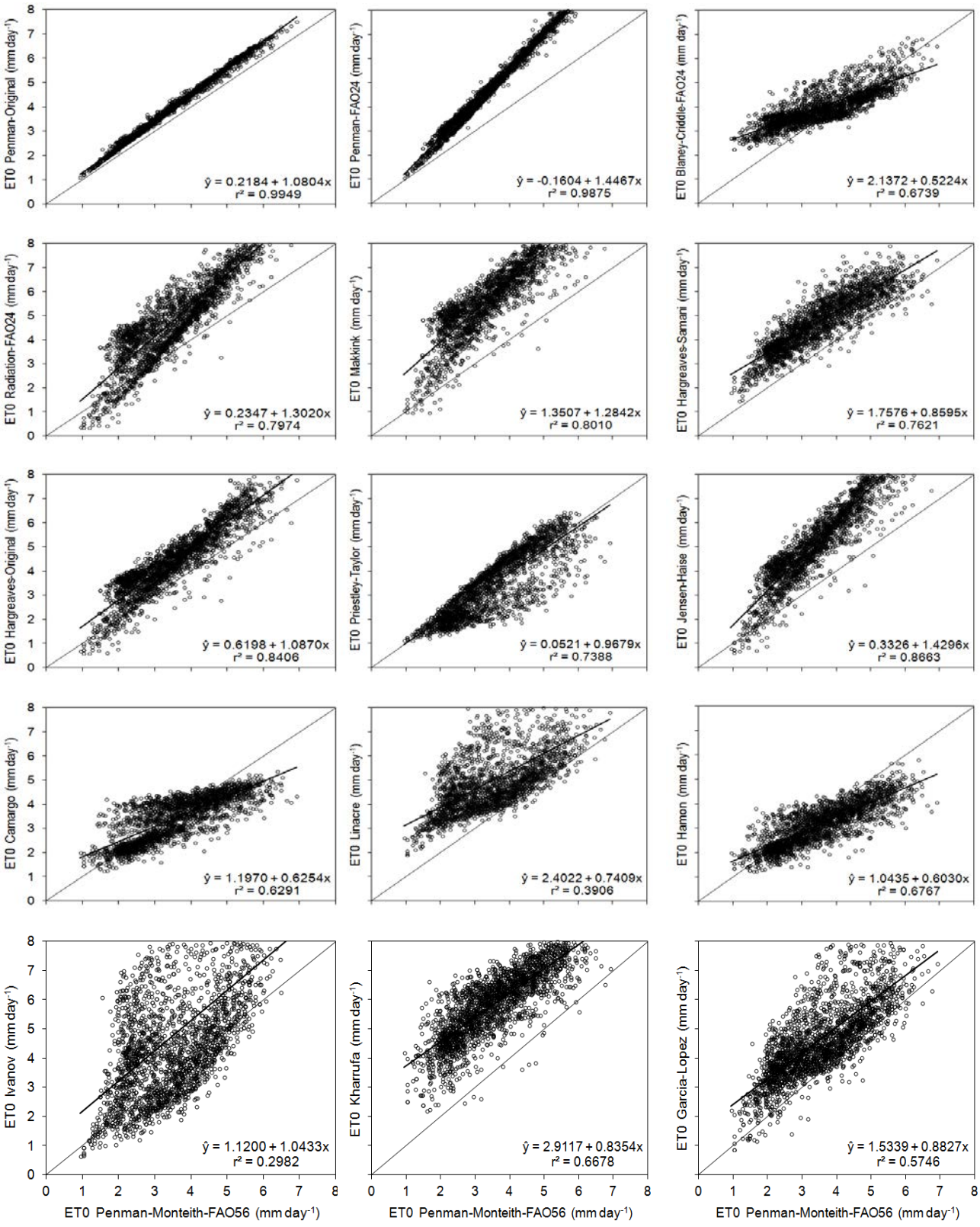

Figure 1 : Values of reference evapotranspiration (ET0) obtained through Penman-Monteith-FAO56 compared with ET0 values obtained through the methods studied.

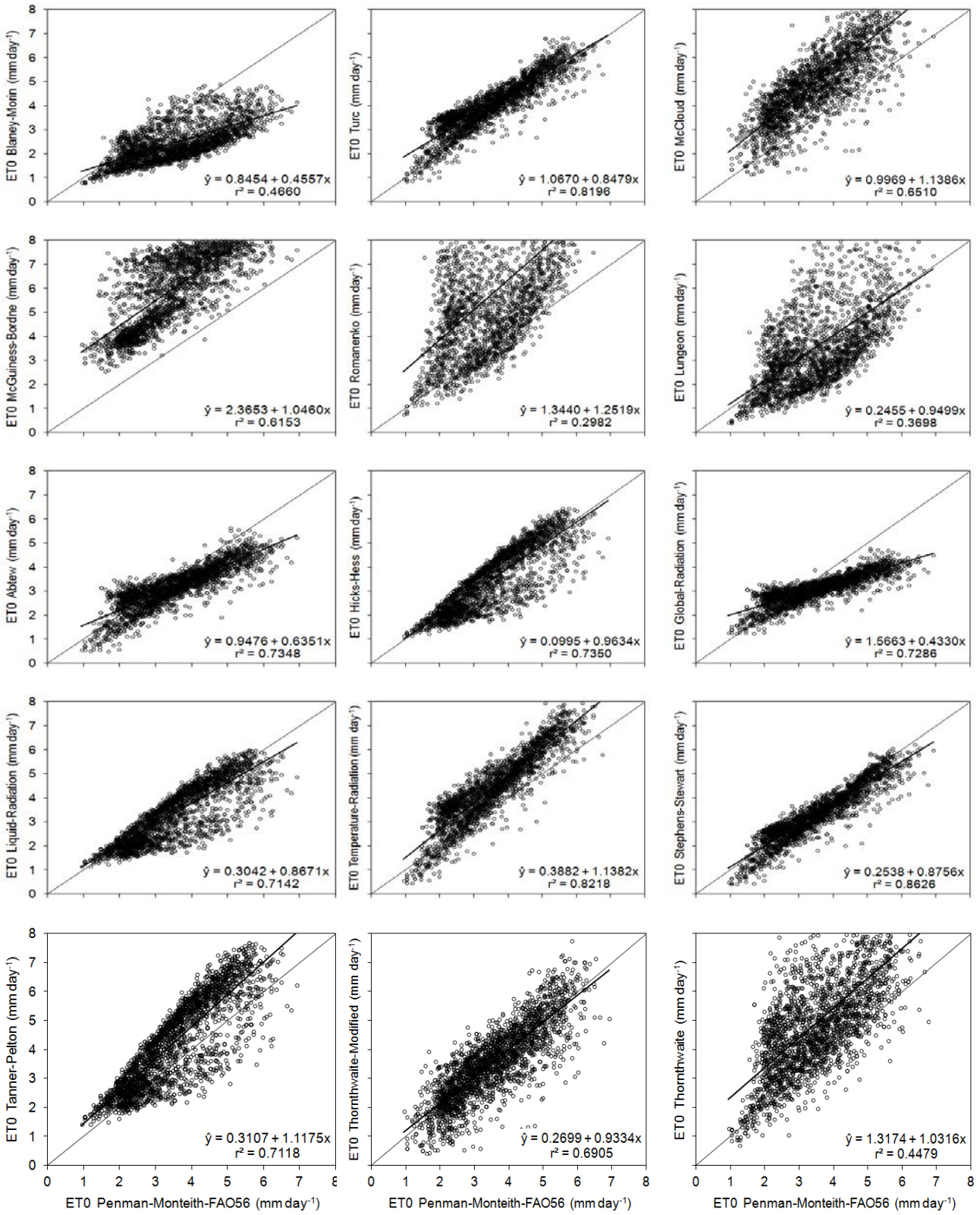

Figure 2 : Values of reference evapotranspiration (ET0) obtained through Penman-Monteith-FAO56 compared with ET0 values obtained through the methods studied.

It is observed also on the Figures 1 and 2 that the methods that presented the better adjustment, according with the determination coefficient (r^2), were the methods of Penman-Original (r^2 = 0.9949) and Penman-FAO24 (r^2 = 0.9875), that utilize the same input parameters that standard method. However, it is observed that the Penman-FAO24 overestimated the ET0 (Figure 1), corroborating with Barros et al. (2009). These authors affirmed that the simple adoption of r^2 as the only criterion of definition of quality of methods is not appropriate, once that this method does not establish the type and the magnitude of the differences between a standard value and a provided value by estimate models.

On the Table 2 are presented the estimate of standard-error (ESE), Willmot's concordance, Pearson's correlation (r), reliable coefficient (c) and performance of Camargo e Sentelhas (1997), obtained of correlation between the values of ET0 by the method of Penam-Monteith-FAO56 with the obtained by the methods available. It is observed that the better model to estimate of ET0 to Paranaíba city, according with the ESE and the performance of Camargo e Sentelhas (1997), was the method of Penman-Original corroboring with Cavalcante Jr. et al. (2011) in semi-arid Northeast, Brazil, Kisi et al. (2012) in United State of America and Cunha et al. (2013) in Chapadão do Sul city, Brazil. The Stephens-Stewart method presented performance "great" by having conciliated high values of Willmot's concordance of and Pearson's correlation. Furthermore, these methods showed the lower value of ESE confirming its satisfactory performance. However, this method need, beyond the temperature, global radiation or actual duration of sunshine in a day as input parameters, difficulting the utilization in relation to methods that need only datas of extraterrestrial radiation, temperature and relative humidity. It is worth mentioning that the extraterrestrial radiation can be obtained only with the date and latitude of the place, therefore not requiring devices to your measurement. Some authors also found satisfactory estimates of ET0 using the Stephens-Stewart method (KISI, 2009; KISI et al., 2012; SAHOO et al., 2012; CUNHA et al., 2013).

Table 2 : Estimate of standard-error (ESE), Willmott's concordance (d), Pearson's correlation (r), reliable coefficient (c) and Camargo and Sentelhas performance, obtained from correlations between the reference evapotranspiration values estimated by the studied methods, with values estimated by Penman-Monteith-FAO56 method in Paranaíba city, Brazil

Method	ET0	ESE	d	r	c	Performance
Penman-Monteith-FAO56	3.5356	-				
Penman-Original	4.0383	0.5193	0.9561	0.9976	0.9537	Great
Penman-FAO24	4.9544	1.5231	0.7771	0.9938	0.7723	Very good
Blaney-Criddle-FAO24	3.9843	0.8298	0.8132	0.8708	0.7082	Good
Radiation-FAO24	4.8380	1.5501	0.7620	0.9090	0.6926	Good
Makkink	5.8910	2.4928	0.5871	0.9074	0.5327	Badly
Hargreaves-Samani	4.7963	1.3888	0.7334	0.8969	0.6578	Average
Hargreaves-Original	4.4629	1.0834	0.8397	0.9270	0.7784	Very good
Priestley-Taylor	3.4741	0.6732	0.9223	0.9023	0.8321	Very good
Jensen-Haise	5.3871	2.0264	0.6775	0.9398	0.6368	Average
Camargo	3.4081	0.7198	0.8726	0.8785	0.7665	Very good
Linacre	5.0218	1.8599	0.6082	0.7441	0.4526	Not good
Hamon	3.1756	0.7601	0.8553	0.8858	0.7576	Good
Ivanov	4.8086	2.2559	0.5808	0.7226	0.4197	Not good
Kharrufa	5.8654	2.4366	0.5397	0.8751	0.4723	Not good
Garcia-Lopez	4.6547	1.4324	0.7279	0.8218	0.5981	Badly
Blaney-Morin	2.4566	1.3738	0.6492	0.7861	0.5104	Badly
Turc	4.0649	0.7250	0.8995	0.9167	0.8245	Very good
McCloud	5.0226	1.7827	0.6883	0.8568	0.5897	Badly
McGuiness-Bordne	6.0635	2.7059	0.5174	0.8759	0.4531	Not good
Romanenko	5.7703	3.1736	0.4755	0.7226	0.3436	Terrible
Lungeon	3.6041	1.4451	0.7318	0.7413	0.5425	Badly
Abtew	3.1932	0.7030	0.8769	0.8783	0.7702	Very good
Hicks-Hess	3.5058	0.6748	0.9216	0.9010	0.8304	Very good
Global-Radiation	3.0972	0.8495	0.7753	0.8760	0.6792	Good
Liquid-Radiation	3.3699	0.6769	0.9138	0.8941	0.8170	Very good
Temperature-Radiation	4.4124	1.0841	0.8455	0.9193	0.7773	Very good
Stephens-Stewart	3.3494	0.4699	0.9558	0.9379	0.8965	Great
Tanner-Pelton	4.2615	1.1090	0.8355	0.8933	0.7463	Good
Thornthwaite-Modified	3.5698	0.7316	0.9064	0.8757	0.7938	Very good
Thornthwaite	4.9645	1.9540	0.6402	0.7773	0.4977	Not good

The methods Penman-FAO24, Hargreaves-Original, Turc, Abtew, Hicks-Hess, Liquid-Radiation, Temperature-Radiation received performance "very good", according Camargo e Sentelhas (1997). This methods can be utilized to estimating of ET0 in Paranaíba city but present the inconvenient dependence of global radiation to your calculate, as reported previously to the method of Stephens-Stewart.

Despite the Penman-FAO24 method have presented r^2 satisfactory, your value of Willmott's concordance not obtained the same success, making with your performance were classified only as "very good". These result can be explained by the fact of the values estimated by Penman-FAO24 have overestimated appreciably the ET0 in relation to standard method in moments of high rate evapotranspirometrical (Figure 1), with this, in comparison between these point values of ET0, there was a reduction in the value of concordance index.

The methods Priestley-Taylor, Camargo e Thornthwaite-Modified also received performance "very good", according Camargo e Sentelhas (1967). The Priestley-Taylor method was development to estimate of evaporation of satured surfaces in a not saturated atmosphere, that is the normal condition of nature (BARROS et al., 2009; CAVALCANTE Jr. et al., 2011) and your performance corroborated with Cunha et al. (2013) in Chapadão do Sul city, Brazil. Oliveira et al. (2011) in Aquidauana city, Brazil and Moura et al. (2013) in the state of Pernambuco state, Brazil also observed good estimates of ET0 by the Camargo method. To be quite simple, requiring only medium temperature data, it is expected that the Camargo methodology to be used by those is producers devoid of complete weather stations. The Thornthwaite-Modified method can be used in the study area. Among all methods studied in this research, the equations Thornthwaite-Modified along with Thornthwaite who received "bad" performance are the only physical equations.

The methods Blaney-Criddle-FAO24, Radiation-FAO24, Hamon, Global-Radiation e Tanner-Pelton received performance "good" and can be utilized with restriction. The Blaney-Criddle-FAO24 methods and Hamon presented simplicity in your calculate, and only the air temperature as input parameter measured. Thus, it will be able to obtain calibration from this methods for those producers without condition of acquire a meteorological station complete can obtain estimate reliable of ET0 to the proper irrigation management, using only a thermometer.

The other evaluated methods received performance "Not good", "badly" or "terrible" performance and should not be used to estimate ET0 in Paranaíba city.

IV. Conclusions

In order, the best methods for estimating evapotranspiration reference to Paranaíba city, Brazil are: Penman-Original, Stephens-Stewart, Priestley-Taylor, Hicks-Hess, Turc, Liquid-Radiation, Thornthwaite-Modified, Temperature-Radiation, Penman-FAO24, Abtew and Camargo.

When have only temperature data, it is recommended using the method of Camargo to estimate reference evapotranspiration in Paranaíba city.

The Blaney-Criddle-FAO24 and Hamon methods after receiving calibration can be used to estimate reference evapotranspiration in Paranaíba city.

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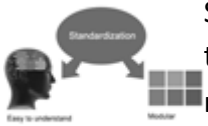

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- Two Column with Equal Column with of 3.38 and Gaping of .2
- First Character must be three lines Drop capped.
- Paragraph before Spacing of 1 pt and After of 0 pt.
- Line Spacing of 1 pt
- Large Images must be in One Column
- Numbering of First Main Headings (Heading 1) must be in Roman Letters, Capital Letter, and Font Size of 10.
- Numbering of Second Main Headings (Heading 2) must be in Alphabets, Italic, and Font Size of 10.

You can use your own standard format also.
Author Guidelines:

1. General,

2. Ethical Guidelines,

3. Submission of Manuscripts,

4. Manuscript's Category,

5. Structure and Format of Manuscript,

6. After Acceptance.

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(b) A brief Summary, "Abstract" (less than 150 words) containing the major results and conclusions.

(c) Up to ten keywords, that precisely identifies the paper's subject, purpose, and focus.

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(e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition; sources of information must be given and numerical methods must be specified by reference, unless non-standard.

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- Please note the criterion for grading the final paper by peer-reviewers.

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- To the point depiction of the research
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- Describe the method entirely
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- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
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Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

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- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
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- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

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- Submit to generally acknowledged facts and main beliefs in present tense.

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References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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