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SUSTAINABILITY EVALUATION THROUGH CARRYING CAPACITIES (CASE OF CEMAC COUNTRIES)

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Abstract

The human habitat conversion is increasingly pressuring the world ecosystem. In Africa the impact of human population growth and its activities is far reaching. The purpose of this paper was to assess the sustainability of the CEMAC group countries. We basically used the carrying capacities, but we also resort to the environmental performance indicator to deepen the environmental health evaluation of the region. Broadening the scope of analysis was essential to tackle the weaknesses of the carrying capacities, namely assessment with regard to one species, (human) and just considering a narrow basket of resources (fuel and wood). We Used secondary data from UN Food and Agriculture Organization's (Faostat-forest database) on fuelwood demand (production) and fuelwood supply (regeneration) for the carrying capacities assessment, and secondary data compiled by Corey J. A et al, (2019), for the environmental performance indicator computation. We came to the conclusion that the environmental health of the region is not appealing, four of six countries of the region have proved to be unsustainable through the carrying capacities analysis. And this situation is supposed to worsen if no mitigation measures are taken. As for which country of the region is the best environment care taker, the ranking differs according to the analysis tool used. We recommend the region population growth' control and the whole world better environmental resources management.

Keywords: Sustainability evaluation, carrying capacities, strong sustainability, CEMAC

INTRODUCTION

Africa is the last global refugium of a functionally intact assemblage of large mega fauna and other species. But many of its natural resources have been exposed to massive exploitation, compared to the rest of the world (W. F, Sayer, J. & Cassman, K. G. 2014). Furthermore, Africa is expected to experience the greatest population growth over the next century, and become home of the highest human density by 2100 (Bradshaw, C. J. A. & Brook, B. W 2014). In fact, the current fertility rate is predicted to make its population to grow by five-seven-folds, moving it to more than 6 billion by the end of the century, while the rest of the world population is expected to stabilize or even decline (Bongaarts, J. & Casterline, J 2013). The tremendous human impact on the biosphere induces the decline and the extinction of the biodiversity (Pimm, S. L. et al 2017). The causes of this biodiversity decline and extinction are clearly identified: the habitat conversion; or the combined effects of agricultural expansion, road development, over-exploitation, pollution, urbanization, climate disruption, and the synergies among these (Ceballos, G et al 2017, Waters, C. N et al 2016, Sodhi, N et al 2009, Bradshaw et al 2009, Butchart, S. H. M. et al. 2010). The contrast between the continuous depletion of natural resources and the increase population size raises several concerns, among them the human population carrying capacities or the maximum number of human beings that can be supported by a given country or area given the initial stock or resource. There is a positive historical relationship between the human population size and the threat to natural or the environmental resources, including the biodiversity extinction (Luck, G. W.2007). In this paper we do not intend to investigate the sustainability of the whole African Continent, instead we focus our attention on a group of six countries, Cameroon, Congo Republic, Central Africa Republic Equatorial Guinea and Tchad. These countries also make up the Central African Economic and Monetary Community (CEMAC). The purpose of this paper is to assess the overall environment health of the region and determine the which of the six countries is doing better in term of environmental custodianship.

We essentially resorted to the carrying capacities, a tool of sustainability evaluation used when considering strong sustainability instead of weak sustainability. Given the flaws of that approach, we extended the analysis to the overall environmental performance evaluation, by computing the geometric mean rank of the countries of the region, including 8 components in order to have better image of the environmental health as well as each country performance with regard to environmental preservation. The results indicate that the entire region is about to become unsustainable, with regard to the human population size versus the fuelwood stock, precisely four country over six that comprises the community are already unsustainable. The countries ranking with regard to the environmental custodianship differs according to the method used. Undoubtedly the ranking provided by the environmental performance indicator is more realistic.

The rest of the paper comprises four sections; the second section defines the sustainability concept, through the operational meaning of strong and weak sustainability; the third section opposes the consistent features of these two concepts, prior to moving to the measurement frame and tools of strong sustainability, in the fourth section. And the fifth section implements the case study of sustainability assessment through the carrying capacities and the environmental performance indicator in the CEMAC region.

SUSTAINABILITY CONCEPT

Sustainability is basically defined as the capacity of the biosphere and the human civilization to coexist, or development that meets the needs of the present generation without compromising those of the future generation to meet its own needs. Since this paper intends to assess the sustainability using the carrying capacities, which is the assessment tool in strong sustainability, our literature is essentially related to the strong and weak sustainability concepts.

Indeed, the weak sustainability derives from environmental economics. It is related from the idea that human capital can replace natural capital. (Solow 1974, 1986 and John Hartwick, J.M. 1977). In revanche, the strong sustainability suggests that human capital and natural capital are complementary, and not interchangeable. In fact, weak sustainability is defined using the concept of human capital and natural capital (Cabeza-Gutes, M. 1996). Produced capital or human capital includes assets like infrastructure, labor and knowledge; while natural capital comprises assets such as fossil fuels, biodiversity and others ecosystem structure as well as function necessary for ecosystem service. With the weak sustainability, both stock of man-made capital and natural capital should remain constant overtime. It also worth mentioning that with weak sustainability, there is infinite or unconditional substitutability between natural and produced assets. This definition implies that weak sustainability allows the stock of natural capital decline, but this depletion needs to be outweighed by the stock of man-made assets.

The strong sustainability' concept is more related to ecological science than, 'weak sustainability'. In fact, the fine distinction between the strong sustainability and week sustainability can be noticed at two levels:

First the strong sustainability denies to a greater or lesser extent substitutability between natural assets and other assets—human and manufactured assets. Hence the two categories of capital, economic and environmental assets are complementary and not interchangeable. With the strong sustainability, there are some functions performed by the environment that cannot be duplicated or be performed by human capital. And secondly the Strong Sustainability emphasizes the ‘discontinuity' and 'non-smoothness' in ecological systems and therefore in the economic damages coming from ecological impairment. Indeed, Strong sustainability is all about ecological imperatives, and this dictates the subsequent form of economic analysis. In the contrary, Weak Sustainability is based on the standard economic assumptions, and this in turn shapes the form in which ecological and environmental concerns are evaluated.

SUSTAINABILITY MODELS

Abundant and rigorous researches have been conducted with regard to provide insight on the concept sustainability development, yet no common agreement has been reached about the interpretation of that concept.

Sustainability development is defined as some indicator describing the state of human well-being which does not decline over time (Pearce et al.1989; Pezzey, 1989). We do not dig deeper in the indicators of well-being in this paper, but these can generally be proxied by the per capita real national income, making due allowance for existing unmeasured factors like environmental services (Hamilton, 1994; 1995a, b, c). Taken in this way, there is no significant difference between Weak Sustainability and Strong Sustainability. Both frames broadly corroborate with the above-mentioned definition of Sustainability Development.

In another perspective, the difference between Strong and Weak sustainability lies on the required conditions to satisfy the achievement of sustainable development. Taking the capital base as the means whereby future human well-being will be sustained, this implies some form of conservation of capital as a condition for Sustainable Development. This 'constant capital' concept underlies Solow (1986) and Maler (1991) contribution. The disagreement arising among economists over the sustainability models relates to the conditions set for the capital stock. In strong sustainability, Sustainable development is achieved by maintaining certain components of the natural capital stock, as well as by setting restrictions for non-decrease of the overall stock of capital. However, in weak sustainability the operative constraint includes the overall stock of capital since all forms of capital are supposed to be substitutable. Although natural capital is a form of wealth whose services contribute to well-being, it has no special role as such in this scheme. The above development implies that, strong sustainable indicators will be considering environmentally related factors, besides weak sustainability measure, while weak sustainability indicators will emphasize assets in general, with no special reference to measure for natural capital. Taken on this perspective the information required for Strong sustainability and Weak Sustainability indicators is the same: both must include the measures of natural capital to be operative, and both have to measure other capital assets as well.

Non-substitutability is supposed to give rise to aggregation problems (Faucheux et al, 1994): in fact, natural capital has to be evaluated separately from human and manufactured assets, and in non-comparable terms. However, the 'constant capital' rule can be maintained even in this context, as capital can be aggregated.

For depletable resources the optimal growth path will not be sustainable if resources are having a crucial role in production and the pure rate of time preference is positive. Mainly, the constant utility path is infeasible when the elasticity of substitution between produced assets and natural resources is less than one. The degree of substitutability is therefore of tremendous importance in order to uncover whether Weak sustainability is possible with depletable resources. If the elasticity of substitution is greater than or equal to one, then the 'savings rules' that states that investment in produced assets should outweigh the value of resource depletion, proves the test of sustainability.

As for strong sustainability, the require condition for its fulfillment is not strictly speaking about elasticities of substitution being equal to zero, since this would imply that capital and resources must be used together in fixed proportions. The main idea behind the strong sustainability is that a given amount of a resource must be maintained intact, in order to guarantee continuous supply of critical services. This could be achieved in two ways: (i) a given amount of the resource can be preserved, which means only the residual can be exploited; or (ii) an alternative way suggest that the resource does not need to be maintained intact, but if the stock size declines below a certain critical level then catastrophic consequences result.

For the first case (i) consider the tropical rainforest for illustration purpose. If preserving some quantity of the rainforest is viewed to be crucial for the long-term well-being of humanity, the effect of this preservation is to reduce the quantity of forest that can be considered to be an economic resource. Other things being equal, the implications of the strong sustainability policy will therefore be to reduce the quantity of harvest that can be carried out sustainably from the remaining stock. This is not without effects, in fact, under standard assumptions about the production function, of the resource price increasing, a different mix of natural resource and produced capital inputs into production will hence ensue. However, the savings rule, as applied to the non-conserved stock, will still be an important determinant of sustainability, this is because the savings rule is related to the change in the real value of stocks instead of the absolute size of the stock.

For an economy operating under strong sustainability, two key indicators can be used for its living-resource measurement: The first indicator measures the state of critical natural assets; precisely, a decline in the critical natural asset would imply unsustainability. The second one the genuine savings rates, a persistently negative genuine rate would also indicate unsustainability.

To shed more light on the second case, one can consider an upland forest, where exploitation beyond a certain point leads to catastrophic losses, as a result of soil erosion.

In such circumstances an optimal resource tax based both on the size of the remaining stock as well as the level of harvest can be imposed to guarantee the long-run steady-state stock greater than or equal to the critical stock size Again, the savings rule determines sustainability.

The usefulness of these quantitative restrictions is to reduce the present value of consumption that would be attained if the restrictions did not exist. This is only an apparent decline in welfare, however, because of the significant welfare losses that would result if the Strong Sustainability regime is not followed. The bottom line of this development is that savings rules provides key indicators of sustainability whether strong sustainability or weak sustainability is the development paradigm.

THE SUSTAINABILITY PARADIGM AND ITS MEASUREMENT

In Weak Sustainability frame, though there is nothing special about natural resources and about the environment as such, it does not allow overly rapid depletion of non-renewable resources or imply that environmental degradation is not a concern. In the latter case these actions induce a decrease in future well-being unless support initiatives related to investment in alternative form of resources are undertaken.

The Strong Sustainability paradigm requires arguments to the effect that environmental assets are special, that is do not have practical substitutes. Pearce et al. (1990) present the key features of such an asset:

(a) Irreversibility: manufactured asset can be created and destroyed according to the cycle controlled by human beings or which are not true of natural assets (especially living species); While the creation of a new technology may be considered as a suitable compensation to future generations for an irreversible transformation of a natural asset, assuming perfect knowledge of future relative prices (Hamilton, 1995a).

If future generations apply high valuation to nature or environmental resources in general, then such compensations measure will be either unfeasible or inadequate. Some human capital may also be characterized by irreversibility features, the case of indigenous knowledge embodied in social custom is a practical example.

(b) Uncertainty: there is extensive uncertainty about the workings of ecological systems and hence about the consequences of impairing the functioning of those systems.

(c) Scale: the existence an optimal level and discontinuities may well lead to large-scale damage once the maximum is exceeded.

If these differing notions of sustainability are to cause operational effects, then measures of progress towards sustainable development are crucial. As Hammond et al. (1995) suggested, indicators can ideally both quantify and simplify complex phenomena for decision-makers. Below we hence examine the types of indicator that have been proposed for measuring strong sustainability.

INDICATORS OF STRONG SUSTAINABILITY

The Weak sustainability frame focuses on the substitutability of manufactured and natural assets, and hence implies the use of some aggregate measures such as the green national income and the genuine savings. On the other hand, a different set of indicators have been designed to impose more strict requirements in order to achieve sustainability. Those indicators have been suggested by ecological economists. Indeed, the Strong Suitability paradigm suggests the use of indicators that focus primarily on ecological assets, functions and processes. Furthermore, those indicators tend to emphasize limiting ecological assets deterioration. Such measures include:

a) Resilience; in this category, some factors such as biological diversity are taken into consideration, since resilience is supposed to be a function of diversity (Common and Perrings, 1992; Arrow et al, 1995).

(b) 'Distance to goal'; these tool help evaluating the deviations of ambient concentrations from sustainability 'targets' are aggregated to derive an overall performance indicator (Hammond et al, 1995). The green national accounting counterpart of this is offered by Hueting et al. (1992) and is couched in terms of the costs of reaching these goals.

(c) carrying capacities measurement; here the focus is to basically assess supply/demand ratios for resources. We focus our attention on this last indicator, since it is used in our case study.

- **Carrying Capacities**

The concept of a carrying capacity takes it roots from biology. The notion of carrying capacity states that a given area can only support a given population of a particular species, and at this upper limit the carrying capacity population will have reached its maximum sustainable level. This concept implies the saturation point of the human population, and the application of it requires to not only consider the level of population but also to account for the level of activity. Besides, the economic output composition can differ significantly, adding a further complication. Therefore, a number of assumptions have to be made when designing an indicator.

Some attention has been given to assess the global carrying capacities, mainly where these calculations are well below the initial population levels or wildly in excess of predicted stationary levels (Ehrlich, 1992; Kahn and Simon, 1984).Generally ecological economists defined carrying capacities in terms of exceeding limits—to be set by ecological criteria. In moving to actual indicators of carrying capacities we require a more detailed specification of ecological limits. Usually, these consist of 'sustainability constraints' with regard to commercial or environmental resources: for example, pollution should not exceed the assimilative capacity of the environment; harvest of renewable resource should not exceed the natural growth level. It is more difficult to develop an appropriate constraint governing the use of non-renewable resources on these terms where growth is by definition zero. The focus of this constraint is to maintain the stock of each resource unchanged. If sustainability implies non-declining human well-being, all specified ecological constraints need to be observed to guaranty non- decreasing human well-being. Carrying capacities indicators tend to be extremely pessimistic with regard to technology or about the ability of people to expand the carrying capacities of the earth (Cohen, 1995). For example, Ehrlich (1992) claims that, at industrialized levels of economic activity per capita, the global population level that would not exceed carrying capacity thresholds is two billion, about one-third of the prevailing population. Although the genuine savings rule also supposes constant technology, the paradigm supporting the savings principle does at least allow for substitution between assets. In the carrying capacity framework each asset is to be preserved intact, and presumably the economic activity or population level is set by whichever constraint is reached first, as suggested by Rees and Wackenagel (1992). This is known as Liebig's law and implies that CC = min CC.

Indeed, the economist supporting carrying capacity indicators claim that there is no substitutability between assets. The difficulties related this argument are well known. Empirically, critical capital or environmental assets for which few or no substitute exist are unknown (Pearce et al., 1994). While some classes of environmental asset can be easily characterized by the lack of substitutability, it is too much to claim that this is true of all such assets. Neither is it the case that limiting factors will remain the same overtime (Cohen, 1995). A proxy of this empirical approach to carrying capacity is to relate population levels to very simple indicators of resource use. The common examples are land use for food production, fuelwood production.

CASE STUDY OF CEMAC COUNTRIES

Table 1 provides an illustration of estimates of carrying capacity populations with respect to fuelwood availability in Central Africa Monetary and Economic Community (CEMAC). These estimates are based on the UN Food and Agriculture Organization's (Faostat-forest database) data on fuelwood demand (production) and fuelwood supply (regeneration). We make thing simple by just linking this information to data in 2020 and projected in 2040. Our investigation takes into consideration ecological concerned that persistent ratio of overharvest will reduce the sustainable yield and therefore the sustainable population overtime.

Table 1. Fuelwood availability and sustainable populations in Africa (millions)

	2020		**2040**	
Countries	Actual Population	Sustainable Population	Predicted Population	Predicted Sustainable Population
Cameroon	26.54	16.2	41.87	12.41
Central Africa Republic	4.82	4.12	7.2	3.32
Tchad	16.42	5	27.64	3
Equatorial	1.41	3.52	2.34	2.81
Gabon	2.22	5.26	3.26	4.31
Congo	5.51	5.22	8.77	3.91

Source: adapted from Atkinson (1993); Population data: Faostat-forest database (2019)

Yet, based on that simplistic approach, fourth countries over six that comprises the region are already unsustainable, in terms of a fuelwood constraint. In fact, the data shows that the current population of Cameroon is 26.54 million, while its current carrying capacities or its sustainable population is 16.2 million. Central African Republic, Tchad and Congo are also currently having an unbalanced position. The remain two countries of the region present a positive balance or a sustainable population. The current population of Equatorial Guinea is 1.41 million while its carrying capacities are 3.52 million, as well Gabon Republic has a population size of 2.22 million compared to the carrying capacity of 5.26.

The sustainability of the region is supposed to worsen in 2040, though some countries will still be sustainable, Equatorial Guinea and Gabon. The overall trend of the region carrying capacities is decreasing. Undoubtedly the whole region will become unsustainable the next 20 or 30 years following our predictions horizon, if no mitigation measures are undertaken.

The low carrying capacities countries like Tchad and Central Africa Republic might be explained by the arid area that made up an important part of these countries. But this opinion is debatable. though having few forest resources, the likelihood of fossil fuel is high in arid areas, which can sustain the overall fuelwood stock. While the case of Cameroon and Congo Republic which have an abundant forest is obviously causes by overpopulation pressure on forest resources and poor environmental resources management. The others countries of the region having a better custodianship also appear to have an abundant forest with somehow a relative low population size.

Pressure on forest resources in sub-Saharan African countries has been well documented (Pearce and Warford, 1993). Arrow et al. (1995) have claimed that carrying capacities are not static, in the perspective that ecological economics apprehended them. Hence, the maximum sustainable population (MSP) is given by MSP = Annual resource yield/Minimum per capita requirement.

MSP can be increased by mining the stock where the resource is renewable, however, this is clearly unsustainable. On the other hand, 'yields' can be raised by technological development in the case of renewable resources, and depletion profiles can be extended by technology for non-renewable resources. Substitutes may also be found (kerosene or biomass charcoal for fuelwood). Besides, interactions between various carrying capacities constraints are seldom taken into account (Cohen, 1995). More importantly, carrying capacities computations have limited relevance when trade is possible, since the limited resource can be imported in exchange for another asset in which the exporting country has a comparative advantage. Neither do these indicators address the measurement of progress in preserving critical natural assets. At best they might be considered as simple poverty measures that applies the concept of sustainable use of resources. Thus, it is difficult to pin down the notion to any single meaningful measurement tool. Instead, Arrow et al. (1995) suggest that a more general indicator be used, such as that set out by Vitousek et al. (1986).

That indicator describes pressures in terms of how much net primary productivity (NPP) human beings currently appropriate, as an indicator of human appropriation of ecosystems under a variety of scenarios. Note that this indicator is not couched in terms of a population carrying capacities, although implicit judgments regarding such a limit may need to be inferred if we are to propose the levels of appropriation to be considered excessive.

Our carrying capacity approach was just focusing on the fuelwood stock versus the population size of the country. But that analysis neglects the broad scale of socioeconomics conditions underlying the environmental degradation. Assuming that the human density and the economic development affects cumulative environment damage, we extended the sustainability evaluation of the region by considering the environmental performance indicator (Table 2), derived from the geometric means of eight factors: national ecological footprint, megafauna conservation index, proportional species threat, recent deforestation, freshwater removal, livestock density, cropland coverage, and per capita emissions. Though that indicator does not provide insight on the sustainability heath of the region, it helps ranking the different countries with regard to the environmental custodianship. From that perspective, the Central Africa

Republic appeared to have the best relative environmental performance indicator, followed by Congo Republic, while Cameroon ranking is the worst, follow by Equatorial Guinea, who however was the leading in environmental care taking when using the carrying capacities with regard to fuelwood.

Table 2: environmental performance assessment

Country	Environmental component variable ranks								ENV_{gm}
	EF	**MCI**	**THR**	**FWR**	**FRL**	**LVS**	**CPL**	**EMI**	
Cent Afr Rep	18	5	1	2	25	44	11	6	7.754
Congo	20	20	9	1	27	2	14	31	9.790
Chad	31	23	11	26	19	13	5	3	12.876
Gabon	NA	30	17	6	23	3	24	44	15.581
Eq Guinea	NA	28	20	4	34	7	32	46	18.650
Cameroon	15	16	39	9	30	40	38	24	23.474

Source : Corey J. A et al, (2019), pp. 4

CONCLUSION

The need to find a balance cohabitation between the human species and the environment with which it interacts is critical. The human uncontrolled habitat conversion is a threat for the biodiversity while the environment degradation is not without consequences on human live, as shows the consequences of climate change. This paper intended to assess the sustainability of the six African countries that make up the CEMAC region. We mostly focused on the carrying capacities, a sustainability analysis tool used in Strong sustainability assessment. The used of this tool motivated the presentation of some literature on sustainable development, from which the carrying capacity tool derives. We first conducted the analysis regarding human carrying capacities of the region in term of fuelwood constraint; we later extended the analysis to the environment performance indicator; a more realistic tool that includes the overall factors of the country sustainability. The results from the carrying capacity analysis indicated that the environmental health of the region is not appealing. Out of the six countries that comprises the CEMAC region, four are already unsustainable, namely, Cameroon, Congo Republic Central Republic Africa and Tchad, while the Equatorial Guinea and Gabon still have a sustainable population. And the situation is to be worsen, if no action taken. The countries ranking in term of environmental custodianship provides by the two sustainability approaches are different. Equatorial Guinea appears to be the best environment care taker with the carrying capacities tool while Central Africa Republic is pointed out by the environmental performance indicator. But we believe the second ranking to be more reliable. Given the continuous depletion of the natural resources. the control population growth is fundamental to increase the carrying capacities of the region. But the correlation between the population growth and the environmental degradation is weak in some area, which implies the population size is not always the cause of the environment degradation. However, the natural resources sourced in Africa and are used by the whole world, hence and effective environmental resource management requires multilateral agreements across the world on reduction of natural resources consumption. Further poverty alleviation, better education and technological advance can also serve the same purpose.

In fact, sustainability development goals, including forest preservation are all among the main objectives of the United Nations Development Program (www.un.org/sustainabledevelopment). But developing countries and especially those of sub-Saharan Africa has been falling behind with regard to these goals. These poor performances can be explained by the lack of supportive measures related to family planning, better education and much more (Rosa, I. M. D. et al, 2017). Ultimately, the objectives of human development and environment preservation are more than ever related. Hence it worth focusing the future researches on the alternative ways to achieve these intertwined goals, as well exploring the potential synergies and trade-offs between environment preservation and human habitat conversion or other development objectives will be insightful.

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