



Effect of Yam (*Dioscorea rotundata*) Cultivar on Physico-Chemical Properties of Instant Yam Flour

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Abstract: The effect of yam (*Dioscorea rotundata*) cultivar on the quality characteristics of instant yam flour was investigated. Three cultivars of white yam (*Dioscorea rotundata*), TDr 275 (efuru), TDr 90-1 (okunmado), and TDr 608 (alasinrin) were processed into instant yam flour and the flour was subjected to physico-chemical analysis using standard methods. Results obtained showed that the carbohydrate, protein and ash content of fresh yam tubers were greater than values obtained for their respective flour samples, while the crude fibre and fat content of instant yam flour samples were greater than the fresh yam tuber samples. In term of bulk density, water absorption capacity, starch solubility, swelling index and starch damage index, sample TDr 275 was highly rated followed by TDr 608 and TDr 90-1 respectively. Sample TDr 275 recorded the highest ratings for peak viscosity (199 RVU), final viscosity (223 RVU), breakdown viscosity (40 RVU), trough (172 RVU) and setback viscosity (66 RVU) followed by TDr 90 – 1 and TDr 608 respectively. TDr 90-1 exhibited the highest degree of whiteness (L*) and least degrees of redness (a*) and yellowness (b*) when compared with other samples. It was closely followed by samples TDr 608 and TDr 275 with no significant difference ($P \geq 0.05$). Therefore, TDr 275 (efuru) can be considered as the most suitable for instant pounded yam flour production, followed by TDr 90-1 (okunmado) and TDr 608 (alasinrin) respectively.

Keywords: *D. rotundata*, cultivar, instant yam flour, physico-chemical properties, standard methods

1. Introduction

Yam (*Dioscorea Spp.*) originated in the tropical areas of three separate continents; Africa, Southeast Asia and South America (Coursey, 1983, IITA, 1992). It is among the oldest recorded food crops and regarded as the most important staple food in West Africa after cereals and second most important root crop in Africa after cassava (Ekwu *et al.*, 2005). The economically important yam species grown are *Dioscorea rotundata* (white yam), *D. bulbifera* (aerial yam), *D. alata* (water yam), *D. cayenensis* (yellow yam), *D. esculenta* (Chinese yam), and *D. dumetorum* (bitter yam) (Degras, 1993; Mc Anuff *et al.*, 2002).

In Nigeria especially in many yam producing areas, fresh yam tubers are processed into yam fufu popularly called pounded yam. Though fufu could be made from different crops such as cassava, cocoyam, breadfruit, plantain etc, but the yam-fufu (pounded yam) is regarded as the best, because it has great social values and highly priced (Coursey, 1983).

In traditional home processing, the use of yam variety in pounded yam production depends primarily on the availability and not on any scientific proof of the suitability of such variety. However, in the production of instant yam flour, various research works had established the white yam (*D. rotundata*) as most suitable variety (Ayenor, 1985; Onayemi and Potter, 1994; Otegbayo, 2005), but little information is found in literature to identify which cultivar of the white yam (*D. rotundata*) is most suitable for instant yam production. The inability to pinpoint a particular cultivar for

instant yam flour production, had contributed immensely to quality variations recorded in instant yam products as manifested in the varying and non – uniform rheological properties of the existing instant yam flour found in our markets. In the light of this, there is a need to study the effect of yam cultivar on the functional and pasting properties and other quality parameters of instant yam flour. In the light of this, there is a need to study the effect of yam cultivar on the functional and pasting properties and other quality parameters of instant yam flour. This will enable yam processor to select a yam (*D. rotundata*) cultivar that is most suitable for instant yam flour production that will ensure a uniform and good quality products at all times.

2. Materials and Methods

2.1. Materials

Wholesome and matured tubers of three cultivars of white yam (*D. rotundata*) TDr 275 (efuru), TDr 90-1 (okunmado) and TDr 608 (alasinrin) free from mechanical or pathological injuries were obtained from International Institute of Tropical Agriculture (IITA) – associated farmers at Fatumo Village, Ibadan, Oyo State. All other materials and equipment used were scientifically sourced for including reagents which were of analytical grade.

2.2. Methods

2.2.1 Production of Instant Yam Flour

Instant yam flour production was done following the method of Ekwu *et al.* (2005). Yam tuber from each cultivar

material providers often lack precision and transparency even if they comply with standards. Based on self-declaration, these documents should be used with caution because they are very complicated to understand for many professionals and the measurements performed vary from one country to the other (Morel *et al.* 2001). It is highly probable that waste and nuisance generation during construction is more alarming than the figures tend to show.

2.1 Social impacts

From another standpoint, a considerable nuisance is linked to the almost inhuman working conditions in France today. In his recent book entitled "Worksite prohibited to the public", (Jounin, 2008) describes in a simple, precise way the very difficult, insecure construction working sites conditions (intense productivity, social standards disrespect...). We do not propose any directly relevant indicator for this problem, but it is possible to put forward the argument that the most deteriorated social and human conditions can be found on the worksites where the highest level of productivity is required. There is a strong convergence, due to the economic context, between the choice of highly mechanized techniques that destroy jobs yet generate just as much waste, and the lack of respect for the people working with these techniques.

There is therefore a link between the embodied energy quantity and respect for workers. It is also highly likely that the self-esteem that allows individuals to resist high pressure is misrelated to the use of recognized know-how. Technique that use material with a low degree of transformation harness workers' know-how much more than technique using highly transformed materials. Thus there is a strong link between the increase in standard techniques used for economic reasons and the decrease in self-esteem. We propose indicators that highlight the extent of material transformation and show the social impact of construction.

2.2 Raw material consumption

The building sector uses 2/3 of the millions of tons (Mt) of cement used annually in Nigeria, 1/3 is used for infrastructure construction, (SFIC, 2007). To make construction practices more legible and their changes more measurable, reliable indicators are required to evaluate resource consumption, waste and nuisance generation, and social quality of a building construction.

2.3 Health impacts

The materials composing impacts on human health requires information from the manufacturers. Trade secrets are often used as an excuse to justify the lack of this information. The regulations should improve this situation in the next 15 years, if they are accompanied by a serious monitoring of health impacts. The existence of a network of building & public works material reclamation centers could already reduce the depletion of resources and the production of waste today, while guaranteeing the economic viability of

numerous jobs, many of which would be accessible to the "employment-challenged".

3. Construction Sustainable Development Indicators Proposal

The existing indicators can be classified in 2 categories: physical and social.

Physical indicators such as thermal conductivity, presence, specific heat, effusivity and emissivity are relevant for buildings' energy efficiency and usage comfort. It is essential to take them into account at the design phase. However, one drawback is that they only offer possibilities in the restrictive industrial framework of the products and processes recognized today by existing legislation. These indicators have not yet been sufficiently extended to non-standard materials.

The data bases in design or energy performance diagnosis software applications, blind to the parameters of these materials, do not encourage their integration in the discussions during the preliminary phase.

As for social indicators, the most well-known one is the (Human Development Index). It is very useful but far removed from the specific features of building sector. The "ecological footprint", (Rees and Wackernagel 1996), is evocative and counts the planet's surface part required to absorb a person's lifestyle. Here again, the fact that these indicators cannot be applied to several scales of territory or activity limit their usefulness in a strategy requiring overall harmonization of actions. We are faced with a problem whose solution includes both technical and cultural aspects. It is no longer simply a question of very short-term efficiency in a limited context (excluding the social environment for example); for technical efficiency to become operational, it must acquire social effectiveness. In the threefold framework of sustainable development (environmental, social, economic), we propose that the Wemb (embodied energy in GJ), MTCO₂Eq (GHG emission in equivalent metric tons of carbon dioxide) and L.I. (labor intensity in hour of work per unit of embodied energy) indicators should be accepted as the first building blocks in an international effort to standardize construction activity.

3.1 Environmental impact

The embodied energy is the amount of physical work required to transform a raw material into building element. In the building sector it is measured in unit of work (GJ) per volume (m³), per weight (ton) or element (Harris, 1999; Morel *et al.*, 2001).

The embodied energy (Wemb) throughout the life cycle of a dwelling or commercial building provides information about its resources consumption. The scarcity or the abundance of the used raw materials is not taken into account. The embodied energy indicator allows comparing the amount of work definitively immobilized in the building according to territories, operations or techniques. This informs the energy resources allocation. It is also a good

representation of global consumption, since it reveals these disparities. In the example illustrating our paper, we chose the GJ/ton unit because it allows us to link the work immobilized in the life cycle analysis with the work consumed by usage.

In a finite world with limited resources, the Wemb can also provide a good idea of the possible social consequences of the disparities in buildings energy immobilization. This indicator shows energy immobilization of a square meter of housing in India, Brazil, USA or Europe does not consume the same amount of global resources. Moreover, the surface area available per person in these countries is very different. The Wemb is a product of both factors. The global amount of resources mobilized per inhabitant for buildings will be much clearer if it is based on a common language.

For example it will make the reality of housing disparities much more tangible and help combat this inequality. Owners, head contractors, constructors as well as policymakers will find this to be a solid decision support tool. In terms of health impacts or the comfort of a dwelling, and in the absence of a more precise analysis, the products, practices or materials with a high Wemb rate will be more likely to affect the health of professionals or inhabitants than raw materials used by a culture with an architecture based on "gathering" with a low embodied energy rate, (Shukla *et al*, 2009). We would then see a process of cultural, technical and regulatory change. Once the Wemb indicator has become the norm, strategies based on effectiveness and simplicity will have a tool that is perfectly coherent and appropriate.

Using the Wemb, one can also represent the advantage for society as a whole of using certain building techniques. By expressing the embodied energy not per ton but per square meter of wall or habitable space, it is possible to compare the energy immobilized during construction by the different techniques envisaged for a project. We thus achieve a social indicator that allows us to choose the technique producing the largest number of square meters of walls or habitable space. Indeed, in a world aiming for more simplicity, the intelligent allocation of economic or energy resources is strategic.

4. Methodology

The research was carried out based on survey conducted in some of the ongoing housing estate building project in metropolitan city thereby using three indicators[Wemb,CO₂ and Labour intensity(LI)].

Social Component - the "LI" Labor Intensity indicator

The Labor Intensity is the ratio between the duration of human labor and the embodied energy. It is measured by the number of hours per GJ of embodied energy used to produce a building material. In the many articles on the notion of sustainable development and its three circles, social criteria are rarely defined. While this situation was relatively acceptable in a first phase, due to the fact that recent social history usually preferred to quantify consumption in terms of

mass and market value rather than to qualify it in terms of cultural or environmental impact, years after the (Bruntland, 1987) report and its adoption in Rio, it is urgent today to agree upon a relevant social/environmental indicator. The Labor Intensity, or L.I., indicator could be the social/environmental equivalent of the economic energy intensity indicator used in conjunction with Gross domestic product - GDP (ton of oil equivalent per unit of GDP) in the sustainable development indicator dashboard in general and especially in the building sector.

From a cultural standpoint and in order to respect human society's diversity, the social or labour intensity indicator is representative of "know-how intensity". A significant portion of individual professional identity and self-esteem lie in the recognition and usefulness of the living, active know-how possessed by human beings in every society. This is therefore an indicator whose cultural impact we cannot yet measure, but that shows great potential. We are not aware of any use of this indicator to date.

4.1 Perspectives

- i. Using the same indicator at different territorial scales is a real asset that can truly accelerate change. In this way the global challenges facing the planet or a country are linked to the day-to-day actions of a large number of stakeholders. These indicators can be used to analyze, forecast and monitor action. If all of the actors in a project take ownership of them in these three phases, they can be excellent tools to profoundly modify the building culture in developed countries. These indicators can also be used in many other sectors in addition to the building sector.
- ii. The systemic and systematic use of these 3 indicators [W_{emb}, CO₂ and Labour intensity (LI)] could be useful when planning and designing buildings. Clauses linked to these indicators concerning types of material, procurement distances, or the distance covered daily by the workers could be included in calls for tender. During the building construction and usage phases, "environmental analytic accounting" could usefully complete the financial analytic accounting.
- iii. At the end of the fiscal year, the income statement of professionals (industrial manufacturers, distributors, designers, public or private owners, social housing owners, contractors or real estate managers...) could also display a balance sheet according to these indicators.
- iv. Used together, these 3 indicators can represent an effective tool to orient the building sector towards more environmentally-friendly practices, yet still let decision-makers choose an orientation that is more intensely social, environmental, energy-oriented or

economic, by weighting each of these indicators in final choices.

- v. The generalization of these 3 indicators will nevertheless require a lot of work by all of the stakeholders. In this respect, the French Environmental and Health Declaration Forms, NF P01-010 (Harris, 1999), or their foreign equivalents must be much more accessible and be made mandatory when new materials arrive on the market. They should be improved by adding a "non-technical summary" of the two indicators already included, and the labor intensity indicator should be added. Communication intended for the general public. They could use the same type of color bars used for energy performance diagnoses or household appliance ratings (scale from A to G).

Measurement protocols and limits must be unified and clarified to allow relevant comparisons between materials, practices or operations.

5. Case Study

5.1 House Projects Description

To illustrate our arguments, the application of these 3 indicators to the different items of a construction project in 2010 is assessed. The house shown here is located on a hillside in Ibadan, Oyo state). Figure 1 shows the house under construction. Roughly 2 meters of its northern portion are underground. The east, south and west walls are made of a wooden construction filled with earth and straw on a cellular concrete base. The upstairs floors are made of wood



Figure 1: Northeast view: concrete blocks and cement concrete wall



Figure 2: Southeast view: filling the walls with earth and straw

Table 1: House distribution

Building Components	Local Material House	Standard House	Fashionable House
Foundation	Concrete placed against natural ground Concrete block retaining wall	Idem	Idem
Walls	Cellular concrete, wood and earth and straw construction	20cm Concrete block and 12cm glass wool insulator	Self-insulated cooked bricks.
Ground Floor	Compact fill, earthen slab except for concrete over 15m square.	Compacted fill. Concrete slab.	Compacted fill, hemp and lime slab.
Upstairs Floor	Wooden floor, sand insulation and wooden flooring	Concrete floor, cement mortar covering to receive carpet	Concrete floor, hemp and lime covering to receive linoleum.
Roofing	Wooding roofing frame, straw insulation, wooden covering on ceiling and roofboard, half round tiles.	Cement blocks construction 20m glass wool insulation, gypsum, plasterboard, half-round tiles	Wooden roofing frame, hemp wood, gypsum, plasterboard, half-round tiles

In order to exploit the 3 indicators presented in this paper, it was necessary to consider other technical choices to determine whether these indicators can really provide support to decision-makers, researchers, contractors and designers. We have simulated the same house built in the same context, but using different solutions: standard industrial techniques and fashionable methods), since these 2 solutions are currently the only ones frequently used in Europe. The composition of each house is indicated in Table 1. For the three projects we used the same techniques for the earthworks, foundations, and retaining walls, since there were not many alternatives to support a house whose load-bearing elements were made of terra cotta or concrete.

We have examined the house made of local materials using the proposed indicators, i.e. Wemb, CO₂ eq, and L.I., and compared its results with the over houses results. We then drew some conclusions, one of which is that these indicators are extremely relevant.

The indicator values were calculated as follows:

- i. Wemb: the materials are quantified by weight and then multiplied by the values of the embodied energies per unit of weight of the material in question contained in the data base. CO₂ eq: likewise, the materials are quantified by weight and then multiplied by the values of the emissions of CO₂ eq per unit of weight of the material in question in the data base.

We must emphasize the importance of comparing the different options, which avoids the problems of indicator values in the absolute. It is preferable to compare one solution to another relatively, by taking data from the same date base.

5.2 Local Materials House

The calculation of the embodied energy for the local materials house (Figure 2) shows that concrete elements (foundation and retaining walls) use the most energy (they absorb more than 1/2 of the total embodied energy (99GJ out of a total 153GJ)). We can also observe that terra cotta tiles also have high-energy consumption. These two items should attract the attention of researchers, contractors, designers and especially legislators, each in their field of competence, in order to reduce environmental impacts. Concerning health aspects (Figure 3), we can observe that the high CO₂

emissions of the foundations and thereof are compensated by a high level of CO₂ sequestration in the walls, floor and roofing (large amount of straw and wood). The ground floors, essentially composed of an earthen slab, emitted very low CO₂ quantities. The items that consume the most energy resources are those that need the least human labor (Figure 4), advice versa. In a society that claims to fight unemployment and protect the environment, the most labor intensive techniques, consume the least energy and offer the most coherent link between message and virtuous action.

5.3 House Comparison

We recall that the other 2 houses (standard and fashionable) are not actually built, but are among the possible choices offered to the owner. The comparison of the Wemb (Figure 5) for the three wall techniques is clear:

- i. Ground floors: the hemp concrete covering has a large impact on the embodied energy in comparison with a mixture of sand, gravel and earth.
- ii. The upstairs concrete floor consumes large amount of energy.
- iii. For the roofing, the regulatory half-round terracotta tiles are the main energy consumer and the second is the insulation.

Likewise, the use of plant materials for the insulation or the structure (wood, straw or hemp) completely determines the CO₂ eq result. The techniques using very little energy resources also need more labour, and therefore call upon the most know-how, allowing the best redistribution of the added value. Table 2 compares the results achieved for the 3 kinds of construction. We divided the values of each indicator by the value achieved with the house made of local materials, to allow a direct comparison of the results. We thus show that the gains range from 1 to 3 for all the indicators.

Table 2: Dimensionless ratio coefficients between the 3 houses

	Local Material House	Standard House	Fashionable House
W _{emb}	100	160	240
C ₀₂	100	170	180
Labour intensity	100	30	20
Price	100	87	120

The local materials house is use as the reference

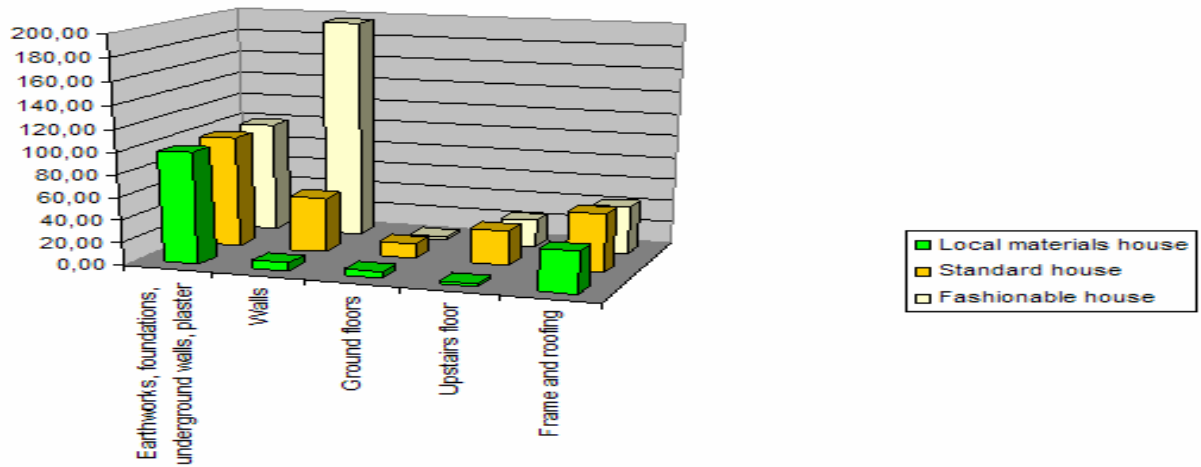


Figure 3: Houses embodied energy repartition comparison (Wemb).

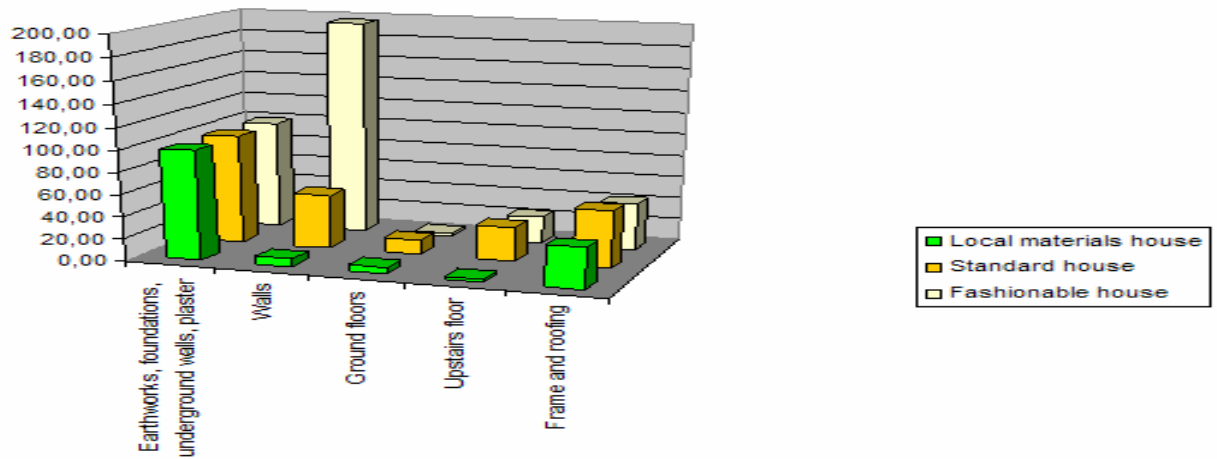


Figure 4 Houses CO₂ emissions / sequestration repartition comparison, (Metric Tons of CO₂ eq)

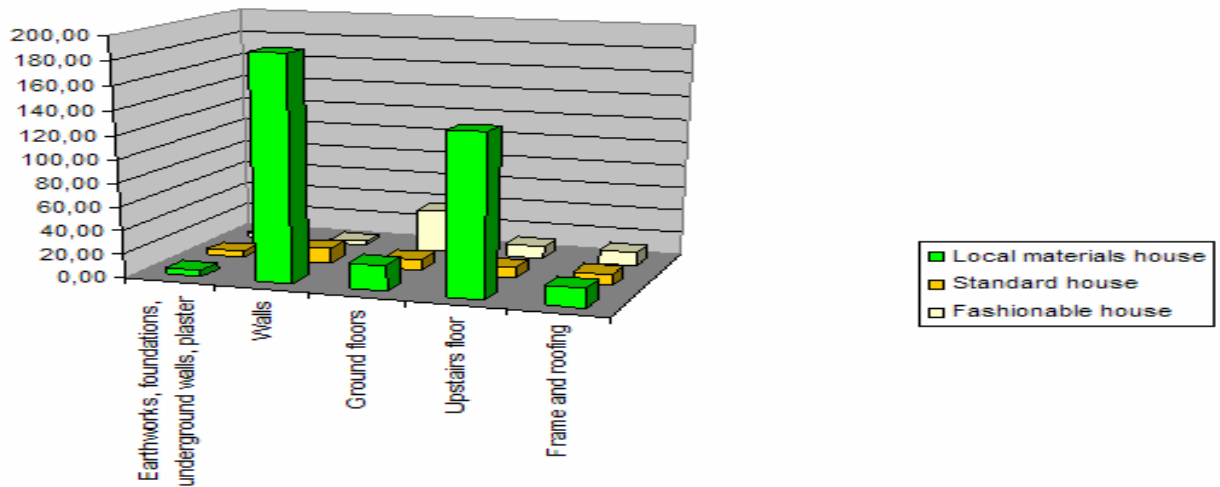


Figure 5: Houses L.I Labor Intensity indicator (hours per GJ) repartition comparison

The standard house has a mediocre balance with respect to energy consumption, a poor CO₂ balance, and tolerable labour intensity. The fashionable house has the worst energy consumption impact, a poor CO₂ emission balance and a low social performance. Yet this house as built only improves the energy resource consumption results of the standard solution by 1/3.

The question of the type of foundation, immobilizing half of the total energy in this solution, must be reexamined. It should be interesting to re-examine techniques using stone, by continuing public works research focused on roadwork ballast or ground support systems on top of gabion layers.

For the roofing and insulation, solutions already exist such as wooden shingles or thatching for the roofing, and all sorts of more or less agglomerated straw for the insulation. However, for many of these existing solutions, we need regulations that are more sensitive to the advantages of eco-materials. To be more effective, the regulations should also place stronger constraints on materials and techniques that are not environmentally-friendly.

6. Conclusion

This study shows that these indicators can help to distinguish between several choices of construction materials. The house made of local materials has a performance of at least 1.6 times better than the other two. By contrast, the house made of fashionable materials has the lowest performance in terms of "sustainability" and up to 5 times lower for labour intensity.

These indicators are the most relevant when used relatively, since they depend on data that can vary according to the environment and also the reliability of the sources. For a given project, these indicators also make it possible to identify the item with the strongest impact. For our study, this item was the foundations, at least twice as impacting as the rest of the carcass. Even though these indicators do not take the entire construction process into account (for example finishing and technical equipments are not considered), they can produce results that allow deliberation.

The choices have to be made in a way that is comprehensible to all, and applied in the most participatory way, with widespread acceptance by the populations concerned. It is important that all of the stakeholders use the same tools. These tools must also be accessible and easy to adopt by all, and policies must be developed in consistency with the realities measured by these tools and the results of public deliberations.

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