

# **Hello can you hear me? On Climate Change: Inequalities and Gender Vulnerability in Benin**

## ***Abstract:***

This paper focuses on gender mainstreaming in modeling the impacts of climate change by development sector. Inspired by the methodologies of the Guillaumont economic vulnerability index (2008, 2009) and the UNDP poverty vulnerability ratio (2011), a synthetic index called the 'Index of Inequality of Gender Vulnerability to Climate Change (IIGVcc)' which is a modeling by development sector, of vulnerability inequalities to climate change between men and women, is proposed. From the data of the second edition of the integrated modular survey on the living conditions of households in Benin (EMICOV 2011), this paper makes a concrete application of the IIGVcc for the Beninese agricultural sector. It shows that in the agricultural sector in Benin, women are about 1.1 times more vulnerable to climate change than men. The "access to land" parameter contributes to 50% of the inequalities of vulnerability, while the "instruction" parameter accounts for 37%.

**Keywords:** Modeling - Climate Change - Gender - Vulnerability - Index - Agriculture-Inequalities.

**JEL Classification :** C43, D13, O12, O13, Q12, Q18.

## **1. Introduction**

Gender refers not to women or men but to relations between men and women. It uses biological differences between the sexes, to focus more specifically on the inequalities of roles between men and women according to the socio-economic, historical, political, cultural and religious context of each society. Gender relations are the basis of any social analysis of gender.

Climate change is a physical phenomenon, the manifestation of which is reflected in the probable important rise in temperatures, and the likely decrease in precipitations, including floods, droughts, strong winds, coastal erosions, saline intrusion, and so on. From this point of view, climate change affects men and women, the rich and the poor, the elders and children equally and without distinction. At first sight, there is no place for the analysis of power relations between men and women in climate change (CC) studies.

However, Gender analysis in climate change finds its legitimacy in the fact that, in face of climate shocks, response varies from one society/community to another, from one individual to another depending on the individual and collective capacities to deal with disasters. Gender analysis therefore integrates the analysis of inequalities in vulnerability to CC, and in the adaptation capacities of men and women to climate shocks, that could degrade their living conditions. This paper focuses on Gender mainstreaming in modeling the impacts of climate change by development sector.

The remainder of the paper is structured in four sessions. The second one concerns the issue of gender mainstreaming in modeling the economic impacts of climate change. The third session presents the methodology of the Gender Vulnerability Inequality Index to

Climate Change (IIVGcc). The fourth session presents and analyzes the application of the IIVGcc for Benin agricultural sector based on data from EMICOVcc 2011, and the fifth session concludes.

## **2. Gender mainstreaming in modeling economic impacts of climate change by development sector**

The initial approach of gender mainstreaming in such modeling, had been to incorporate gender inequality parameters into the sectoral modeling of CC's economic impacts. Referring to this sectoral work, the analysis of input and output data from sectoral models showed that different development sectors use simulation models that do not incorporate gender inequality-related variables. In the agricultural sector for example, the modeling of the economic impacts of climate change uses the DSAAT model, whose input data are essentially of three types: (i) daily climate data, (ii) information on the sites and (iii) information on crop management such as type of plowing, sowing density, type of sowing, etc. The focus is on the needs of the plant (in terms of water and temperature) but no analysis of human factors (ability of men and women to respect the date of sowing, to use quality fertilizers, etc.) that can influence the respect of the agricultural calendar, and the agricultural yield is not integrated. In Benin context where agricultural roles are divided between men and women, it is necessary to analyze the capacities of each to assume their roles in the context of climate change.

Similarly, water resources sector uses hydrological and socio-economic models that simulate water availability (BenHydro) and water demand (BenEau) or water resource management (WEAP). No input or output data are available for the differentiated impacts of climate change on men and women, while some information could be disaggregated such as (i) the number of people affected by floods by sex, (ii) the number of deaths by sex, etc. It thus appears that existing simulation models at sectoral level do not integrate social variables and are not revisable by users. This raises the question of how to measure the inequalities between men and women in a given sector in face of the occurrence of climate change.

There are international indices of inequality measurement and vulnerability indices that have contributed to the development of the conceptual framework for gender mainstreaming in climate impact assessment modeling by sector development. Several index construction initiatives measuring the combination of different dimensions of gender inequalities in human development have been completed.





Amongst others, the proposed methodology in this paper is specifically based on three main indices, namely: (i) the UNDP Vulnerability Index to Poverty (2011); (ii) the Guillaumont economic vulnerability index (2008,2009) and (iii) the Guillaumont and Simonet physical vulnerability index to climate change (2012).

- **UNDP Vulnerability Index to Poverty (2011)**

This index determines the vulnerability of the population considered from the analysis of the movements of entry, exit and maintenance in poverty during the period. Four types of probabilities are calculated between the date  $t$  and the date  $t + p$ : (i) the probability of remaining non-poor, (ii) the probability of getting out of poverty; (iii) the probability of

falling into poverty and (iv) the probability of remaining poor. The probabilities thus obtained make it possible to assess the vulnerability of poverty at the national level. An analysis of the relationship between the probability of falling into poverty and that of getting out of poverty provides indications of the effectiveness of poverty reduction programs from the point of view of vulnerability prevention. It allows us to qualify trends in the incidence of poverty. Table 1 below presents the theoretical illustration of the movements of entry, exit and maintenance in poverty.

**Table 1: Theoretical illustration of the entry-exit movements, and maintenance in poverty**

Situation of the year t	Situation of the year t+p		Total
	Non-Poors	Poors	
<b>Non-poors</b>	Number of non-poor individuals at t and remaining non-poor at t + p (N1) 	Number of non-poor individuals at t and becoming poor at t + p (N2) 	N <sub>1</sub> +N <sub>2</sub>
<b>Poors</b>	Number of poor people at t and becoming non-poor at t + p (N3) 	Number of poor people at t and remaining poor at t + p (N4) 	N <sub>3</sub> +N <sub>4</sub>
<b>Total</b>	N <sub>1</sub> +N <sub>3</sub>	N <sub>2</sub> +N <sub>4</sub>	

Source : Excerpt from UNDP (2011)

- **Economic Vulnerability Index - EVI (Economic Vulnerability index)**

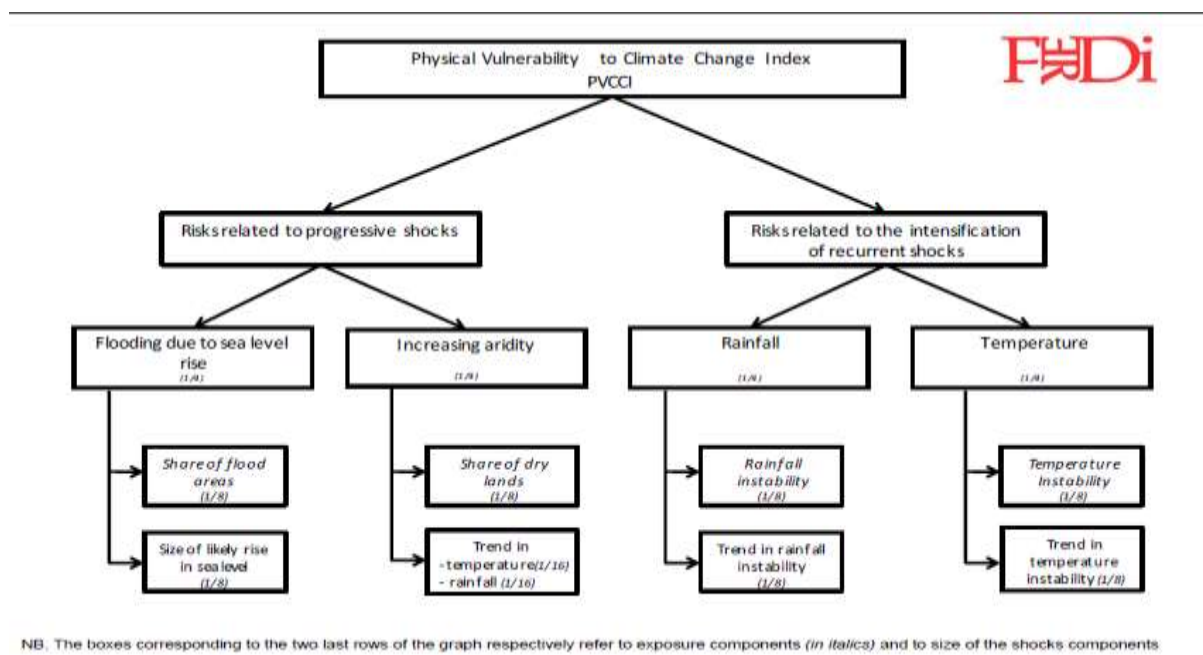
The EVI is a synthetic indicator, developed by Guillaumont (2008, 2009) whose calculation is based on a weighted average of two indices (exposure index and shock index), grouping five subscripts or seven components. The exposure index is an average of three indices reflecting exogenous shocks: (a) for external shocks, the volatility of exports of goods and services; for natural shocks, an average of (b) the average instability of agricultural production and (c) the "homeless" component of the natural disaster index. The shock index is an average of four indices reflecting structural exposure to shocks: (d) a population dimension index (in logarithms), (e) an index of distance from world markets (adjusted for land-lockedness), and an index of structural weakness, itself an average of (f) an index of the relative share of agricultural value added in GDP, and (g) an index of export concentration.

The EVI is the simple arithmetic mean of the exposure index and the shock index (Cariolle, 2010):

$$EVI = 0.5 * Exposure + 0.5 * Shocks.$$

- **Physical vulnerability index to climate change**

In addition to economic vulnerability, Guillaumont proposed an index of physical vulnerability to CC shown in Figure 1:

**Figure 1: Physical vulnerability index to climate change ...**

**Source:** Guillaumont & Simonet (2012, p16)

This index makes it possible to identify the specific vulnerability of states to climate change and then to integrate it into the definition of appropriate adaptation policies. Guillaumont (2012) also examined how the structural economic vulnerability indicator (EVI) and the indicator of physical vulnerability to climate change differed and could or could not be combined. These indices are used in the allocation of international resources available for official development assistance (ODA) and for adaptation to climate change.

### 3. Methodology of the Gender Vulnerability Inequality Index to Climate Change (IIVGcc)

#### 3.1. Structuring the IIVGcc

Based on the methodology proposed by UNDP (2011) for the measurement of vulnerability to poverty and the calculation of the economic vulnerability index (EVI) at country level, developed by Guillaumont (2008, 2009) and mentioned in Cariole (2010), we propose in this paper, a methodology for calculating the index of inequality of gender vulnerability to climate change (IIVGCC) by development sector within a country. In fact, it is the spirit of the calculation procedure of the EVI that we have borrowed. This is not the transposition of components and sub-indices.

The IIVGCC for the development sector named 'S' is the simple arithmetic mean of S risk exposure index (IERs), and the potential CC shock index on S rated by IYs, with Ys the combination of the 'climatic proxy' variables identified for sector S. Let:

$$CCSVI_s = 0.5 IER_s + 0.5 IY_s$$

**The index of inequality of gender vulnerability to climate change by sector within a country (IIVGCC)** is a synthetic indicator defined as the ratio to the vulnerability index to climate change (IVCC) of men divided by the one's for women, according to each

development sector. It therefore measures by development sector, the relative vulnerability of men to climate change compared with that of women.

**The sub-index of risk exposure before climate change (IERs)** for a given development sector is calculated on the basis of a weighted average of the health status (or vulnerability) indicators of the different components/variables that are critical for emergence of this sector. It measures the global vulnerability of men or women (as the case may be) in the sector in the absence of the exogenous shock of climate change. It is calculated according to the following formula:

$IER_s = \sum_{i=1}^n \alpha_i RX_i$  with  $\alpha_i$  the weight of  $X_i$  in the development of sector  $S$ , and  $RX_i$  the vulnerability ratio of the variable  $X_i$ .

**The sub-index of Climate Change shock (IY<sub>s</sub>)** for a given development sector is a simple arithmetic mean of climatic indicators calculated from the potentials climatic variables (which we call the climate proxies) that can influence the considered sector. It measures in a given sector, the potential vulnerability (independently from gender) that the shock of "climate change" will transmit to men and women. Its value is therefore by sector the same whatever the gender, because the direct physical effects of CC will be received in the same way by men and women. This sub-index is in fact similar to the index of physical vulnerability to climate change (IPVCC) proposed by Guillaumont and Simonet (2012). It is above all the variables such as temperature, rainfall, sea level, the level of rivers, the extent of drought, which participate in the calculation of the sub-index of CC shock.

### 3.2. Procedure for variables standardization

The calculation of climate indicators by climate proxy (for the CC shock sub-index) and health status indicators by sector  $S$  component quantitative variable (for the exposure sub-index prior to CC) is done by the **min-max standardization** technique (Cariolle conf (2010)). This technique involves, among other things, transforming the original data of the variable concerned into indices between 0 and 100. The lower and upper bounds are imposed and constant over time, in order to prevent distortions from queued distributions, extended distributions or containing outliers, and to obtain comparable index values over time. The index obtained for each variable is between 0 and 100 and **is positively related to the vulnerability** (the closer the index is to 100, the greater the vulnerability).

About **the min-max standardization procedure**, the variables at the base of the calculation must be positively related to the vulnerability (or defective health). For these variables, the calculation for the indicator (or index) is as follows:

$$I = [(Value - Min) / (Max - Min)] \times 100.$$

In the case where a variable is negatively related to the vulnerability, the formula for calculating the index changes. It becomes:

$$II = [(Max - Value) / (Max - Min)] \times 100 \text{ or } II = 100 - I$$

**NB:** The different weights to be used throughout the IIVGCC calculation are not chosen at random. They must be chosen on the basis of a factorial analysis of the data.

## 4. Application of the IIVGCC to the agricultural sector of Benin

The availability of data from the 2011 EMICOVcc survey and climatic data (mainly temperature and rainfall) enabled testing of the IIVGcc in the agricultural sector.

#### 4.1. Data and sources

Climatic data were used for the calculation of the climate change shock subindex. Sectoral data from agriculture were used to calculate the exposure sub-index prior to the shock.

##### 4.1.1. Climate data

The climatic data used in the context of the IIVGcc calculation application for the agricultural sector of the Beninese economy are temperature and rainfall. In Benin, climate data are collected by six (6) synoptic meteorological stations and a hundred rainfall stations scattered throughout the country. These stations collect daily data on temperature and rainfall. The climate data used in this study come from each of these stations. For temperature, these are daily maximum and minimum temperatures from January 1, 1960 to December 31, 2011 in the North, South and Central Benin regions. As for rainfall, the data used cover, by decade, the same period from 1 January 1960 to 31 December 2011 in the same regions of North, South and Central Benin. Since our analysis is global (national) and not by region, these regional climate data were aggregated by weighted averages after principal component analysis (PCA).

##### 4.1.2. Agriculture sector data

The data used for the calculation of the risk exposure sub-index (REI) before the CC shock in the agriculture sector in this study is in snapshot section and comes from the Integrated Modular Survey on Household living conditions (EMICoV, 2011) of INSAE.

The sample thus extracted comprises a total of 16097 workers in the agricultural sector, including 9268 men (ie about 58%) and 6829 women (42%). In order to be able to calculate the risk exposure index before the CC shock for men and women, the database of the sample of men was separated from that of women.

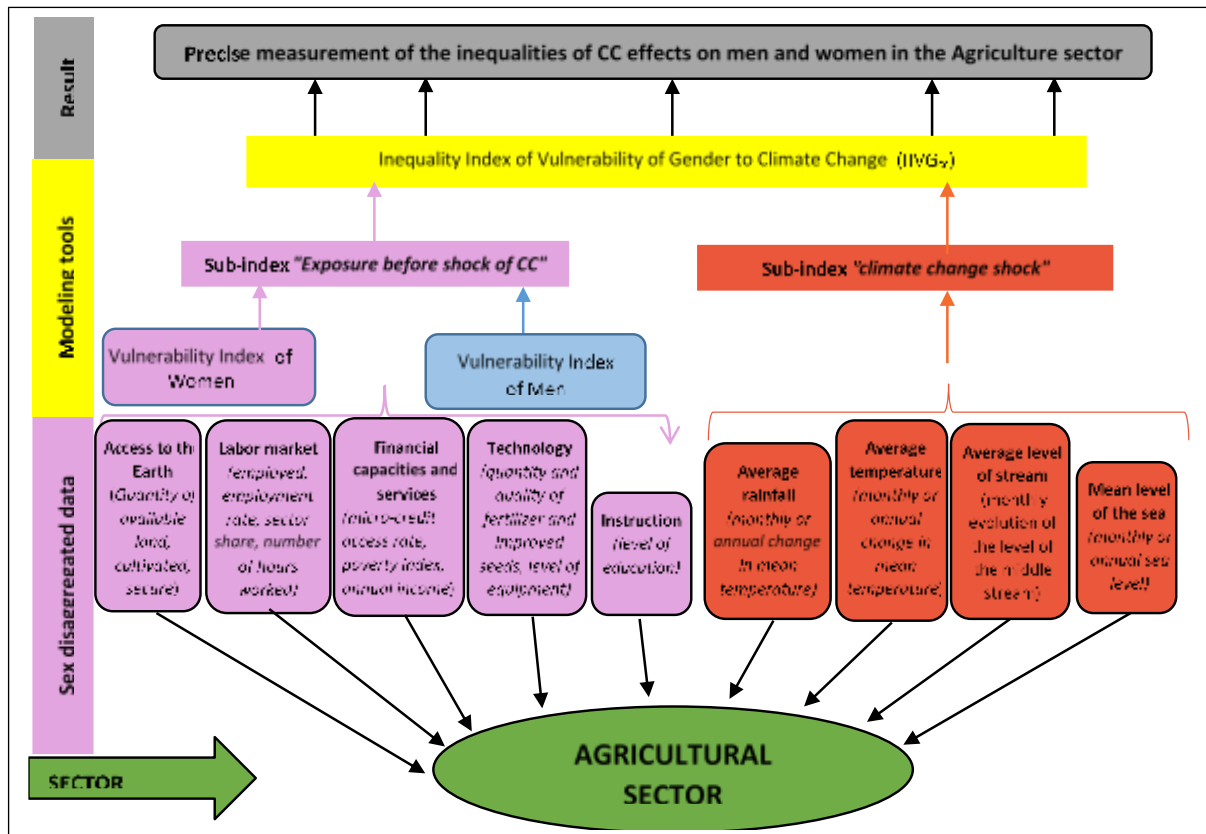
#### 4.2. Variables used for the calculation of the gender inequality index of vulnerability to CC (IIVGcc) in the agriculture sector.

Figure 2 illustrates the architecture for calculating the Gender Equality Vulnerability Index for CCs for the agriculture sector.

### **Figure 2 : Architecture of the Gender Vulnerability Index to Climate Change (IIVGCC) for the Agricultural Sector<sup>1</sup>**

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<sup>1</sup> Table 4 below describes the modeling and computing variables of the climate change vulnerability inequality index.



Source: Authors

According to this figure, the pre-shock risk exposure index (for men or women) is a function of 5 parameters (access to land, access to the labor market, capacity and financial services, technology and education).

### 4.3. Findings about the IIVGCC in Benin agricultural sector

Table 5 below gives the gender-specific index values obtained in the agricultural sector.

**Table 5 : Index Values of Agricultural Sector Determinants by Gender**

Parameter (X <sub>i</sub> )	Variables for modeling and calculating the Vulnerability Index	Indices (v <sub>i</sub> ) (obtained by min-max standardization or by rate calculation)		Weighting coefficient (α <sub>i</sub> ) according to X <sub>i</sub> (obtained by the prior Principal Component Analysis (PCA))	α <sub>i</sub> × v <sub>i</sub>		Parameter weight X <sub>i</sub> /100 points
		Men	Women		Men	Women	
Land : Land access and control	Possession of arable land by the household of the individual (dichotomous variable)	93.12	93.98	α <sub>1</sub> = 25/100	23,28	23,495	4
	Number of hectares of cropland per year	4.69	4.58	α <sub>2</sub> = 25/100	1.1725	1,145	
	Possession of arable land by the individual (dichotomous)	85.1	14.9	α <sub>2</sub> = 30/100	25.53	4.47	
	Number of hectares of secure land per year (possessing an administrative possession certificate)	69.3	72.1	α <sub>3</sub> = 20/100	13.86	14.42	
	<b>TOTAL</b>				<b>63.84</b>	<b>43.53</b>	
Labor market :	Total number of people employed in agriculture	3.11	3.30	α <sub>1</sub> = 4/100	0.1244	0.132	45



Parameter (X <sub>i</sub> )	Variables for modeling and calculating the Vulnerability Index	Indices (v <sub>i</sub> ) (obtained by min-max standardization or by rate calculation)		Weighting coefficient (α <sub>i</sub> ) according to X <sub>i</sub> (obtained by the prior Principal Component Analysis (PCA))	α <sub>i</sub> × v <sub>i</sub>		Parameter weight X <sub>i</sub> /100 points
		Men	Women		Men	Women	
access to agricultural labor	Number of hours devoted to agricultural activities per week	55.76	41.29	α <sub>2</sub> = 49/100	27.3232	20.2362	
	Number of hours devoted to domestic work per week	1.89	14.32	α <sub>3</sub> = 24/100	0.4536	3.4368	
	Number of hours spent searching for water	2.12	12.43	α <sub>4</sub> = 23/100	.4876	2.8589	
	<b>TOTAL</b>				<b>28.81</b>	<b>26.39</b>	
Financial Capabilities	Monthly income by sex of agricultural producers	9.21	6.48	100/100	9.21	6.48	1
	<b>TOTAL</b>				<b>9.21</b>	<b>6.48</b>	
Instructions	Level of education of farmers	27.49	9.59	= 50/100	13.745	4,795	50
	Literacy (nominal)	21.37	7.61	= 50/100	10.685	3,805	
	<b>TOTAL</b>				<b>23.43</b>	<b>8.60</b>	
Parameterization of the climate change shock (obtained by min-max standardization)							
		52.59		= 50/100			

Parameter (X <sub>i</sub> )	Variables for modeling and calculating the Vulnerability Index	Indices (v <sub>i</sub> ) (obtained by min-max standardization or by rate calculation)		Weighting coefficient (α <sub>i</sub> ) according to X <sub>i</sub> (obtained by the prior Principal Component Analysis (PCA))	α <sub>i</sub> × v <sub>i</sub>		Parameter weight X <sub>i</sub> / 100 points
		Men	Women		Men	Women	
Climatic changes	Average daily temperature						
	Average rainfall per decade	4.67					= 50/100

Source: Authors calculations

Thus, Table 7 presents the final calculations results.

**Table 7 : Results of calculation of gender vulnerability indices in the sector of agriculture in Benin and the IIVGcc sector**

Components	CC Vulnerability Index (CCSVI)	
	Men $\sum p_i v_i$	Women $\sum p_i v_i$
Risk exposure before the shock of CC	71.60	81.50
Shock of CC	28.63	
CC Vulnerability Index (CCSVI)		
Men : 50.115		Women : 55.115
Gender Vulnerability Inequality Index to CC ( IIVGcc ) = 0.90		

Source: Authors calculations based on EMICoV2011 data

$$CCSVI_{men} = 50.115 \quad CCSVI_{women} = 55.115$$

$$IIVGCC_A = 0,90$$

These outcomes show that women are 1.10 times (inverse ratio of IIVGCC<sub>A</sub>) more vulnerable to Climate Change than men in the Beninese agricultural sector. **The 'access to land' parameter contributes to 50% of the inequalities of vulnerability**, while the "instruction" parameter accounts for 37%.

## 5. Conclusion

The index of inequality of vulnerability of gender to climate change (IIVGCC), developed in this paper, is inspired by the methodology of calculation of the EVI developed by Guillaumont (2008, recalled in Cariolle, 2010), and that proposed by UNDP (2011) for measuring vulnerability in the context of poverty. It combines exposure to climate change vulnerability and climate shock vulnerability. From the data of 2011 EMICOVcc survey of Benin, it is shown that women are 1.10 times more vulnerable than men in the Beninese agricultural sector. In terms of measures to reduce gender inequalities in CC adaptation and resilience, **this result suggests the implementation of social policies in favor of women in the agricultural sector in Benin**, for example, the **promotion of women's access to land and tenure security**, the promotion of literacy and education of girls and women, the development and practical implementation of a communication strategy adapted to rural women, and the promotion of productive work for women to master the technology and planting timing. In addition, it was not possible to estimate the future evolution of this IIVGCC given the lack of a study on the predictions (integrating climate change) of the IIVGcc calculation parameters defined in this document. study for the agricultural sector. At the end of the day, for the other sectors of the economy (water, food security, health, and so on), the calculation of the IIVGCC could also be done. It is therefore of crucial interest to: complete the calculations of the IIVGcc for the food security, water, and health sectors by organizing the collection of data needed for these calculations; initiate studies on forecasting sectoral parameters integrating climate change that will allow a dynamic calculation of the IIVGCC on future horizons.

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