

An Innovative Model Based on Carvalho Rodrigues's Entropy to Assess Governance in Africa: A Guinea-Bissau Case Study

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Abstract: Governance is an abstract, intersubjective, fluid concept, meaning that it is built upon shared beliefs, norms, and practices that are collectively agreed upon by a society, community, or group. It means different things to different cultural environments and scopes. Our current research addresses the challenge of obtaining insight into Governance's underlying mechanisms by using the concept of Cohesion derived by Carvalho Rodrigues from applying Shannon's Entropy. Our study is based on empirical data obtained from field observations across Guinea-Bissau.

This paper presents our cohesion model and a first outlook for using it in the available data sets. It shows the impact of several potential Governance Determinants over a set of specific Governance Dimensions, demonstrating that Ethnicity Variation, local Community Morphology and the distance of Central Government facilities are the most impacting determinants for better cohesions.

1 INTRODUCTION

There's no consensus about the meaning and scope of Governance, which may be related to organisation sizes, from simple families to countries. Within the specific context of our work, governance is understood as the *structuring of Governance*, which is distinct from *government*, which refers to the act of governing. As defined by the Institute on Governance in Canada, Governance refers to the way society or groups within it organise themselves to make decisions (Institute on Governance, 2022). Consequently, in this study, the term *Governance* focus on social Governance rather than narrower concepts such as corporate Governance. Specifically, it pertains to how public institutions and systems of authority operate to manage public affairs and serve citizens' needs and interests.


Governance is a complex intersubjective phenomenon influenced by various political, economic, social, and geographic factors. Significant and recurring failures of international policies and institutions in effectively stabilising societies and promoting global


prosperity and well-being are of particular concern. Examples include governance crises in regions such as West Africa, e.g., Mali, Burkina Faso, Guinea-Conakry, and Nigeria.


In recent years, there has been a growing interest in understanding the drivers that impact Governance, particularly in peripheral sphere of the European Union, such as West Africa as it is illustrated by the work of many scholars such as (Abubakar et al., 2020; Achanso, 2022; Krawczyk & Sweet-Cushman, 2016).

Guinea-Bissau, a small country in this region characterised by its ethnic, religious, and social diversity, irregular political trajectory—including a civil war, political instability and economic underdevelopment, in par with formal institutions, such as a constitution derived from external concepts, presents a compelling case for exploring this issue.

Our research seeks to obtain insight into how some candidate Governance determinants influence governance outcomes in Guinea-Bissau, taken as a proxy of West African societies. To achieve this, our group used as a keystone the concept of Cohesion as proposed by Carvalho Rodrigues (Carvalho Rodrigues,

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1994; Carvalho Rodrigues & Peixoto, 1991). This was used to assess several Governance dimensions and for several possible drivers or *Determinants*.

2 CONCEPTUAL FRAMEWORK

2.1 Baseline Model

2.1.1 Complexity of Behaviour and Information

In the book *Systems, Entropy and Cohesion* (Carvalho Rodrigues & Peixoto, 1991, p. 213), the authors introduce a fundamental distinction: the differentiation between *Complexity* and *Behavioural Complexity*, quoting, "[...] *there are systems that contain or encompass many elements, or parts, with very predictable behaviour, we would even say simple, and there are very simple systems with few parts or elements with enormous behavioural complexity*", a distinction that is considered fundamental for the research we have set to carry out, which focuses precisely on the behavioural elements derived from Governance. The authors add: "*Complexity comes primarily from the number of components, while behavioural complexity is due to the type and degree of links [between the components]*".

They go on to say that there is a relationship between these two concepts, which, in the authors' interpretation, is achieved through the "*amount of information needed to describe or interpret the behaviour of the system*", which does not depend on the number of constituent elements, but instead on the type and diversity of their connections.

An example of this situation, in terms of urban organisation figure below shows two communities with roughly the same population: Gendo and Sansanto, in the Oio region, north of Bissau. Gendo is a type of agglomeration with no orientation and Sansanto is a street type Community, with a clear orientation and organisation around the road.

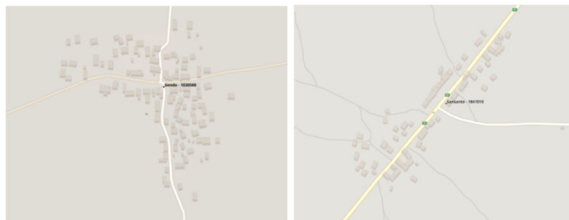


Figure 1: Spatial organisation of two typical communities in Guinea-Bissau in the Oio region. Gendo (left) and Sansanto (right).

Thus, Gendo exhibits a higher complexity in household distribution with a similar number of constituents; however, it requires more information to properly describe as it exhibits greater entropy.

2.1.2 Information, Entropy and Cohesion

It is possible to determine the degree of Cohesion of a structure maintained by information, as is the case in social structures, based on the quantity of information in that structure, which in human society can translate into a sense of well-being or degradation (Carvalho Rodrigues & Peixoto, 1991, pp. 217–223). To determine this, they use the results of Fisher as mentioned by Frieden (Frieden, 1998), Shannon (Shannon, 1948) and the equation derived by F Carvalho Rodrigues for the quantity of information (Carvalho Rodrigues, 1994, p. 22):

$$H(N, \sigma, p) = - \frac{\sigma}{N} \log_e p = - p \log_e p \quad (1)$$

Where σ is the number of occurrences of an event and N the number of possible events. Estimating H for of the communities and for each of the Governance dimensions and determinants is the keystone constituent of our work.

2.1.3 The Cohesion Curves

Carvalho Rodrigues (Carvalho Rodrigues, 1994, pp. 42–43), established the behaviour of a system cohesion as it depends on a relevant factor. The figures below, illustrate the situation.

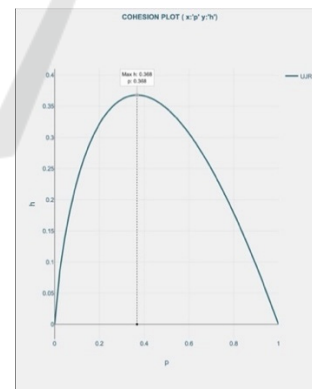


Figure 2: Justice Dimension Cohesion function extracted from the actual Guinea-Bissau dataset. The maximum Cohesion was obtained at 0.368.

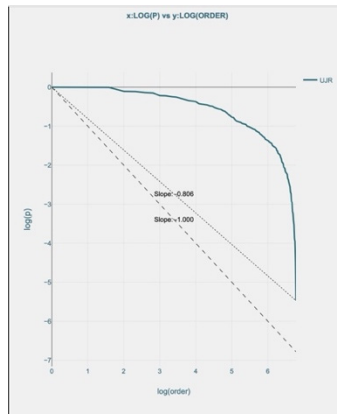


Figure 3 : Justice Dimension Cohesion function. This plot illustrates that, for Justice, the larger portion of the communities have a slope greater than -1 , or 45° , which can interpret as this being strongly cohesive and *export entropy* to a relatively small number of communities – the ones having slope greater than 1 . In social terms it may mean that people are comfortable with Justice, a natural outcome, since most of the Justice is practices by *Big Men* and *Good Men* representants. A compound slope greater than -1 , actually, -0.806 may be interpreted as an overall positive cohesion, in this case, for the *Justice Governance Dimension*.

2.1.4 Governance and Cohesion

Vergolini (Vergolini, 2011, pp. 198–199), quoting Canadian Heritage, defines Social Cohesion as "*a process that contributes to building a common sense of belonging to the same community*" and Lafaye (Lafaye, 2011) refuses a clear definition, preferring to describe and discuss various types of interpretation of social Cohesion, including societal, individualistic and mixed models, and thus finding multiple definitions.

It is important to clarify that in our study, the concept of Cohesion does not directly correspond to social Cohesion, but to the more abstract concept of *Cohesion of a System*, regardless of its specific type.

It is also assumed that governing a society consists of introducing mechanisms to organise it. In other words, governing consists on reducing the Entropy of the society system, which, by direct implication, corresponds to increasing the Cohesion of that system.

To explain the behaviour of the constituents of an anarchic society with maximum Entropy requires a vast amount of information describing all the individual behaviours; to describe the behaviour of a completely organised society with recognised, shared and obeyed laws, you need to know the rules that shape the personal behaviours, which are necessarily far fewer in number. Thus, it is essential to distinguish

between two broad classes of concepts: the dimensions of Governance, i.e. the elements that allow us to gauge how Governance is practised, and the determinants of Governance, i.e. the elements that can potentially impact the sense of Governance, a sure sense and coherence, concepts that we intend to clarify and characterise below.

The essential assumption here is that Governance contributes to structuring a society, which globally corresponds to lowering its Entropy, which will be reflected in the fact that cohesion indicators indicate a change of phase at higher values on the scale of loss of Cohesion.

2.2 Governance Dimensions

Various groups of *Governance Indicators* have been proposed by various organisations.

To move forward with the identification of indicators, we have taken the following indicators commonly accepted as universal as a basis for governance indicators: Education, Health, Justice, Food Security and Infrastructure. This selection is based on a combination of perspectives from three public sources: the World Bank indicators (World Bank, 2023), the UNDP indicators to make up the HDI¹, and the United Nations SDGs² (United Nations Department of Economic and Social Affairs, 2015, 2023). From these, the below *Governance Dimensions* were structured to obtain an understanding of the possible impact.

Table 1: The studied Governance Dimensions.

ACRONYM	DESCRIPTION
uer	Education
usr	Health
ujr	Justice
uar	Food Security
urr	Family Wealth
uir	Infrastructure equipment
ucr	Culture
upr	Community Assets
ufr	Happiness

2.3 Possible Impacting Governance Determinants

The authors found no significant body of research work linked to empirical data regarding drivers of governance at a Community level, leaning to the conclusion that its scope and granularity are not mainstream investigations. In fact, mainstream work is much related to abstract concepts such as some key

¹ HDI: Human Development Index

² SDG: Sustainable Development Goals

determinants reported in the African Governance Report (Africa Governance Report, 2023) and by the World Bank (World Bank, 2023), to not only account for actual livelihoods but also carry a pure top-down perspective on Governance. Two simple examples illustrate the situation in rural West-Africa: on *Rule-of-Law* villagers find, regularly, that the Koran along with their social norms, provides any requirable rule to be obeyed, thus the ultimate State Law, the Constitution, written somewhere by non-related (normally dead) people, is not really to be considered, and *Control-of-Corruption*, villagers find that this concept somehow contradicts what is, for them, considered normal business procedures.

Nevertheless, the work of scholars such as Rotberg (Rotberg, 2009), Alence (Alence, 2004), and Chabal (Chabal, 2009), should be noted as they address relevant elements of livelihoods and their linkage to forms of governing.

Nevertheless, the African Union published its own Development Agenda for 2063, linked to the SDGs, containing 7 major aspirations from which potential drivers for Governance could be drawn and would constitute the foundation of our set of Determinants.

In fact, the determinants of Governance will be the elements that contribute to Governance taking place in the society under analysis, in this case Guinea-Bissau, taken as a proxy for West Africa, which implies, that in terms of the basic principles of information theory which are directly related to the concept of Entropy in the 2nd principle of thermodynamics: *the lower the Entropy, the more organised the system is* and likely to attain the ultimate goal of Governance: organise.

The final list of potential Determinants to evaluate is listed in the below table

Table 2: The suggested Governance Determinants.

ACRONYM	DESCRIPTION
mrp	Community Morphology
dst	Distance to Government Service.
etn	Ethical Variation
pss	Chabal Rules
nds	Needs and Wants Satisfaction
env	Environment Stress
piv	Public Investment
sec	Secularity Bias
soc	Social Organisation and relations with neighbour communities

³ Naturally, this situation must be taken with extreme caution as there is no distinction from democracy to dictatorship which may carry similar cohesion values but may also have wildly different outcomes in respect to

2.4 Modelling Determinants' Impact

The next step in the work is to propose a method to evaluate the impact on Governance, of the several Determinants under analysis. To assess this, the following set of axioms was accepted:

- Governance intimately implies the structuring of a society; this means that the higher the cohesion value of an indicator, the *best* Governance is in that specific indicator³.
- The impact of a specific Determinant, can be measured by identifying the Communities for which the cohesion value (H) is higher than the median, doing the same for the Communities with H lower than the median, and computing for the specific Dimension analysis, the values of H on the Dimension for both sets and the picture below illustrates this strategy.

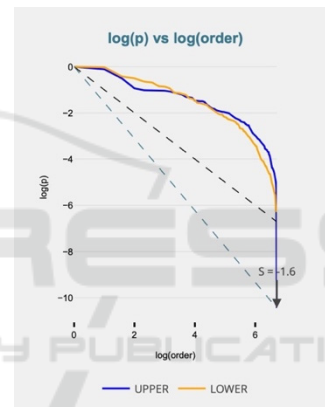


Figure 4: The impact of the *Determinant Environment Stress on Community Wealth*. It may be noticed that both curves are pretty much aligned, which suggests that there is no real noticed impact of the *Environment* on local wealth conditions.

3 ASSESSING AND COMBINING DATA

3.1 Strategy to Address Core Concerns

3.1.1 Key Concerns

The strategy to address data quality and completeness of the available data sets is bound to two sets of core

their sustainability and/or development and happiness, so *best* must be framed under the limited concept of detaining better cohesion.

concerns: first, there exist no surveys that directly question the adopted Governance Dimensions or Determinants, so a means of converting the available information into observed variables had to be established and, secondly, the available data, itself, needed to be assessed for its quality, namely in what regards the explanation of the variations, i.e., the independency of the available 1,400 data points per each of the 208 communities, which conducted to a separated study whose results are summarised below.

3.1.2 Raw Data Analysis Outlook

Raw Data Analysis, consisted in obtaining preliminary insight into the data collected, and checking some of their key parameters, such as the likeliness of its consistency, namely for explaining the variation, identification of correlations, etc...

3.1.3 Correlation Analysis

Correlation analysis was carried using both Pearson and Spearman methods.

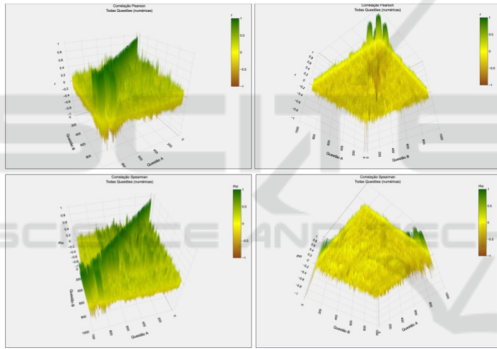


Figure 5: The figure suggests an overall comprehensive set of data points, with 90% of them having correlation factors less than 0.3. The negative correlation, the % is much higher, suggesting that the Data Set displays a significant orthogonality.

3.1.4 Principal Component Analysis

The goal of carrying out this analysis was to identify the most relevant questions as measured by their contribution to the most relevant Factors. For this, the following SPREE plot was obtained.

3.1.5 Combining Raw Data into Dimensions and Determinants

To achieve this all the data elements were analysed and classified into one of the *Dimensions* or one of the *Determinants*, avoiding any overlap to ensure orthogonality.

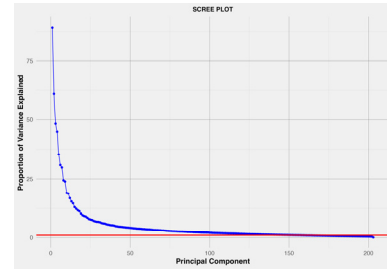


Figure 6: The plot displays the relative relevance of the PC and, Kaiser Criterion, in red in the figure. Principal Component with an eigenvalue less than 1 explains less variance than one of the original variables in standardised data. However, a quick observation hints that, with roughly 20 components, we could explain most of the variation.

4 COHESION ANALYSIS

4.1 Cohesion Assessment Highlights

A thorough analysis is out of the scope of the current communication, so we present its current outcome as per the estimated impact of Determinants on Governance.

The next table presents a quick outlook of the overall Cohesion analysis.

Table 3: Cohesion Highlights.

DESCRIPTION	p @ max H	max H	global slope
DIMENSIONS			
Education	0.370	0.368	1.394
Health	0.414	0.365	1.078
Justice	0.368	0.368	0.806
Food Security	0.367	0.368	0.705
Family Wealth	0.365	0.368	1.357
Infrastructure equipment	0.368	0.375	1.118
Culture	0.368	0.368	0.499
Community Assets	0.368	0.378	1.447
Happiness	0.368	0.361	0.724
DETERMINANTS			
Community Morphology	0.368	0.378	1.507
Distance to Government Service.	0.369	0.368	1.083
Ethical Variation	0.374	0.368	1.225
Chabal Rules	0.353	0.368	0.778
Needs and Wants Satisfaction	0.358	0.368	0.600
Environment Stress	0.003	0.016	1.541
Public Investment	0.080	0.201	2.728
Secularity Bias	0.368	0.368	0.385
Social Organisation and relations with neighbour communities	0.367	0.368	0.716

The interpretation is that the lower the *max H* and/or the *p@max H*, the less cohesive the structure. Subsequently, the outline values shown in Table 3,

suggest that the *Health Dimension* is more cohesive than any other *Dimensions* or *Determinants*, as it peaks at 0.414 for the $p@max H$ parameter. However, its global scope of 1.078 hints that the number of communities with low entropy levels is less than *Justice*, *Food Security* or *Culture*. A likely interpretation is that, for instance, *Culture* and *Justice* are more homogeneous than *Health* across the country. A special note is the value of the slope found for *Happiness*, which is consistent with *Culture*, *Food Security* and *Justice*, which is likely to suggest that they are interrelated, potentially due to the type of West-African communities.

Finally, we should mention two outliers, *Environment Stress* and *Public Investment* that clearly require a close inspection of the source data, as they present slope values very high, accompanied by p -axis values very low.

4.2 Impact Evaluation Highlights

4.2.1 Impact on Dimensions

To estimate the overall impact of the studied *Determinants*, our project obtained the sum of the lags between the *High Cohesion* and *Low Cohesion* curves as illustrated above in Figure 4 for each specific *Dimension*.

The open source *meethere app*, developed within our project provides a detailed output of this analysis and it is not in the scope of the current communications to analyse the full set of outcomes. Nevertheless, we show the result for the Education Dimension in the below figure to illustrate our analysis.

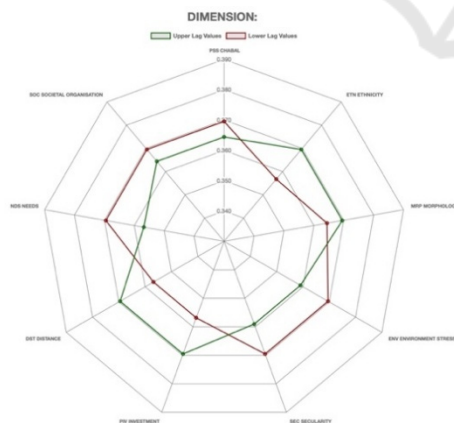


Figure 7: The impact of the *Determinants* on the *Education Dimension*.

The above figure shows that the different *Determinants* have different impacts and, out of the nine *Determinants*, only four, *Ethnicity Variation*, *Community Morphology*, *Public Investment* and *Governmental Distance* carry better results. These findings suggest that if the Government wants to focus its meagre resources on improving Education, it will benefit by addressing its policies, investment, and budget spending, specifically in those factors.

4.2.2 Overall Impact on Governance

To obtain the Overall impact on Governance for each *Determinant*, the project added all individual contributions to each dimension:

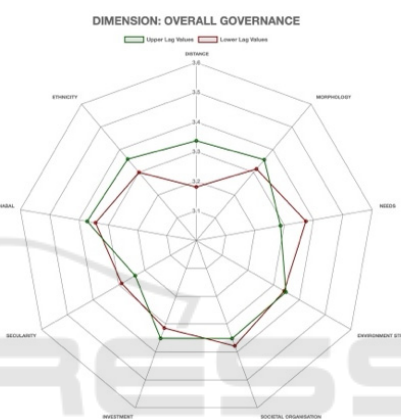


Figure 8: The figure show that the most relevant drivers of *Governance*.

The above figure shows that *Public Investment*, *Chabal Principles*⁴ (Chabal, 2009), *Ethnic Variation*, *Government Services* availability, and *Community Morphology*, have an edge over *Secularity*⁵, *Societal Organisation*, *Environment Stress* and *Satisfaction of immediate Needs*.

This can be interpreted as, being drivers of Governance, namely the availability of Government Services at community level, expenditure in them will likely potentially bring the best outcomes. A good example, when we look at the detailed inputs for this list *Determinant*, is the benefit of replacing the process of Citizen card, which currently is at the Region⁶ level, to at a Sector⁷ level, which would come at almost zero spending.

⁴ The Chabal Principles represent the local societal norms

⁵ Several scholars, such as (Fox, 2015), incorporate the concept of *Secularity* within *Liberalism* they consider it a

vital element within liberalism, acting as a safeguard for individual freedoms, equality, and pluralism

⁶ Region: Admin 1

⁷ Sector: Admin 2

4.3 Applicability Outside Guinea-Bissau

Societies across West Africa, such as in Senegal, Mali, Guinea and Guinea-Bissau do have similitudes, both Cultural, Linguistic and Norms as it is proposed by Ameka *et alia* (Ameka & Breedveld, 2004), when studying local norms and do not consider the specific country level separation, but West-Africa as a whole, which concurs with scholars such as Herskovits in several publications such as (Melville & Herskovits, 1924), Conton (Conton W.F., 1961), (Achebe, 2022) and (Bohas et al., 2018). All these authors stress commonality either due either to similitude of local norms and mores or the impact of roughly 1,400 years of Islam governing framework. Illustrating this situation, the two below Figures evidence the similitude of the Social Norms, Mores and Religion.



Figure 9: Map produced by Herskovits evidencing areas of cultural similitude.

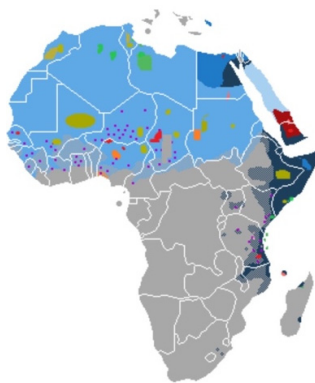


Figure 10: Map sourced from Wikipedia (Wegomakity-Tri-noyesi, 2024), showing the current impact of Islam in West-Africa.

5 CONCLUSIONS AND FURTHER WORK

The present communication highlights the use of Cohesion as a means to uncover and substantiate political drivers and subsequent options for Governance. Its first findings are positive and provide clues for detailed modelling, namely enabling machine learning geographic prediction algorithms, which is the next step in our work.

In addition, the authors are keen to, after completion of the current work, obtain insight into how the *memes* related to the Dimensions and Determinants propagate within the geographical space, testing their propagation through several methods.

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