American Journal of Environmental Protection, 2023, Vol. 11, No. 2, 41-48
Available online at http://pubs.sciepub.com/env/11/2/2
Published by Science and Education Publishing
DOI:10.12691/env-11-2-2

Climate Change, Decentralization and Territorial Resilience in Burkina Faso: Case of the Center-West Region (Burkina Faso)

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Received September 16, 2023; Revised October 17, 2023; Accepted October 24, 2023

Abstract In Burkina Faso, efficient management of political, social and economic regression caused by the intensification of disaster risks, climate change and security risks practically require a significant effort in taking into account these risks in the political, economic and social governance. This paper addresses an approach, methodologies and decision-making tools for the development of a policy reference framework for the efficient management of the economic, social and political threats relating to disaster risks, climate change and security risks for Burkina Faso. The scientific framework for the content of the paper is the Badolo class of tools for resilience and sustainability, consisting of the analogue vector, the Climprospect methodological framework, the resilience triangle, the resilience trajectory segments and the Badolo model for resilience patterns. The implementation of the Badolo class of tools generates categories of information for resilience objectives which are based on contextual capacities for action and resilience needs and priorities. These include a number of direct and indirect impacts, sets of vulnerability factors, resilience solutions and vulnerability indicators. These sets are characterized by their multi-dimensional and multi-hazard approaches, by the inclusion of indirect impacts, gender issues and contextual specificities. Basically, an integration of the decision-support tools we addressed will make available for Burkina Faso resilience schemes governed by criteria of relevance, efficiency and performance. Such schemes make it possible to break down complex resilience trajectories into segments of less complex resilience trajectories, requiring less effort and investment.

Keywords: *climate change, decentralization, territorial resilience in Burkina Faso*

Cite This Article: Mahamadou Yorke Ouédraogo, and Arnaud Ouédraogo, "Climate Change, Decentralization and Territorial Resilience in Burkina Faso: Case of the Center-West Region (Burkina Faso)." American Journal of Environmental Protection, vol. 11, no. 2 (2023): 41-48. doi: 10.12691/env-11-2-2.

1. Introduction

Contemporary climate change is one of the many obstacles to the socio-economic development of sub-Saharan populations [1]. The increase in the frequency and intensity of several types of extreme weather events is causing irreversible impacts pushing natural and human systems beyond their adaptation limits [2]. Previous studies show that societies that are most vulnerable to climate change are deprived of the resources to prepare and adapt [3].

In Burkina Faso, the intensification of disaster risks, climate change and security risks threaten the economic, social, environmental, infrastructural, institutional and political spheres [4,5]. Burkina Faso, like many Sahelian countries, is facing the effects of climate change, exposing it to the risk of food insecurity [6].

To protect Burkina Faso's development achievements and prospects, these threats should be considered in political, economic and social governance schemes, on the basis of robust, scientifically-based decision-making tools [5]. In so doing, these plans must be based on good governance that takes account of local realities and the close involvement of stakeholders. The process of decentralization throughout the world, although it takes a variety of forms, remains closely linked to national political and administrative contexts. Above all, it is about recognising the role of local stakeholders in development processes [7]. In this paper, we suggest an approach, methodologies and decision-support tools for developing political, economic and social governance schemes for efficient management of the economic, social and political threats caused by disaster risks, climate change and security risks for Burkina Faso [8-12]. The scientific framework in the paper is the Badolo class of tools for resilience and sustainability, consisting of the analogue vector, the Climprospect methodological framework, the resilience triangle, the resilience trajectory segments and the Badolo model for resilience schemes.

The analogous vector is used to formulate multidimensional resilience processes; the Climprospect

methodological framework includes an algorithm for mapping the direct and indirect impacts of climate risks, an algorithm for mapping vulnerability factors to climate risks and an algorithm for mapping resilience solutions [13].

The resilience triangle is a tool for information, dialogue and participatory consultation on resilience; the resilience trajectory segments are specific resilience paths governed by specific resilience objectives; the Badolo resilience model is a tool for establishing and implementing contextual resilience schemes.

The implementation of the Badolo class of tools generates bodies of information for contextual resilience processes based on local capacities for action and resilience needs and priorities. These include families of direct and indirect impacts, families of vulnerability factors and families of resilience solutions. These families of information can be used to formulate resilience plans which take account of contextual specificities, limitations, strengths and weaknesses.

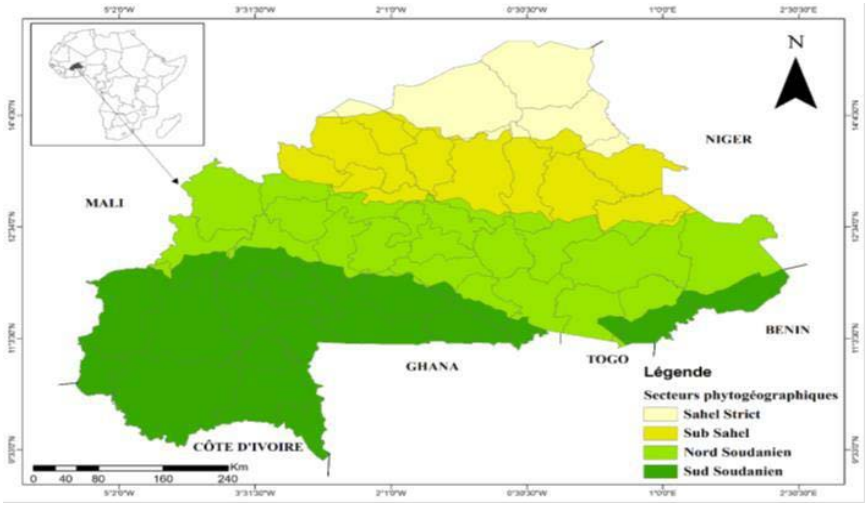
Overall, the Badolo class of tools underpins management by resilience and sustainability objectives. It is characterised by a multi-dimensional, multi-hazard approach that incorporates indirect or contextual impacts. It makes it possible to formulate resilience dynamics that meet the requirements of relevance, efficiency and performance.

2. Materials and Methods

The methodological framework of this article is the Badolo class of tools, which comprises five specific tools: the system vector, the Climprospect methodological tool, the resilience triangle, the resilience trajectory segments and the Badolo model of resilience and sustainability.

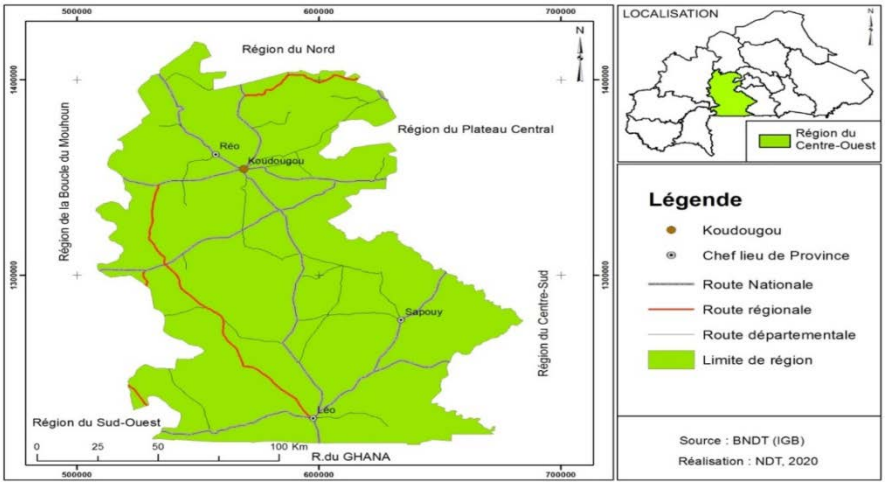
2.1. Geographical Context of the Study Area

The study was carried out in Burkina Faso in the sub-Saharan region of West Africa. It is located between 9° and 15° north latitude and 3° and 6° west longitude. Burkina Faso has a predominantly Sudano-Sahelian tropical climate, with a long dry season alternating with a short rainy season. Burkina Faso is subdivided into two phytogeographical domains based on the climate-flora-vegetation trilogy (Figure 1).



Source: Excerpt, MECV, 2007

Figure 1. Phytogeographical regions in Burkina Faso



Source: BNDT/ NDT, 2020

Figure 2. Location of the Region center-west in the Burkina Faso

The study was carried out more precisely in the Center-West region. The Center-West region is one of the thirteen regions of Burkina Faso. It is located between 11° and 12°50 north latitude and between 1°30 and 3° west longitude. Its capital, the town of Koudougou is located 100 km from Ouagadougou, capital of Burkina Faso. The region covers an area of 21,891 km², which represents 8% of the national territory.

Bordering with a neighboring country and 6 regions of the country (Figure 2), it is delimited as follows :

- to the south by the Republic of Ghana;
- to the north by the Northern region;
- to the East by the Centre-South and Center regions;
- to the west by the Boucle du Mouhoun and South-West regions;
- to the northeast by the Central Plateau region.

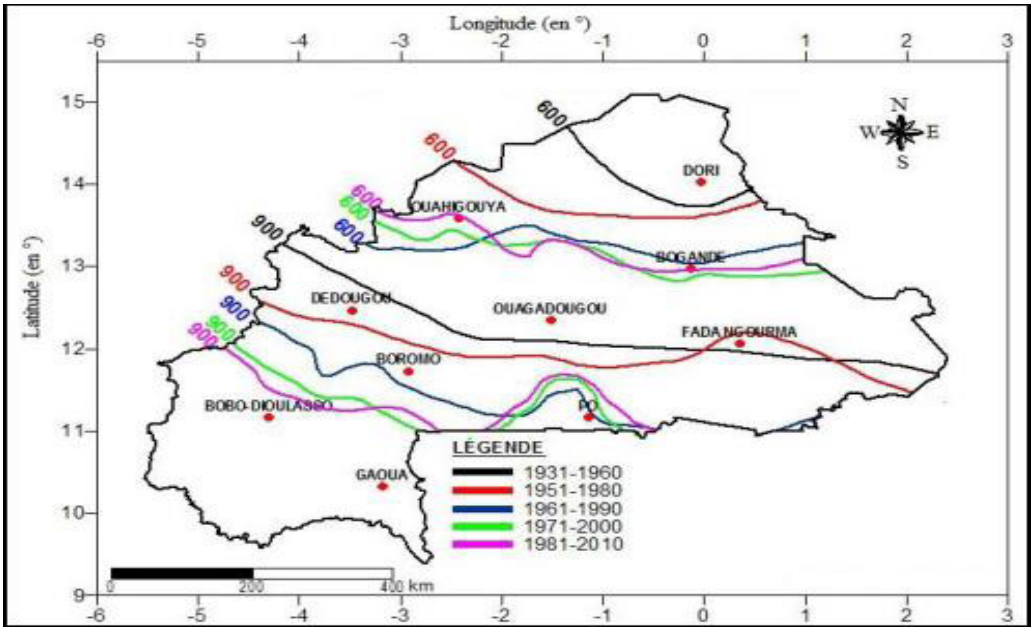
The Center-West region brings together the provinces of Boulkiemdé, Sanguié, Sissili and Ziro with respectively the towns of Koudougou, Réo, Léo and Sapouy as capitals. It has four (04) urban communes, thirty-four (34) rural communes and 595 administrative villages.

Rainfall in Burkina Faso, as in most Sudano-Sahelian countries, is linked to the monsoon season. Rainfall is unevenly distributed. Generally speaking, rainfall decreases from south to north (Figure 3).

The population of Burkina Faso was estimated at 20,487,979 in 2021 [14] with an average density of 65 inhabitants/km^2.

2.2. Analogue Vector

In the implementation of the Badolo class of tools, a vector e = e (e1,..., en) of dimension n is associated with the system S considered for the resilience pathways. Its components are specified components or dimensions of S. In practice, the vector e allows a multidimensional approach to resilience or sustainability issues.



Source : National Meteorological Department (Burkina Faso), 2015

Figure 3. Migration of 600 and 900 mm isohyets in Burkina Faso

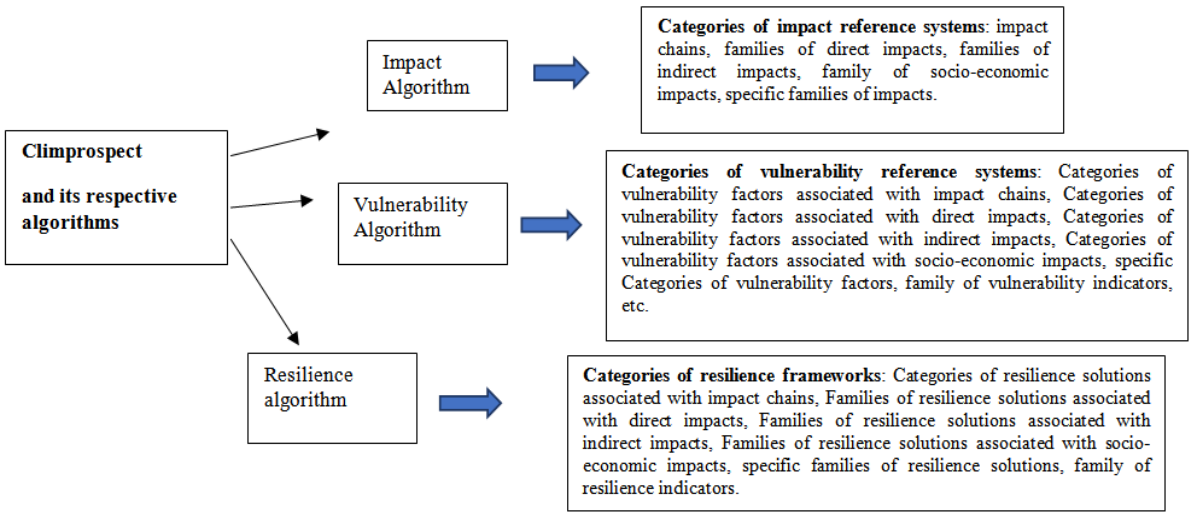


Figure 4. Climprospect and its algorithms

2.3. Climprospect Methodological Tool

Figure 4 illustrates the Climprospect methodological framework and its three algorithms, the direct and indirect impacts algorithm, the vulnerability algorithm and the resilience solutions algorithm [9] [15,16,17] [12]. ClimProspect is used to establish families of impacts, families of vulnerability factors and families of resilience solutions.

2.4. Resilience Triangle

Figure 5 illustrates the structure of a resilience triangle. It is a tool for information, dialogue, consultation and decision-making. For a given development sector in a specified context, the resilience triangle comprises the corpus of direct and indirect impacts of climate risks, the corpus of vulnerability factors to climate risks and the corpus of resilience solutions. The resilience triangle provides information for short-term, medium-term and long-term resilience processes.

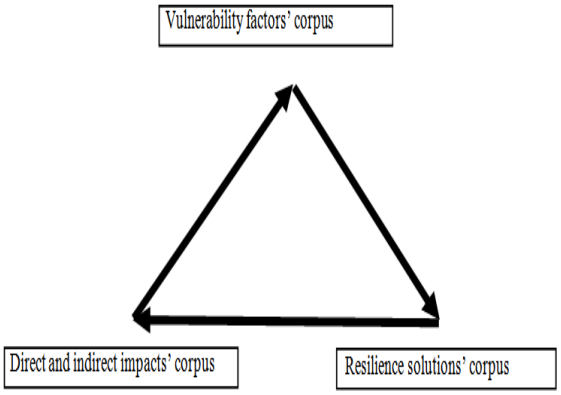


Figure 5. Resilience triangle's information corpus

2.5. Resilience Trajectory Segments

In practice, it may be more appropriate to achieve resilience configurations to a given risk by resilience trajectory segments. Each resilience trajectory segment achieves a partial resilience configuration by mitigating impacts under a given subset of impacts. The efforts required for a resilience trajectory segment are focused on the sub-set of impacts considered. This approach includes investments in resilience and sustainability.

2.6. Badolo Model for Resilience and Sustainability

Figure 6 illustrates the structure of the components of the Badolo model for resilience and sustainability. The Badolo model is a tool for developing, implementing, monitoring and evaluating specific resilience schemes. To do this, it integrates the categories of information generated by climprospect.

3. Results

In the developments, we propose an analogous vector e of dimension five (05) which refers to Burkina Faso. It subdivides into five sectors:

- e1 = economic sector
- e2 = basic social services sectors
- e3 = natural resource sector
- e4 = socio-economic infrastructure sector
- e5 = institutional organisation sector

An envelope ṙ of disaster risks, current and future climate risks and security risks is associated with the analogous vector (e). In practice, the ṙ envelope, which forms the basis of the multi-risk nature of the decision support tools that are going to be proposed, is developed in a participatory manner.

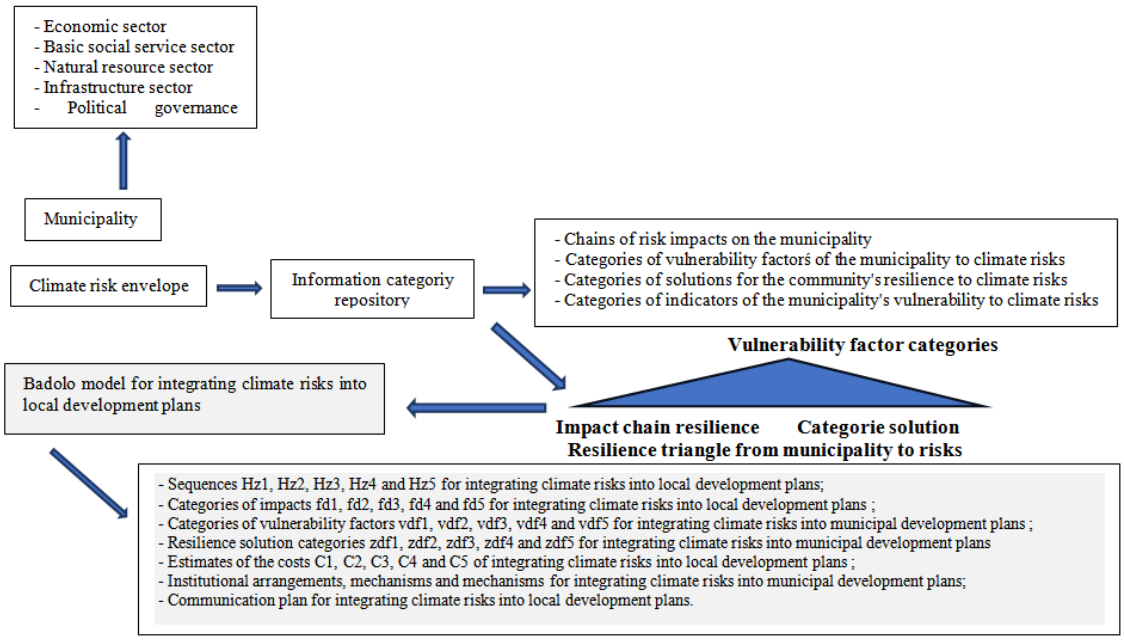


Figure 6. Badolo diagram for risk integration

3.1. Impact Chains

The impact of one ṙ envelope of risks on a given system generates successive repercussions, which may be economic, social, environmental, institutional or political [12,13]. An impact chain comprises the impact and its various consequences [9]. For Burkina Faso, five impact chains of length (p) are established for the ṙ envelope :

- *ce1 ≡ e1d0, e1d1, ..., e1dp*
- *ce2 ≡ e2d0, e2d1, ..., e2dp*
- *ce3 ≡ e3d0, e3d1, ..., e3dp*
- *ce4 ≡ e4d0, e4d1, ..., e4dp*
- *ce5 ≡ e5d0, e5d1, ..., e5dp*

In an impact chain : a) do is the direct impact and b) dj (j=1, ..., p) is the indirect impact of order (j). It is the result of impact d(j-1).

Indirect impacts indicate Burkina Faso's contextual vulnerability to disaster risks, climate change and security risks.

3.2. Impact Categories

For decision-making purposes, impact chains are used to draw up impact categories. An impact category refers to all five sectors in Burkina Faso and is made up of impacts of the same order. The different impact categories for impact chains of length p = 5 are :

- *fdo, = {e1d0, e2do, e3do, e4d0, e5do}*
- *fd1 = {e1d1, e2d1, e3d1, e4d1, e5d1}*
- *fd2 = {e1d2, e2d2, e3d2, e4d2, e5d2}*
- *fd3 = {e1d3, e2d3, e3d3, e4d3, e5d3}*
- *fd4 = {e1d4, e2d4, e3d4, e4d4, e5d4}*
- *fd5 = {e1d5, e2d5, e3d5, e4d5, e5d5}*

In a multidimensional approach to resilience, impact mitigation actions include manay impacts known as of impact categories.

3.3. Vulnerability Categories

In practice, a risk impact is mitigated by reducing a specific subset of vulnerability factors. In the proposed approach, each category of impacts fdj (j = 0, ..., 5) is associated with a category of vulnerability factors vfdj (j = 0, ..., 5) which indicate the vulnerability to be reduced in order to mitigate the impacts under the impact category . Formally, the categories of vulnerability factors for Burkina Faso consist as follows :

- *vfdo = {ve1d0, ve2do, ve3do, ve4d0, ve5do}*
- *vfd1 = {ve1d1, ve2d1, ve3d1, ve4d1, ve5d1}*
- *vfd2 = {ve1d2, ve2d2, ve3d2, ve4d2, e5d2}*
- *vfd3 = {ve1d3, ve2d3, ve3d3, ve4d3, ve5d3}*
- *vfd4 = {ve1d4, ve2d4, v e3d4, v e4d4, ve5d4}*
- *vfd5 = {ve1d5, ve2d5, ve3d5, ve4d5, ve5d5}*

The elements of a category of vulnerability factors may be biophysical, economic, social, environmental, scientific, technological, institutional or political. If necessary, we could also consider structural vulnerability, vulnerability relating to early warning, vulnerability relating to response and recovery.

3.4. Resilience Solution Category

Resilient solutions are solutions for reducing vulnerability. They are essentially contextual and relative. For each category vfdj (j = 1, ..., 5) of vulnerability factors, a category of resilience solutions zfdj (j = 0, ..., 5) is developed. Formally, the categories of resilience solutions for Burkina Faso include the following elements :

- *zfd0 = {ze1d0, ze2do, ze3do, ze4d0, ze5do}*
- *zfd1= {ze1d1, ze2d1, ze3d1, ze4d1, ze5d1}*
- *zfd2 = {ze1d2, ze2d2, ze3d2, ze4d2, ze5d2}*
- *zfd3 = {ze1d3, ze2d3, ze3d3, ze4d3, ze5d3}*
- *zfd4 = {ze1d4, ze2d4, ze3d4, ze4d4, ze5d4}*
- *zfd5 = {ze1d5, ze2d5, ze3d5, ze4d5, ze5d5}*

Resilience solutions can be biophysical, economic, social, environmental, scientific, technological, institutional or political. They can also be structural solutions, early warning solutions, response solutions or recovery solutions.

3.5. Resilience Triangle

Figure 7 shows a resilience triangle for Burkina Faso with the ṙ envelope of disaster risks, climate risks and security risks. It is a synthesis, for information, of families of impacts, families of vulnerabilities and families of resilience solutions.

It sets out the challenges posed by disaster risks, climate change and security risks, as well as the guidelines for meeting these challenges and the solutions to be implemented.

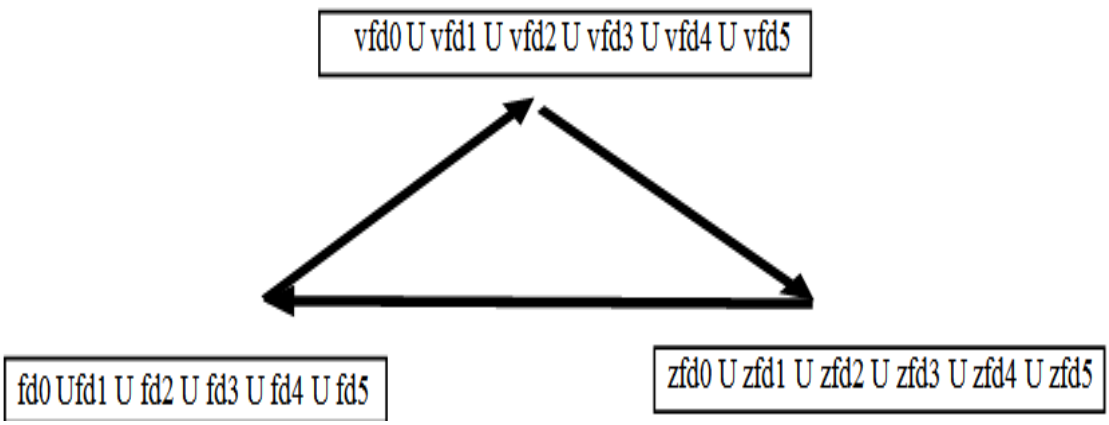


Figure 7. Resilience triangle information categories

3.6. Partial Configurations and Resilience Trajectories

For Burkina Faso, resilience horizons that could be envisaged are:

- fdo, = {e1d0, e2do, e3do, e4d0, e5do} ≈ ø
- fd1 = {e1d1, e2d1, e3d1, e4d1, e5d1} ≈ ø
- fd2 = {e1d2, e2d2, e3d2, e4d2, e5d2} ≈ ø
- fd3 = {e1d3, e2d3, e3d3, e4d3, e5d3}≈ ø
- fd4 = {e1d4, e2d4, e3d4, e4d4, e5d4} ≈ ø
- fd5 = {e1d5, e2d5, e3d5, e4d5, e5d5} ≈ ø

The resilience trajectory segments for these resilience horizons are:

- Trajectory segments 1 : Pz1 (fd5, vfd5, zfd5) = *ez1, définie par fd5 ≈ ø*
- Trajectory segment 2 : Pz2 (fd5, vfd5, zfd5) = *ez2, définie par fd4 ≈ ø*
- Trajectory segment 3 : PZ3 (fd5, vfd5, zfd5) = *ez3, définie par fd3 ≈ ø*
- Trajectory segment 4 : PZ4(fd5, vfd5, zfd5) = *ez4,defined as fd2 ≈ ø*
- Trajectory segment 5 : PZ5(fd5, vfd5, zfd5) = *ez5, defined as fd1 ≈ ø*
- Trajectory segment 6 : PZ6 (fd5, vfd5, zfd5) = *ez6, defined as fd0, ≈ ø*

Resilience trajectory segments are functions whose independent variables are a category of impacts, vulnerability factors and resilience solutions. Theoretical analyses show that performance is enhanced if the first resilience trajectory segment relates to the last category of impacts.

3.7. Vulnerability Indicators

For each component e1, e2, e3, e4 and e5, a vulnerability indicator was suggested:

- For e1 = economic sector, the proportion of agricultural sector funding allocated to rainfed agricultural production
- For e2 = basic social service sectors, proportion of population in the basic education sector without access to learning continuity mechanisms in disaster risk situations
- For e3 = natural resource sector, the proportion of the natural resources population whose management policies do not explicitly incorporate disaster risks, climate change and security risks.
- For e4 = socio-economic infrastructure sector, proportion of pollution from socio-economic infrastructure whose design and construction do not explicitly take disaster risks into account.
- For e5 = institutional structure sector, the proportion of the public instruction population that has not integrated disaster risk continuity mechanisms

3.8. Political, Economic and Social Governance

On the basis of the capacity, needs and priorities for Burkina Faso's resilience to disaster risks, climate change and security risks, the suggested categories of information can be used to draw up a political, economic and social governance plan for Burkina Faso's resilience and sustainability. The variables in such a framework consist as follows**:**

- Horizons of Resilience categories
- Resilience trajectories categories
- Monitoring, evaluation and accountability systems
- Institutional mechanisms for resilience
- Social mobilisation mechanisms for resilience and sustainability
- Mechanisms for mobilising partnerships
- Mechanisms for mobilising financial resources.

4. Discussion

The categories of impacts address the relevance of resilience schemes in relation to the needs and priorities of political, social and economic resilience in Burkina Faso. The impact chains include the direct impacts of climate risks and the indirect impacts, which are the successive consequences of the direct impacts. Specifically, indirect impacts indicate the economic, social, environmental, institutional or political changes induced by the impacts of the risks.

Impact chains can be used to identify the social groups in Burkina Faso most affected by the direct or indirect impacts of disaster risks, climate change and security risks, and to develop integrated economic and social resilience processes. These processes must be made in a well-structured framework such as decentralization. Indeed, the implementation of development processes has been highlighted by institutions such as the World Bank and other development agencies, which have associated it with the notion of "good governance" [18]. However, the question of the appropriate scale at which it should be implemented often remains unanswered [19], as does the question of the dynamics of the networks that will drive it [20]. To this end, decentralization has been presented as being capable of creating a relevant framework for the implementation of local development, by providing an appropriate institutional framework, networks of stakeholders and a model of local governance [21,22].

In a given context, the direct and indirect impacts of a climate risk connect all the dimensions of the systems to be considered in resilience processes. Impact categories are therefore a particularly appropriate body of information for initiating multidimensional resilience processes to mitigate direct or indirect impacts.

Impact categories can be used to specify resilience horizons, depending on resilience priorities and capacities for action in a given context.

The categories of vulnerability factors and those of resilience solutions form the basis of the efficiency of resilience schemes based on the Badolo class of tools. In practice, reducing vulnerability will help mitigate the direct and indirect impacts of climate risks. The categories of information collected through Climprospect methodological framework are the bodies of vulnerability factors to be addressed in order to mitigate the impacts under the categories of impacts. The approach to developing categories of resilience solutions is the basis for their effectiveness in reducing vulnerability.

For Burkina Faso, the resilience triangle is a tool for information, dialogue and consultation to create a collective and participatory dynamic for resilience and sustainability. Regular communication makes it possible to maintain trust, transparency and authenticity of information in order to create and maintain healthy and dynamic relationships [23]. The categories of information that make it up provide information on the direct and indirect impacts of the ŕ envelope of risks, the vulnerability to the ŕ envelope of risks and the resilience solutions to be envisaged. Depending on resilience needs and priorities and capacity for action, iterative resilience processes can be developed and implemented to move towards partial resilience configurations.

In the global approach we are proposing through the Badolo class of tools, a resilience trajectory segment implements efforts and resources for a specific resilience objective linked to a given category of impacts. The result is a continuous relevance of the overall resilience trajectory. In contexts with limited capacities and resources for resilience to climate change, the resilience segment approach is particularly appropriate. It breaks down, by resilience horizon, the efforts and resources to be mobilised for resilience.

The need to improve resilience practices and solutions in the context of increasing disaster risk and climate change, as suggested in the scientific literature, has been addressed in this article [24,25,11,12]. The theoretical, methodological and decision-making elements proposed here are a new contribution in terms of improving the relevance, efficiency and performance of interventions for resilience and sustainability. The scope of the approach and reference frameworks suggested in this article could be improved by explicitly taking gender issues into account, and by favoring the participation and contribution of the populations affected by resilience processes.

In practice, resilience trajectory segments can be gradually implemented while integrating climate change into development policies and programmes [8,12]. The categories of information proposed can be used in this way, depending on the capacities and resources of the socio-economic context under consideration.

5. Conclusion

This paper aimed to suggest an approach, methodologies and decision-making tools for the development of policy governance schemes for the efficient management of the economic, social and political threats posed by disaster risks, climate change and security risks for Burkina Faso. The scientific framework of the paper is the class of Badolo tools for resilience and sustainability.

The main results proposed include categories of direct and indirect impacts, vulnerability factors, resilience solutions, a vulnerability indicator framework and a reference framework for political, economic and social governance schemes for resilience and sustainability. In Burkina Faso, if the results proposed in this paper are to be implemented, the interfaces between the spheres of governance and the centres of scientific research will have to be consolidated in order to meet the needs of development actors for confidence, information and skills in relation to categories of direct and indirect impacts, vulnerability factors, resilience solutions and resilience schemes.

In the context of Burkina Faso, efficient and effective policies for managing the threats caused by disaster risks, climate change and security risks will require specific scientific research efforts, new practices for transferring trust and skills, and new interactions between political spheres and scientific research centres.

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