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Andreea-Loreta CERCLEUX¹

O POVESTE CONTINUĂ DE 75 DE ANI PE HARTA ȘTIINȚEI

Anul 2026 este un an extrem de important pentru revista științifică *Analele Universității din București. Geografie*. Publicația cu cea mai îndelungată istorie din cadrul Facultății de Geografie a Universității din București împlinește trei sferturi de veac de apariție editorială neîntreruptă. Fondată în anul 1952 sub denumirea de *Revista Universității C.I. Parhon și a Politehnicii București – seria Științe ale Naturii*, publicația a reunit încă de la primele sale volume și abordări din cadrul științelor pământului redactate în limba română și însoțite de rezumate în franceză și rusă. Parcursul revistei și al volumului dedicat ulterior doar Geografiei au oglindit transformările administrative ale universității, dar și procesul de diversificare pe domenii științifice. Prin urmare, denumirea revistei a cunoscut modificări succesive: în perioada 1956-1961 revista a purtat denumirea de *Analele Universității C.I. Parhon București*; la începutul anilor 1960 a apărut o serie separată pentru domeniul Geologie-Geografie și spre sfârșitul acestui deceniu una doar pentru Geografie; din 1962, noul titlu al revistei devine *Analele Universității din București*, titlu purtat până în prezent.

Primul volum dedicat exclusiv domeniului Geografie, volumul XVII, a văzut lumina zilei în anul 1969 în urma procesului de diversificare științifică a științelor naturii, intitulându-se *Analele Universității din București. Geografie*.

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Această etapă de maturizare a permis acoperirea exhaustivă în timp a diverselor subramuri din sferele geografiei fizice și umane, alături de abordări de mediu, prin integrarea de contribuții fundamentale ale unor profesori remarcabili și cercetători de renume din comunitatea academică românească și de peste hotare. Din diferite motive, unele volume din doi ani consecutivi au fost ocazional îmbinate într-o singură publicație. Tranziția către modernitate a fost marcată în ultimele decenii prin publicarea unor volume tematice de înaltă valoare științifică, precum cel dedicat celebrării centenarului învățământului geografic bucureștean în anul 2000 sau unele volume legate de manifestări științifice internaționale de anvergură. Structura volumului s-a diversificat substanțial cu trecerea anilor prin inserarea unor secțiuni complementare, precum recenzii și prezentări ale unor evenimente științifice, concomitent cu deschiderea către internaționalizare prin redactarea materialelor în limbile de circulație mondială, respectiv engleză și franceză, venite atât din partea autorilor români, cât și din străinătate.

Site-ul dedicat revistei, lansat în anul 2011, a îmbunătățit interacțiunea cu cititorii și a simplificat fluxul editorial pentru potențialii autori. Revista este indexată în diferite baze de date internaționale și garantează alocarea codurilor DOI prin intermediul platformei CROSSREF pentru toate materialele științifice publicate.

La aniversarea celor 75 de ani, urăm un călduros "La mulți ani" și viață lungă revistei *Analele Universității din București. Geografie*! Un parcurs de succes, cu noi ediții captivante care să inspire în continuare comunitatea academică!

A CONTINUOUS 75-YEAR STORY ON THE MAP OF SCIENCE

The year 2026 is an extremely important milestone for the scientific journal *Analele Universității din București. Geografie* [*The Annals of the University of Bucharest. Geography Series*]. The publication with the longest history within the Faculty of Geography at the University of Bucharest celebrates three-quarters of a century of uninterrupted issuance. Founded in 1952 under

the title *Revista Universității C.I. Parhon și a Politehnicii București – seria Științe ale Naturii* [*The Journal of the C.I. Parhon University and the Bucharest Polytechnic – Natural Sciences Series*], the publication brought together, from its very first volumes, earth science approaches written in Romanian and accompanied by abstracts in French and Russian. The trajectory of the journal, and of the volume subsequently dedicated exclusively to Geography, mirrored both the administrative transformations of the university and the process of diversification into distinct scientific fields. Consequently, the journal's title underwent successive changes: between 1956 and 1961, it was named *The Annals of the C.I. Parhon University of Bucharest* [*Analele Universității C.I. Parhon București*]; in the early 1960s, a separate series emerged for the field of Geology-Geography, and by the late 1960s, a dedicated series for Geography alone was established; since 1962, the journal has borne its current title, *Analele Universității din București* [*The Annals of the University of Bucharest*].

The first volume dedicated exclusively to the field of Geography, volume XVII, was published in 1969 following the scientific diversification of the natural sciences, under the title *Analele Universității din București. Geografie* [*The Annals of the University of Bucharest. Geography Series*]. This stage of maturation has enabled a comprehensive long-term coverage of various subfields within physical and human geography, alongside environmental approaches, by integrating fundamental contributions from remarkable professors and renowned researchers from both the Romanian and international academic communities. Due to different reasons some volumes of two consecutive years were occasionally combined into a single publication. The transition toward modernity has been marked in recent decades by the publication of highly scientific valuable thematic volumes, one dedicated to celebrating the centenary of Bucharest geographical education in 2000 and some other volumes related to some major international scientific events. The structure of the volume has diversified substantially over the years through the inclusion of complementary sections, such as book reviews and reports on scientific events, concurrently with a shift toward internationalization by publishing papers in international languages – specifically English and French—from both Romanian and foreign authors.

The journal's dedicated website, launched in 2011, enhanced reader engagement and streamlined the editorial workflow for prospective authors. The journal is indexed in various international databases and guarantees the allocation of DOI codes through the CROSSREF platform for all published scientific materials.

On the occasion of its 75th anniversary, we wish a warm 'Happy Anniversary' and long life to the journal *Analele Universității din București. Geografie* [*The Annals of the University of Bucharest. Geography Series*]. May our journal have a successful journey ahead, with captivating new editions that continue to inspire the academic community!

UNE HISTOIRE CONTINUE DE 75 ANS SUR LA CARTE DE LA SCIENCE

L'année 2026 revêt une importance capitale pour la revue scientifique *Analele Universității din București. Geografie* [*Annales de l'Université de Bucarest. Série Géographie*]. La publication qui possède la plus longue histoire au sein de la Faculté de Géographie de l'Université de Bucarest célèbre trois quarts de siècle de parution éditoriale ininterrompue. Fondée en 1952 sous le nom de *Revista Universității C.I. Parhon și a Politehnicii București – seria Științe ale Naturii* [*Revue de l'Université C.I. Parhon et de l'École Polytechnique de Bucarest – série Sciences de la Nature*], la publication a réuni, dès ses premiers volumes, des approches des sciences de la Terre rédigées en langue roumaine et accompagnées de résumés en français et russe. Le parcours de la revue, ainsi que celui du volume dédié ultérieurement à la Géographie, ont reflété les transformations administratives de l'université, mais aussi le processus de diversification par domaines scientifiques. Par conséquent, la dénomination de la revue a connu des modifications successives : au cours de la période 1956-1961, la revue a porté le nom de *Analele Universității C.I. Parhon București* [*Annales de l'Université C.I. Parhon de Bucarest*] ; au début des années 1960, une série distincte est apparue pour le domaine Géologie-Géographie et, vers la fin

de cette décennie, une série consacrée uniquement à la Géographie ; depuis 1962, le nouveau titre de la revue devient *Analele Universității din București* [*Annales de l'Université de Bucarest*], titre qu'elle porte encore aujourd'hui.

Le premier volume exclusivement dédié au domaine de la Géographie, le volume XVII, a vu le jour en 1969, à la suite du processus de diversification des sciences de la nature, sous le titre *Analele Universității din București. Geografie* [*Annales de l'Université de Bucarest. Série Géographie*]. Cette étape de maturation a permis de couvrir de manière exhaustive, au fil du temps, les diverses branches de la géographie physique et humaine, ainsi que les approches environnementales, en intégrant les contributions fondamentales de professeurs remarquables et de chercheurs de renom issus de la communauté académique roumaine et internationale. Pour diverses raisons, certains volumes de deux années consécutives ont parfois été regroupés en une seule publication. La transition vers la modernité a été marquée, au cours des dernières décennies, par la publication de volumes thématiques d'une haute valeur scientifique, dont un consacré à la célébration du centenaire de l'enseignement géographique de Bucarest en 2000 et d'autres volumes liés à d'importants événements scientifiques internationaux. La structure du volume s'est considérablement diversifiée au fil des ans par l'insertion de sections complémentaires, telles que des comptes rendus des livres et des présentations d'événements scientifiques, parallèlement à une ouverture vers l'internationalisation à travers la rédaction des contributions dans des langues de circulation internationale, à savoir l'anglais et le français, provenant d'auteurs tant roumains qu'étrangers.

Le site internet dédié à la revue, lancé en 2011, a amélioré l'interaction avec les lecteurs et a simplifié le flux éditorial pour les auteurs potentiels. La revue est indexée dans diverses bases de données internationales et garantit l'attribution de codes DOI via la plateforme CROSSREF pour tous les travaux scientifiques publiés.

À l'occasion de ce 75^e anniversaire, nous souhaitons un chaleureux « Joyeux anniversaire » et une longue vie à la revue *Analele Universității din București. Geografie* [*Annales de l'Université de Bucarest. Série Géographie*] ! Nous lui souhaitons un parcours couronné de succès, jalonné de nouvelles éditions captivantes qui continueront d'inspirer la communauté académique !

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MIGRATION DRIVERS FROM RURAL SENEGAL TO DAKAR: LACK OF JOBS IN A CLIMATE CHANGE SCENARIO

Abstract. Migration is a form of adaptation to climate change, the most relevant environmental problem that humanity faces at the moment. We aimed to improve our knowledge on the perceptions about migration drivers of people emigrating from rural areas suffering land degradation and to characterize their social profiles and their migration projects. With this aim, internal migrations from rural areas to Dakar (Senegal) were chosen as our study system. We carried out a survey to immigrant workers in Dakar. We hypothesized that internal migrations in Senegal would be induced by multiple factors, with environmental conditions related to desertification and climate change playing important roles. Internal migrations from Senegalese rural areas to Dakar were mostly concentrated in arid and semi-arid regions. Lack of job opportunities was the dominant driver of migration. However, land degradation and climate change were not the main perceived drivers of migration, immigrants in Dakar thought that the climate was changing. These perceptions of climate change depended on gender and on the place of origin of immigrants in Dakar. The vast majority of respondents (85%) thought the climate was changing, but there were differences between the perception of people from arid zones and those from humid areas. Restoration efforts on degraded land are needed to fight desertification, increase social and ecosystem resilience, and increase job opportunities in rural areas.

Keywords: drought, ethnic group, land degradation, survey

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1. Introduction

Climate change is the most relevant environmental problem that humanity faces at the moment. Human activities will cause +1.5°C of global warming above pre-industrial levels between 2030 and 2052 if it continues to increase at the current rate. The consequences of global warming are multiple and closely related, including increases in mean temperature, extremes of high temperature, heavy precipitation and drought (Intergovernmental Panel on Climate Change, 2018). In this global environmental crisis, drylands are especially threatened by land degradation in the form of desertification, in addition to climatic disturbances such as drought, dust storms, heat waves and extreme rainfalls (Pravalie, 2016). So, there is a need for change in land management practices to address the challenges of climate change adaptation (Smith et al., 2020).

In the context of climate change, migration is a form of adaptation (Black et al., 2011; Cattaneo et al., 2019). Environmental migrants are increasing since more people can no longer gain a secure livelihood in their homelands because land degradation in the form of desertification and other environmental problems (McLeman & Gemenne, 2018). Moreover, environmental problems are aggravated by socioeconomic problems such as poverty, making migrations complex multi-causal processes (Henry et al., 2003; McLeman, 2014). The numbers of environmental migrants may swell dramatically with increasing desertification and global warming (Castillo, 2011). In fact, gradual environmental degradation such a desertification influence more on environmental migrations than extreme meteorological events such as severe droughts (Henry et al., 2004). However, there is no consensus about the role of environmental change in shaping migration decisions, and little is known about the perceptions of migrants about climate change and the relationship with that and the perceived causes driving migration (Koubi et al., 2016; Shi et al., 2019). In fact, the adaptive role of subsistence farmers, a vulnerable population who often migrates, is largely overlooked (Tschakert, 2007).

The main aim of our study was to improve our knowledge on the perceptions about migration drivers of people emigrating from rural areas suffering desertification and to characterize their social profiles and

their migration projects. With this aim, internal migrations from rural areas to the capital Dakar (Senegal, Sahel, Africa) were chosen as our study system. The severe Sahel droughts in the late 20th century were very harmful to both human societies and nature (Epule et al., 2014). Afterwards, however, although rainfall increased slightly in some areas, the Sahel's biodiversity continued to become impoverished (Walther 2016). Moreover, food yields remained low and tree mortality rates were still high denoting desertification (Epule et al., 2014). Peanut production fell to 18% from 1960s to 2002 (Faye et al., 2007). Decades of peanut monoculture and the lack of financing and means to diversify crops and improve agricultural techniques have depleted agricultural soils in Senegal (Ministry of Agriculture, 2008). Regional climate change promotes strong declines in the forest area, high erosion, salinization and overgrazing (Sambou et al., 2016, Capozzi et al., 2018;). As a consequence, overwhelmed by desertification and territorial pressure, many Senegalese rural residents are attracted to Dakar (Gueye et al., 2015; Food and Agriculture Organization, 2020). Internal, intra-African and international migrations are important in sub-Saharan Africa (Morrissey, 2014). These migrations have often a significant environmental component, among others including historical, political and socioeconomic drivers of migration (Beauchemin et al., 2018). Even from environmentally fragile areas, people have many different reasons to migrate, which often go beyond risk prevention and adaptation to environmental stress (van der Land et al., 2018). The future predictions based on global climate models indicate increasing temperatures, rainfall variability and aridity in the Sahel (Masih et al., 2014; IPCC, 2018). In this context, there is a potential risk of large-scale out-migrations if adaptation measures to combat desertification are not carried out (Lambin et al., 2014).

The aim of this study is to analyse the reasons behind internal migration from rural areas to the Senegalese capital, particularly those linked to climate change. The focus is on the social profiles of migrants, their migration plans and their strategies for integrating into urban life. We hypothesised that internal migration in Senegal is driven by multiple factors, with environmental conditions linked to desertification and climate change playing a significant role.

2. Material and Methods

Study area

Senegal is located in West Africa and has c. 18 million inhabitants with 45,3% living in rural areas (ANSD, 2023).

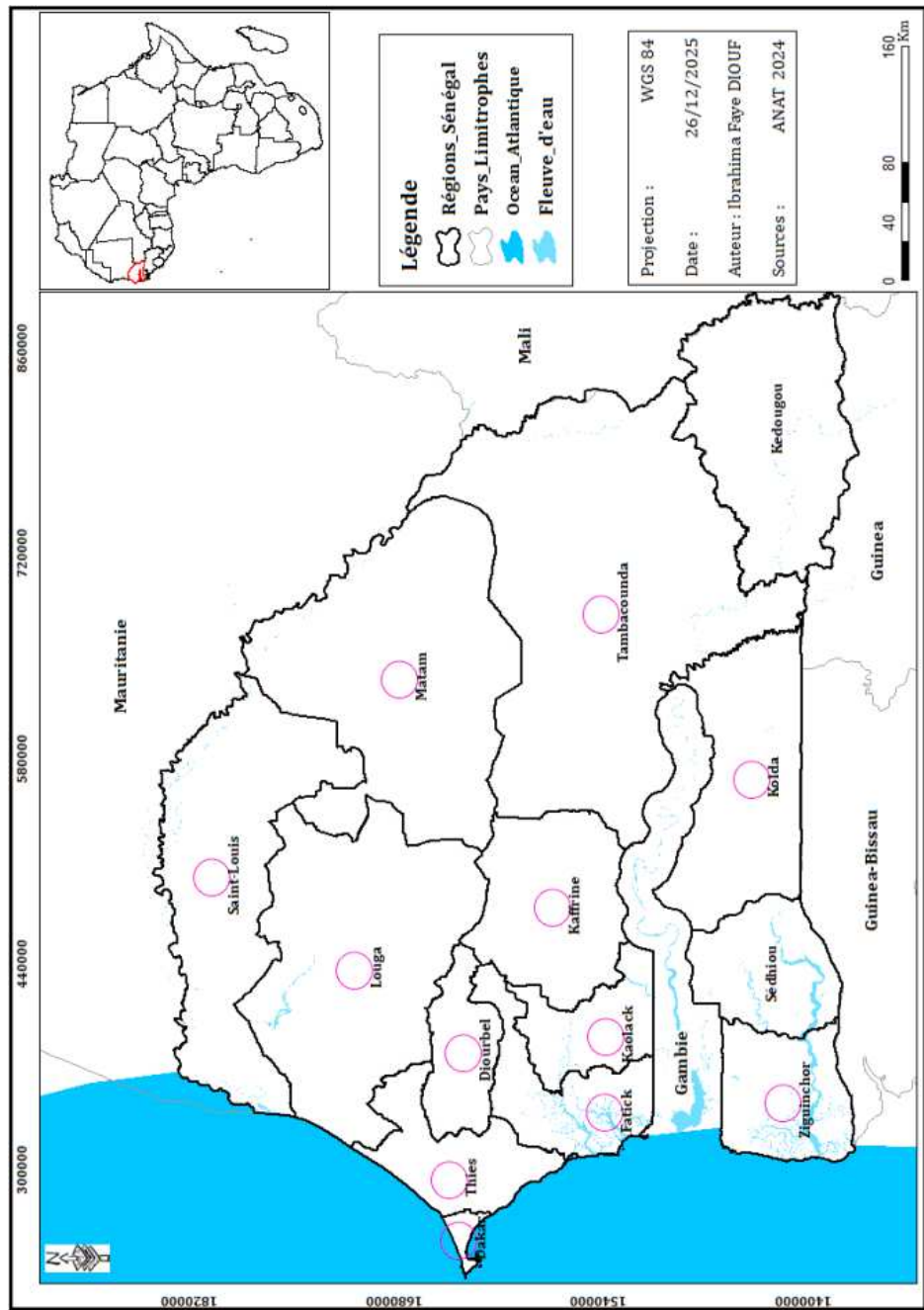
The economy of Senegal is predominantly rural. Agriculture employs over 70% of the labor force (Martin-Gutierrez et al., 2016). Most of the agriculture is based on small land properties. In large cities, c. 53% of the population works in street trading and other informal⁵ economic activities (ANSD, 2013). In addition, Senegalese fisheries generate a high economic value for local communities (Belhabib et al., 2014). Immigration has long been a permanent part of Senegal's history due to its colonial heritage, political stability and economic growth (Diatta & Mbow, 1999). In the last decades, north and central areas of Senegal have been suffering from severe land degradation and desertification due to multiple causes such as biological invasions, vegetation degradation, overgrazing and decreasing rainfall (Brandt et al., 2014; Herrmann et al., 2020).

Our work was carried out in the Senegalese capital Dakar (Figure 1). Dakar population has been growing markedly during the last decades, having 2318004 inhabitants in 2013 (ANSD, 2013) and 3215000 inhabitants in 2017 (Oficina de Información Diplomática, 2017), 4.004.426 inhabitants in 2023. Dakar is divided into 19 districts. Our survey was carried out in Ouakam District (14°43'26'' N, 17°29'21'' W) which occupies c. 500 ha with a growing population of c. 80000 inhabitants, (Ouakam District, 2016). The Ouakam District was chosen since it had a high rate of immigration compared to other districts in Dakar.

Survey instrument, organization and participants

A two-page questionnaire with 27 questions was developed as a quantitative survey instrument, primarily using a qualitative exploration of the thematic dimensions (Myers & Oetzel, 2003).

⁵ Informal employment: People are considered to be in informal employment if their employment is, in practice, not subject to national labour legislation, income tax, social security or entitlement to certain benefits (2019, ERI-ESI).



The questionnaire was developed by us following our knowledge about climate change and migrations and some recommendations of Haladyna and Downing (1989) about the format. The definitive survey was conducted after testing the questionnaire on one sampling day (December 7th 2017) in order to avoid possible misunderstandings in its implementation. The quantitative data date from 2017, prior to a series of global crises: the COVID-19 pandemic and political crises with their economic implications. In the current context, the results should be interpreted as reflecting migration dynamics prior to the aforementioned crises, providing a critical baseline against which more recent migration dynamics can be assessed, rather than as a direct description of current migration patterns.

The survey used multiple-choice questions in 21 items with a variable number of response categories according to the targets measured, and 6 open-ended questions (items 8, 10, 19, 21 and 27).

The survey was carried out by means of a street questionnaire at work places (mainly mobile stalls, manual car washes, and construction sites) in the Ouakam District (Dakar) between 9:00 am - 14:00 pm from December 8th to 19th 2017 (except on Sundays). Interviewees were chosen randomly among people who worked and lived in Ouakam District, and have migrated to Dakar. The overall interview usually required about 10 minutes. A total of 242 people were asked by trained interviewers to participate in the survey, with a response rate of 95% (a total of 231 completed questionnaires were ultimately obtained). This number of questionnaires was significantly representative of the estimated immigrant population in the Ouakam District (7615 inhabitants) with an error probability of 0.05, a standardized distance (Z) of 1.96, a population variance (V) of 0.15 and a precision error (E) of 0.05 (calculated using the free software MAS (Manzano-Arrondo, 2010)).

This work was supplemented by a qualitative and observational study in the municipality of Ouakam. Conducted in 2024, it focused on migrant populations.

Data analysis. The data collected was analyzed using SPSS v. 15.0. (SPSS Inc., Chicago, IL, USA). Deviations were calculated as the standard error of the mean (SE). A significance level of 0.05 was applied for every analysis. Data was tested for normality with the Kolmogorov–Smirnov

test and for homogeneity of variance with the Levene test. Since normality and/or homogeneity of variance were not reached and our dependent variables were discrete, differences in the answers to the survey between genders, ages, ethnic groups, arid and humid zones, and income levels before migrating were compared using the non-parametric Kruskal-Wallis test and Mann-Whitney U-test. The Spearman correlation coefficient (ρ) was applied to analyze the relationships between the answer to different questions.

3. Results

Socio-demographic profile of emigrants

The graph below clearly illustrates the socio-demographic profile and geographical origin of migrants.

Considering the socio-demographic variables, 83% of the respondents were men and 17% women. The majority of the respondents were between 26-40 years old (53%) (Figure 2A). The percentage of men was c. 25% higher in people younger than 40, whereas the number of women was c. 27% higher than the number of men in older than 40 (Kruskal-Wallis test, $\chi^2 = 15.901$, d.f. = 4, $P < 0.005$; U-test, $P < 0.05$). Most of the respondents were married (61%) (Figure 2B). Nevertheless, 69% of the respondents migrated alone. Relatively more men than women (75% vs 44%) migrated alone (Mann-Whitney test, U-test = 2573.000, $P < 0.0001$). Most of the respondents were born and migrated to Dakar from the Senegalese regions Diourbel (28%), Fatick (11%) and Thiès (10%) (Figure 2), and the foreign country that contributed the most immigrants was Guinea-Conakry (12%) (Figure 2C). The predominant ethnic group was Serer (41%) (Figure 2D), who came mostly from Diourbel Region (49%). On the other hand, 65% of respondents migrated directly to Dakar from their place of origin, and 77% of respondents had lived in Dakar for 1-10 years.

In their place of origin, 69% of respondents worked in the primary sector (agriculture and pastoralism), with the remainder working in sixteen other types of occupation. Only 3% were unemployed before migrating (Figure 3A).

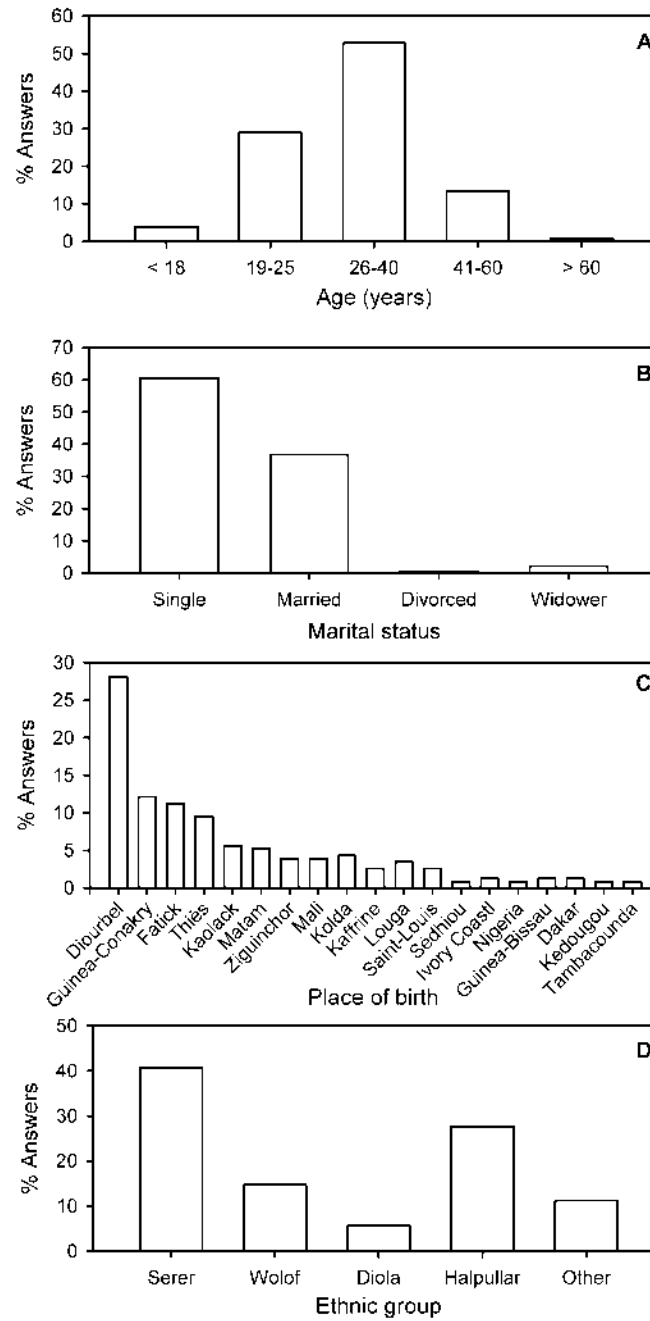


Figure 2. Socio-demographic profile and geographical origin
(Source: Field Survey, 2017)

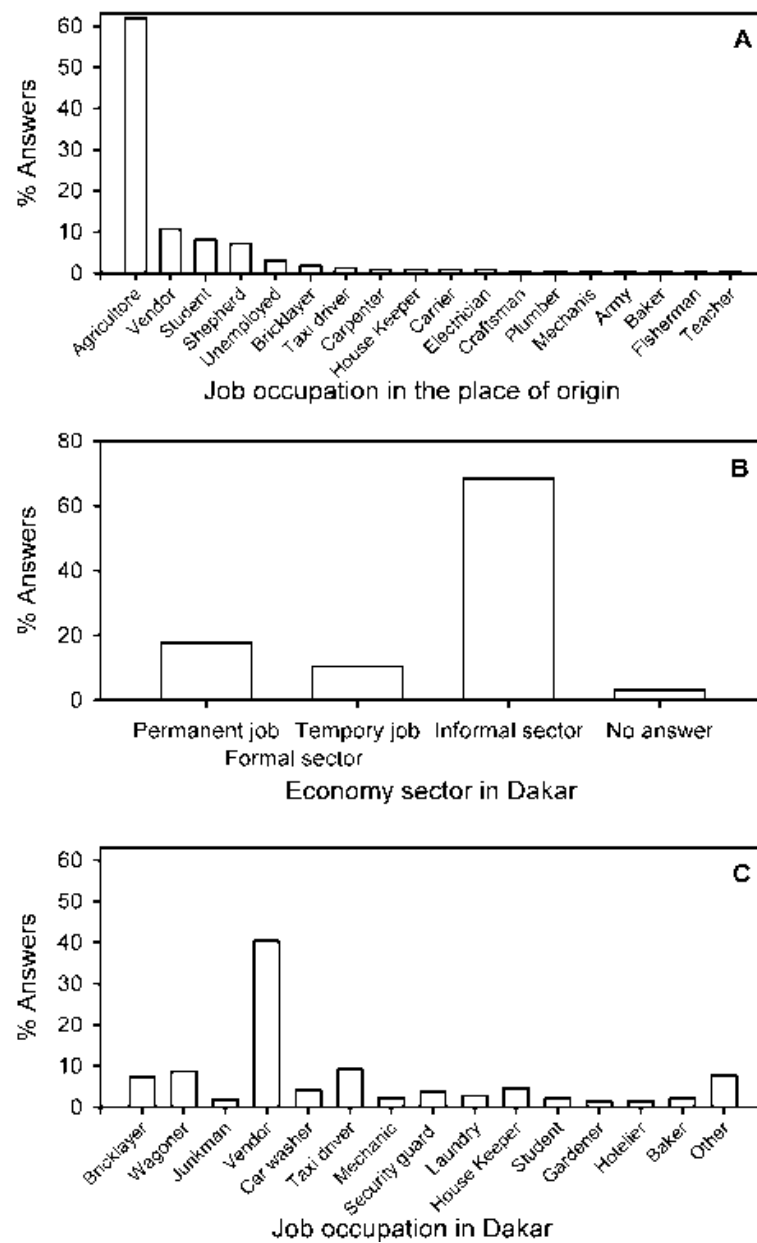


Figure 3. Job occupation in economy sector
(Source: Field Survey, 2017)

In response to the question ‘What was your previous job?’ (immediately prior to their current one), the results of the Mann-Whitney test ($U = 3086.500$ [MV1], $P < 0.05$) reveal that, prior to their current employment in Dakar, women were relatively more likely than men to have worked as domestic workers (14% versus 0%), shop assistants (21% versus 9%) or to have been unemployed (28% versus 14%), whilst men were more likely than women to have been in education (12% versus 3%). Before migrating, respondents from arid or semi-arid areas were more likely to work in the primary sector than those from humid areas (52% versus 33%), who were more likely to work as salespeople (18% versus 8%). In Dakar, the vast majority (91%) of respondents were in employment, mainly in the informal sector (68%) (Figure 3B). The analysis also examined the employment status of populations from Senegal’s various ethnic groups. The Kruskal-Wallis test provides significant insights into employment rates and the nature of the jobs held. The Diola suffered more from unemployment (31%) than other ethnic groups (around 10%)(Traders and street vendors were the most common occupations (40%) in Dakar (Figure 3C). The Serer were more likely than other ethnic groups to work as bricklayers (12%), and cart drivers (14%), the Wolof and Halpullars worked more frequently as vendors (74% and 51% respectively), and the Diola were more often students (27%) and hotel employees (18%).

Most respondents (92%) knew someone else who had migrated to Dakar (question 9), and of these, 29% knew more than 50 people from their hometown who had migrated to Dakar. Furthermore, 96% knew other migrants in Dakar from towns other than their own; 58% of them stated that they knew more than 10 people fitting this description. Indeed, 79% answered in the affirmative when asked whether they thought their place of birth was becoming significantly depopulated; the percentage was higher among men than among women (82% versus 65%).

Migration drivers: multifaceted causes

Regarding the drivers to migrate to Dakar, 89% migrated due to lack of job opportunities and 27% specified also economic problems derived from unemployment. Only 4% migrated due to land degradation or because of land grabbing (Figure 4A). The Diola migrated more than the

other ethnic groups because of armed conflict, political persecution and land grabbing (Kruskal-Wallis test, $\chi^2 = 10.307$, d.f. = 4, $P < 0.05$; U-test, $P < 0.05$). People with the highest income before migrating (> 1000000 CFA yr⁻¹) were the only income group that migrated to study in the university (Kruskal-Wallis, $\chi^2 = 17.953$, d.f. = 4, $P < 0.01$; U-test, $P < 0.05$). On the other hand, the majority of respondents answered that they would return to their place of origin if they could find a job (61%), specifying in most cases that they would work as a farmer, rancher or merchant. It should be noted that 22% responded that they would return if they had financial support to improve their means for agriculture, livestock or trade, despite this not being an option in the survey. Only 3% stated that they did not want to return, and 2% answered that the problem was the climate and that as long as it did not change for the better, they could not return (Figure 4B).

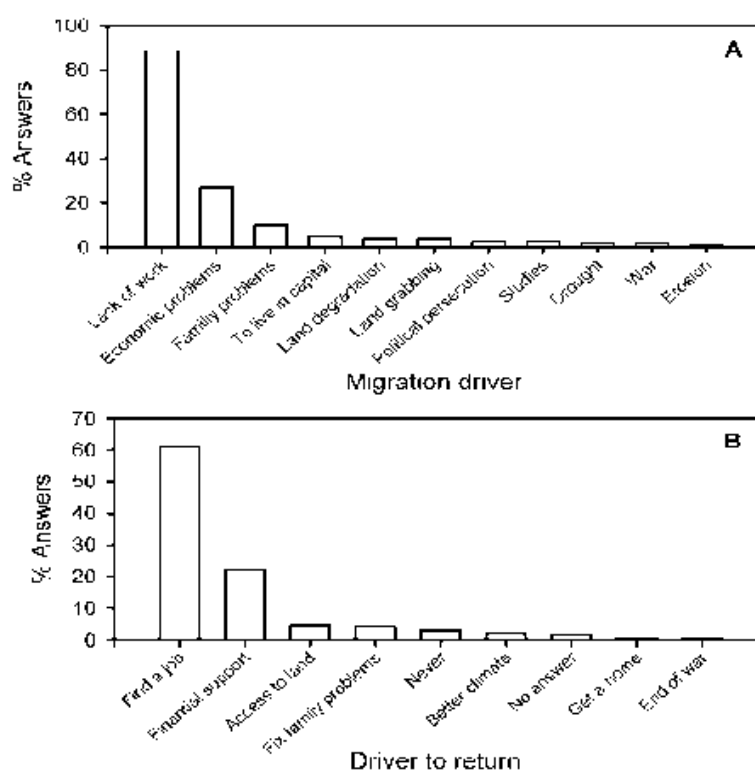


Figure 4. Migration et return drivers
(Source: Field Survey, 2017)

The vast majority of the respondents (85%) thought that climate was changing. Of those who answered affirmatively, 67% thought that weather was warmer than before, 65% thought that it rained less and, on the contrary, 35% thought that it rained more. 24% of the respondents said the weather was cooler than before.

Only 4% believed that dust storms were more frequent, and just 1% pointed to increasing torrential rains (Figure 5A). The results of the test (Mann-Whitney $U = 2684.000$, $P < 0.0001$) show a significant difference between the sexes in terms of perceptions of climate change. 34% more men than women thought that the climate was changing in their hometown (Mann-Whitney test, $U = 2684.000$, $P < 0.0001$) (Figure 5B), and 62% more respondents from arid and semi-arid zones thought that it rained less than those from humid zones.

Living in Dakar: diversifying livelihoods

Most of the respondents (86%) believed that their situation had improved after migrating to Dakar. Before migrating to Dakar, 26% of the respondents had no income from subsistence agriculture, and only 10% earned more than 1000000 CFA francs yr^{-1} (Figure 6A). After migration, 35% of the respondents had an income exceeding 1,000,000 CFA francs yr^{-1} (Figure 6B). Salaries before migrating were positively correlated with salaries after migrating to Dakar. Migrants who were in a more favorable economic position before migrating tend to fare better. This suggests that the process of accumulating resources continues throughout the migration trajectory.

When asked about the time they intended to stay in Dakar, 82% did not know. Those immigrants who had already stayed for longer in Dakar wanted to keep staying longer and they expressed more frequently that they did not know how long they will stay in the capital than those who had been for shorter periods in Dakar ($Q = +0.251$, $P < 0.0001$, $n = 231$). The majority (80%) of the respondents were long-term migrants who stayed in Dakar for longer than 1 yr. When asked if the respondents wanted to emigrate internationally, the answer was affirmative in 61% of the cases in which 74% wanted to migrate to Europe. The percentage of people between 41-60 yr old who wanted to migrate to African countries bordering Senegal (12%) was higher than for the other age intervals (c. 2%) (Kruskal-Wallis, $\chi^2 = 12.372$, d.f. = 4, $P < 0.05$; U-test, $P < 0.05$).

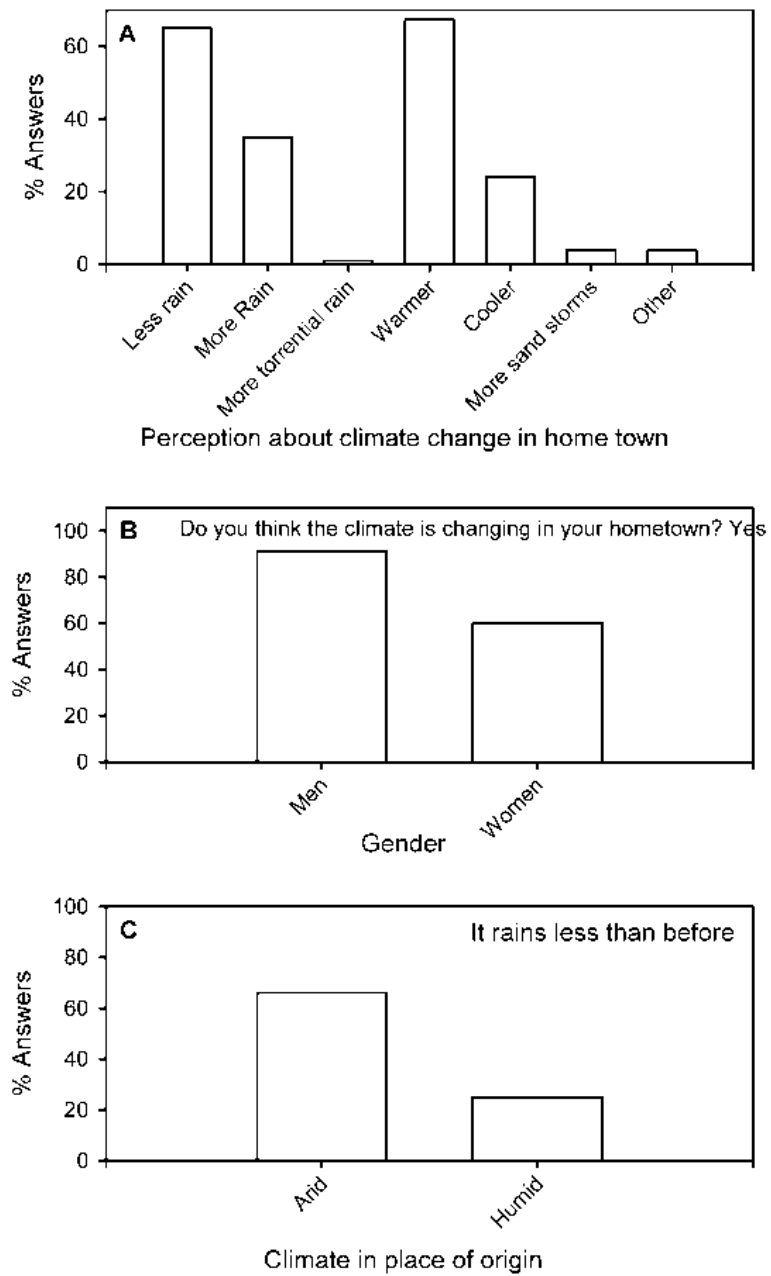


Figure 5. Perception about climate change
(Source: Field Survey, 2017)

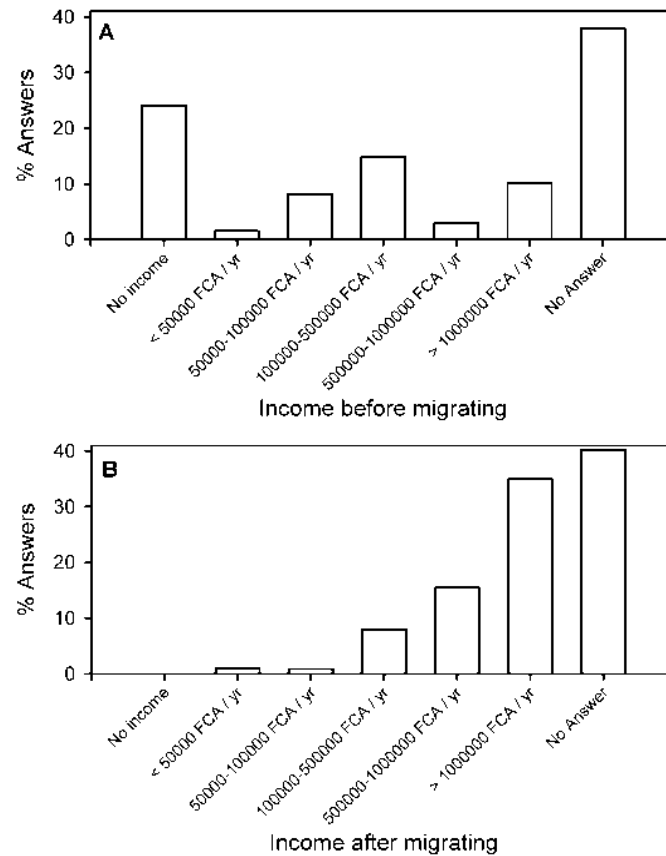


Figure 6. Income before and after migrating
(Source: Field Survey, 2017)

The informal sector offers young migrant populations opportunities for socio-professional integration. The residential and entrepreneurial paths of migrants are deeply marked by the weight of community logic. The village or even regional community structures the economic integration networks of the migrants surveyed in Ouakam. Many of them build their entrepreneurial careers within the community's solidarity networks and then break away from them or become independent. They are active in a wide variety of sectors, from personal services (car washers) to food trade and informal transport. Migrants from peanut-growing regions favour activities related to agriculture, drawing on the skills they have acquired in their new activities. These include the sale of peanut straw and/or

agricultural products (Photo 1), and horse-drawn transport (Photo 2) in Ouakam District, 2024.

Their presence is visible through the ways in which they occupy public space. By appropriating the interstices of the city through undeclared entrepreneurial activities, these migrants engage in daily negotiations of their presence in the city. These practices of misappropriation and privatisation of public spaces keep these migrants in a state of precariousness and insecurity vis-à-vis the municipal authorities. Those who are in formal spaces and pay the daily tax of '100 Fcfa' are relatively spared from administrative hassles, while other occupants of public space are frequently evicted. These were some representative comments added by respondents at the end of the survey: "we could work in the fields if we had more means and help", "We have the knowledge about how to cultivate the land but we have no means", "I come from a very fertile area but the lack of rain has lowered the crop yields", "If agriculture went well I would return to my town", "I would like to have land and means for agriculture to return to my town", "the soils are running out, and water salinization is also a problem", "there is an ambition to work in rural areas with tractors but we do not have access to them", "land is lacking in rural areas, especially for large families", and "Dakar is only a temporary place on my journey".



Photo 1. Peanut straw is a highly prized resource for urban livestock farming. Sold in sacks, it provides additional income for producers. Most of the production comes from the peanut-growing region
(Ly et al, 1998)

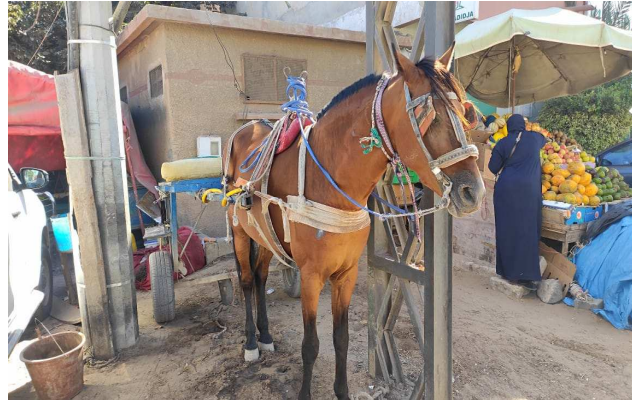


Photo 2. The draft horse used in agricultural activities and rural trade is mobilised for horse-drawn traction. It still plays a fundamental role in the marketing of agricultural products, the supply of inputs and consumer products, and the transport of people (Ly et al, 1998)

4. Discussion

The link between migration and climate change is highly complex. The alarmist discourses of the 1990s, which dominated research (Mérenne-Schoumaker, 2025), are now less prevalent. They have given way to a holistic approach to environmental migration, which is increasingly considered an adaptation strategy to climate change and a means of diversifying livelihoods (Bruning, 2021). The results of our research reflect this complexity and highlight the diversity of causes of environmental migration.

While the interviewees considered that the climate was changing in their place of origin – that the weather was warmer and rainfall had decreased – socio-economic causes such as lack of job opportunities were the main motivations cited. In the context of semi-arid zones, faced with the omnipresence of risks, seasonal migration has always been an alternative for diversifying income sources. These seasonal movements have now become permanent due to land degradation, which reduces agricultural yields and provisioning services in fragile Sahelian ecosystems (Sonneveld et al., 2016). These findings are confirmed by ANSD (2023) data, which indicates that interregional (internal) migration is higher among individuals working in the primary sector, in agriculture (4.6%)

and forestry (4.6%). These are populations from the semi-arid rural areas of Senegal, threatened by drought episodes.

This land degradation is linked to a sharp increase in minimum temperatures, more frequent heatwaves, and a decrease in rainfall since the mid-20th century (Tidiane et al., 2017). Furthermore, land access issues have emerged partly due to steady population growth in Senegal, particularly since the 1970s (Lo, 2014). In this context, the lack of job opportunities was the dominant migration factor, which explains why people from wetter areas also chose to migrate.

However, most respondents worked only in subsistence and poorly paid agricultural jobs due to a lack of opportunities. The emigration of labor from rural areas, as recorded in our study, is common in national and international migration. It results from intertwined environmental, demographic, and socio-economic factors, such as lack of financial resources, investment, and industrialization (Naude, 2010; Cohen et al., 2013; Sterie, 2020). These results confirm the multi-factorial nature of environmental migration reasons. Migration decisions are the result of an accumulation of crises faced by rural populations and the need to improve household adaptation, thus confirming Brüning's (2021) conclusions on the consequences of migration for adaptation strategies to coastal erosion in Senegal.

Most respondents did not directly link their migration to environmental causes, but rather to socio-economic ones. However, although land degradation and climate change were not the main perceived migration factors, immigrants in Dakar believed, as previously reported by Mertz et al. (2008), that the climate was changing. In this sense, Voss (2021) reported that most Senegalese farmers perceived substantial environmental change, amplifying ongoing agrarian transformation processes, increasing dependence on non-agricultural livelihoods, and migration of youth in particular. Smallholder adaptation strategies to drought include techniques to improve fertility, conserve water, manage trees, and increase livestock (Tiffen & Mortimore, 2002). However, these adaptation strategies are undermined by poverty, poor health, rural unemployment, household adaptive capacities, and inadequate village infrastructure in the Sahel (Mortimore & Adams, 2001; Tschakert, 2007). In this context, land degradation can indirectly influence migration decisions from arid zones by affecting socio-economic factors, as previously recorded, for example, in Guatemala (Sivisaca et al., 2015) and southwestern China

(Shi et al., 2019). As confirmed by Mérenne-Schoumaker (2025), drought is a slower process that, by deeply affecting the population by reducing harvests, does not necessarily lead them to migrate immediately, but it is the recurrence and multiplication of events that push them to flee. The African continent remains the most vulnerable, with 22.8% of the displaced in 2022 (Mérenne-Schoumaker, 2025) due to higher risks (hazards + vulnerabilities).

Analyzing the environmental causes of migration also poses a methodological challenge. The livelihoods approach allows for linking economic vulnerability and ecological crises. Analyzing income levels and perceptions of environmental change in rural areas was a privileged entry point. Discourse analysis showed that perceptions of climate change varied according to the immigrants' place of origin in Dakar. The vast majority thought the climate was changing, but there were differences between the perceptions of people from arid and semi-arid areas and those from wetter areas. Most interviewed immigrants from arid and semi-arid areas thought the climate was changing because it rained less. However, relatively more people from wetter areas thought the climate was not changing, and most of those who thought it was changing believed it rained more.

The profile and stated motives show that migrants integrate both individual logics of social advancement and strengthening the resilience of family members who remained in the areas of origin. We recorded a low percentage of female migrants (17%), and they traveled accompanied by their family more often than men. Traditionally, Senegalese women do not migrate as they are responsible for domestic work (as recorded in our study), although the number of migrating Senegalese women has increased as they have greater marital independence than most African women (ANSD, 2013). Willekens et al. (2017) recorded a higher migration rate for men than for women in the Dakar region. In this context, migration for Senegalese people is a collective decision made by the extended family as a strategy to fulfill family obligations (Azam & Gubert, 2006; Moreno-Maestro, 2012). We found that, despite 61% of respondents being married, most of them (69%) migrated alone, which can be explained by the fact that men are traditionally expected to earn money for the family. Remittances help maintain the link with the community and prevent food insecurity.

At the spatial level, the Dakar metropolis is strongly influenced by migratory behaviors in terms of human mobility, but also of goods in a dynamic and reflexive interaction (Sakho, 2014). Thus, the strong interaction between Dakar and Senegal's regions occurs through internal migration and entrepreneurial activities occupying public space. The opportunities offered by the Senegalese capital for diversifying rural household income sources make Dakar the receptacle for the majority of internal migration. The migration balance between 2008 and 2013 was negative for all Senegalese regions, except for Dakar (ANSD, 2013). In 2023, Dakar recorded a migration balance of +20.7%, followed by Diourbel and Thiès, with +4% and +1.1% respectively (ANSD, 2023), areas that are becoming increasingly attractive. In this context, our data recorded signs of the current rural exodus, as the vast majority of respondents (79%) stated they believed their hometown was severely depopulating, and they knew many immigrants in Dakar. We only recorded Senegalese regions with higher emigration to Dakar, such as Diourbel, Fatick, and Thiès, located near the capital in the "Peanut Basin," affected by desertification (ANSD, 2015). The French colony introduced large peanut (**Arachis hypogaea* L.*) plantations in the 19th century (Ministry of Agriculture, 2008). On the other hand, immigration to Dakar from other countries was dominated by Guinea-Conakry (12% of respondents), where over 40% of the population lives below the poverty line (Oficina de Información Diplomática, 2017).

Our research conclusions support the idea that the Dakar region, due to its position, is a crossroads for internal and sub-regional mobility, as an area of arrival, departure, and transit. Migration is described as a social fact inseparable from Senegalese reality (Liza Rives & Lama Kabbanji, 2012; PNMS, 2018). The country faces multiple structural vulnerabilities such as low productivity, limited human capital, and a high level of informality (World Bank, 2024). These structural constraints are reinforced by exogenous shocks that continue to fuel both internal (from rural areas to cities) and international migration of a significant portion of youth with multiple profiles and migratory projects (Marei et al., 2018). Between 2008 and 2013 alone, about 50,000 people left Dakar to undertake international migration (ANSD, 2013). In this sense, most respondents in our study were engaged in a broader migratory project than simply moving to

Dakar. Furthermore, most did not know exactly how long they would stay in Dakar, probably because they had to work in precarious jobs to save enough money before international migration. Despite this, migration within Senegal's borders is higher than migration abroad (ANSD, 2013; Linares, 2003). In our study, older people who had lived in Dakar longer wanted to stay longer or emigrate to neighboring countries. Some people waiting to resume their journey in Dakar may ultimately stay in the Senegalese capital or redirect their routes towards the Global South (Zuluaga, 2015). Furthermore, most respondents in our study expressed a desire to return to their place of origin, but savings and investments were considered a prerequisite for return (Hernandez-Carretero, 2015).

Adaptation strategies depend both on the mobilisation of community networks for socio-professional integration and on skills acquired in the regions of origin. Serer migrants, originally from the peanut-growing region, are more involved in horse-drawn transport and the sale of agricultural products. Others occupy completely different jobs that do not require a high level of skill. These findings overlap with those of Ndiaye et al. (2024) on informal sector workers, some of whom mobilise their cultural capital and know-how in their new activities in the city, while local inter-village solidarity networks facilitate the settlement of newcomers in the Dakar region.

These findings, based on data from 2017, remain relevant today and reflect a growing trend of migration from rural areas to cities. Data from the latest population census (RGPH) on internal migration over the last five years (since 2018) confirm this trend, with Dakar playing a significant role (accounting for nearly 46.9% of recorded arrivals over the last five years) as a destination, and work being one of the main reasons for migration (30.7%) (ANDS, 2025).

5. Conclusion

Our study highlights a significant process of internal migration from rural areas of Senegal to Dakar. This out-migration has been concentrated mainly in arid and semi-arid regions. A variety of factors have driven migration to Dakar, primarily due to the socio-economic situation and

the irregularity of agricultural yields from one year to the next. In light of our findings and against the current backdrop of climate change and desertification, soil degradation could play a major role among the factors driving migration. This migration links rural areas facing agricultural crises with urban areas offering opportunities for integration into the informal sector. Migrants achieve remarkable integration into Dakar's urban economy by mastering the trade in agricultural by-products. These migration-generated resources meet the needs of families in the countries of origin and also help sustain the dream of an international migration project. The diversity of the areas of origin reflects a widespread social phenomenon in Senegal. This internal mobility could constitute a first step towards international migration. There is every reason to believe that Dakar, by virtue of its geographical location, serves as a point of departure, a destination and a transit point for migration to the Maghreb countries and Europe.

Policies focused on funding agricultural projects that incorporate best practices for biodiversity conservation and carbon sequestration could promote development in rural areas. All these climate change adaptation measures would increase employment opportunities in rural areas and should help to stem the rural exodus observed in Senegal. Against a backdrop of multiple crises and a return to normal rainfall patterns in the Sahel, a broader study could provide a better understanding of the link between climate change, the degradation of agricultural resources and migration.

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COMPOSER AVEC DES POSTURES MULTIPLES : ITINÉRAIRE DE RECHERCHE-ACTION DANS UN TERRITOIRE APPRENANT

Résumé. Cet article analyse la manière dont les postures du doctorant-chercheur, des chercheurs et des acteurs se construisent dans une recherche-action territoriale conduite en CIFRE à Thiers. À partir d'un itinéraire méthodologique déployé entre 2023 et 2026, il interroge l'articulation entre production scientifique, action collective et apprentissages situés dans un territoire apprenant. La démarche repose sur une approche qualitative et inductive mobilisant participation observante, observation flottante, entretiens exploratoires, comités de suivi, ateliers, productions collectives et séminaire chercheurs-acteurs. L'étude identifie six postures – chercheur, apprenant, agent, encadrant, accompagnant et évaluateur – et montre qu'elles ne se succèdent pas linéairement, mais se recomposent selon les temporalités, les objectifs opérationnels et les interactions. Les résultats soulignent le rôle

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de l'incertitude, des objets intermédiaires et des médiations dans la co-construction des savoirs, ouvrant une lecture réflexive et rythmique des dynamiques territoriales.

Mots-clés : territoire apprenant, recherche-action, CIFRE, réflexivité, temporalités, intelligence collective, itinéraire méthodologique

I. Introduction

Les recherches doctorales menées en CIFRE (Conventions Industrielles de Formation par la Recherche) s'inscrivent dans des configurations hybrides, entre production scientifique et action collective. En France, ce dispositif associe un doctorant salarié, une structure employeuse – entreprise, collectivité, association ou autre organisation – et un laboratoire de recherche, avec l'appui de l'Association Nationale de la Recherche et de la Technologie. Dans les collectivités territoriales, la CIFRE ne finance pas seulement un doctorat : elle répond aussi à une attente de connaissances utiles à l'action publique locale, à l'analyse des dynamiques territoriales et à l'accompagnement de démarches collectives. Ces dispositifs interrogent la production des connaissances, les relations entre chercheurs et acteurs de terrain, ainsi que les postures, comprises comme dispositions orientant l'action ou comme situations morales, politiques, sociales et économiques (Centre National de Ressources Textuelles et Lexicales). Ils s'inscrivent dans la recherche partenariale et les épistémologies de la connaissance située, qui rappellent le caractère contextualisé, négocié et collectif des savoirs (Chauvin & Jounin, 2012).

La CIFRE peut ainsi être rapprochée de la recherche-action et du doctorat en organisation, car elle engage une production scientifique située avec des acteurs non académiques (Liu, 1997 ; Soulard et al., 2007 ; Vinck, 2009). La réflexion s'inscrit dans une thèse CIFRE associant la Ville de Thiers, structure partenaire et employeuse, au Laboratoire de Recherche en Architecture et à l'UMR Territoires. Thiers constitue à la fois un terrain d'enquête et un cadre d'action visant à éclairer ses enjeux territoriaux. La thèse naît de la rencontre entre les attentes de la Ville – comprendre les dynamiques territoriales, les coopérations d'acteurs et l'émergence d'un territoire apprenant – et les orientations scientifiques des laboratoires, articulant commande territoriale, problématisation scientifique et construction progressive du terrain. Cette phase éclaire les choix méthodologiques et les postures. Au-delà de son ancrage institutionnel, cette recherche

interroge les conditions de production des savoirs dans des dispositifs territoriaux fondés sur l'action collective, notamment ceux qualifiés de « territoires apprenants » (Bière, 2010). Dans cette configuration, le doctorant compose avec des exigences et temporalités divergentes entre recherche, action publique locale et acteurs du territoire. Les attentes de la collectivité orientent les choix méthodologiques vers l'analyse des interactions, des médiations et des connaissances produites en situation. La posture devient ainsi un processus situé et négocié, permettant d'analyser la co-construction des savoirs et la transformation progressive des rôles (Rieutort, 2021 ; Gwiazdzinski & Cholat, 2021).

Comment les postures du doctorant-chercheur, des chercheurs et des acteurs se construisent-elles, s'ajustent-elles et se recomposent-elles au fil de l'action collective ? À partir du cas de Thiers, l'article analyse les dimensions réflexives et relationnelles de la recherche partenariale en territoire apprenant. Il n'évalue pas directement les effets des postures sur les apprentissages, mais les conditions qui les rendent possibles. Il identifie six postures méthodologiques, étudie leur déploiement sur le terrain et analyse les agencements possibles entre ces postures, afin de montrer comment le chercheur en CIFRE ajuste sa place pour favoriser la circulation des savoirs et la production de connaissances situées.

II. État de l'art

Cette partie articule territoire apprenant, recherche partenariale, CIFRE et posture pour comprendre la production des savoirs dans l'action territoriale. Elle montre que les apprentissages collectifs dépendent du cadre partenarial, des interactions et des ajustements de posture.

1. Territoire apprenant, partenariat et cifre : articuler recherche, apprentissages collectifs et action territoriale

Un territoire apprenant peut-être défini comme un espace où des acteurs locaux – collectivités, entreprises, associations, habitants, chercheurs – coopèrent pour produire, faire circuler et partager des connaissances utiles à l'action collective. Les savoirs s'y construisent à partir des situations

vécues, des interactions et des problèmes concrets rencontrés dans l'action (Bier, 2010 ; Rieutort, 2021 ; Gwiazdzinski & Cholat, 2021 ; Berterreix & Chaliès, 2024). Les apprentissages collectifs, la gouvernance partenariale et la connaissance située en constituent ainsi des dimensions centrales.

Les travaux sur les territoires apprenants soulignent la capacité des acteurs à organiser des espaces d'échange, à confronter leurs représentations et à transformer les expériences locales en ressources pour l'action. La connaissance ne relève donc pas seulement du registre scientifique : elle émerge aussi des pratiques professionnelles, des savoirs d'usage, des expérimentations et des ajustements entre acteurs. L'action collective permet alors de co-produire des solutions adaptées au contexte, parfois transférables à d'autres situations territoriales (Colligence, 2013).

Dans ce cadre, la recherche partenariale, notamment la CIFRE, constitue un dispositif privilégié pour observer la fabrication des connaissances entre monde académique et monde territorial. Le doctorant CIFRE occupe une position intermédiaire : il produit des données scientifiques tout en participant à des scènes d'échange, de médiation et de traduction. Le Comité de Pilotage, le Comité Technique et le Comité de Suivi Individuel peuvent ainsi être compris comme des espaces intermédiaires où se négocient les attentes, les usages de la recherche et les connaissances jugées pertinentes pour le territoire (Soulard et al., 2007 ; Vinck, 2009).

L'approche par les postures montre enfin que l'apprentissage collectif dépend non seulement des dispositifs, mais aussi des manières dont les acteurs y prennent place, traduisent les attentes et ajustent leurs rôles. Dans un territoire apprenant, les postures structurent ainsi les conditions de médiation, de circulation des savoirs et de co-construction entre recherche et action territoriale.

2. Posture, marge de manœuvre située et incertitude : dimensions réflexives et relationnelles dans la recherche partenariale

La posture se manifeste dans des attitudes, discours et pratiques traduisant l'inscription sociale du chercheur, ses dispositions et son rapport aux autres. Elle comporte trois dimensions : interactionnelle, centrée sur les situations d'échange (Goffman, 1973) ; relationnelle, liée aux réseaux d'acteurs et aux traductions entre mondes sociaux (Latour, 2006) ; réflexive, fondée

sur l'analyse de sa propre position dans la recherche (Bourdieu, 1980). Elle constitue ici une catégorie d'analyse pour comprendre comment le doctorant-chercheur négocie sa place et ajuste ses méthodes dans une recherche partenariale. Dans l'accompagnement, la posture repose sur un « contrat de confiance » temporaire, fondé sur la reconnaissance mutuelle, l'explicitation des attentes, la possibilité du désaccord et une confidentialité relative. On qualifie le doctorant de médiateur, car il assure une fonction de traduction entre mondes sociaux, institutionnels et scientifiques, à travers des objets intermédiaires – comptes rendus, cartes, grilles, ateliers ou récits – facilitant la circulation des savoirs (Vinck, 2009).

La recherche partenariale souligne le rôle des dimensions relationnelles et organisationnelles dans la production de connaissances partageables (Liu, 1997). Dans ce cadre, le doctorant ne dispose pas d'une liberté totale, mais d'une marge de manœuvre située, encadrée par la CIFRE, la collectivité employeuse, les laboratoires, les directeurs de thèse, les acteurs du territoire et les temporalités du projet. Cette marge suppose des ajustements permanents entre exigences académiques, besoins territoriaux et conditions d'enquête. L'incertitude propre à toute recherche en situation devient alors une ressource analytique : elle oblige à ajuster les méthodes, expliciter les choix, observer les frictions et transformer les imprévus en données d'analyse (Liu, 1997 ; Schön, 1983). Ainsi, l'approche par les postures prolonge les travaux sur les territoires apprenants en montrant que les apprentissages territoriaux dépendent aussi des manières dont les acteurs, et en particulier le chercheur, habitent les dispositifs, traduisent les attentes et ajustent leur position au fil de l'action.

III. Collecte et analyse des données

1. Terrain d'étude : Thiers, un territoire "apprenant"

a. Le terrain d'étude : Thiers

Capitale historique de la coutellerie, Thiers fonde son identité sur un héritage industriel indissociable de la rivière Durolle. Ce patrimoine s'inscrit toutefois dans une géographie de ruptures où le relief escarpé complexifie la modernisation urbaine.

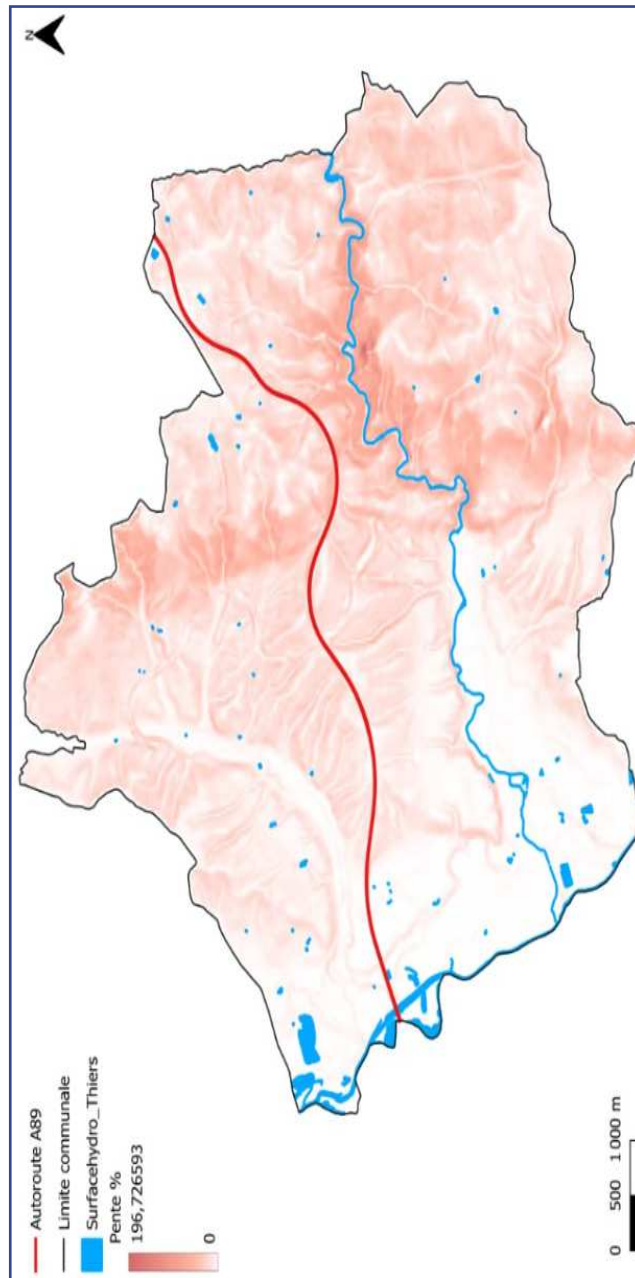


Figure 1. Thiers : une topographie de rupture comme contrainte structurelle
(Sources : BD TOPO, BD ALTI@IGN, réalisation Merveille Tawab et Sidik Diabagate, 2026)

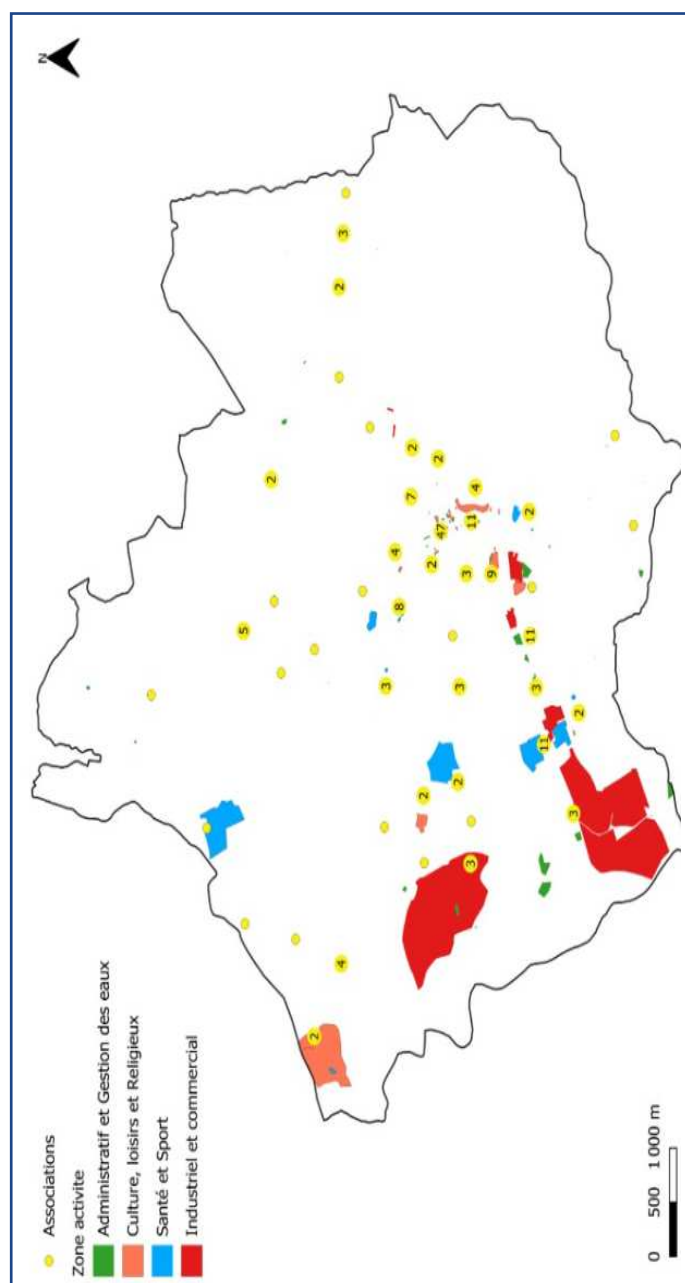


Figure 2. Thiers : Le maillage territorial : une interface de forces à mettre en cohérence
(Sources : BD TOPO, BD ALTI@IGN, réalisation Merveille Tawab et Sidik Diabagate, 2026)

La ville de 13 700 habitants est le pôle de centralité de la Communauté de communes Thiers Dore et Montagne et une interface majeure du Parc Naturel Régional Livradois-Forez (PNRLF, 2025 ; TDM, 2024). La commune subit précarité, avec 24 % de pauvreté, vieillissement et crise de l'habitat, marquée par 21 % de vacances au centre-ville. Ce déclin résidentiel et commercial vers la périphérie fragilise le cœur de ville (Insee, 2023). L'industrie thiernoise descend également en plaine : des quartiers bas, le long de la RN89, jusqu'aux zones industrielles bordant l'autoroute Clermont-Lyon. Si le développement industriel avait profité de la vallée encaissée de la Durolle, fournissant une énergie abondante, cette « géographie de ruptures » thiernoise (Frémont, 1976 ; Zaharia, 2024), illustrée par les pentes fortes du massif oriental (Figure 1), oblige une « intelligence en situation » (Turco, 2015). Ce relief fragmenté reflète les tensions socio-spatiales et transforme le chercheur en « passeur », capable de stabiliser le projet commun par-delà les discontinuités territoriales et institutionnelles.

Le maillage d'acteurs (Figure 2) révèle une organisation polycentrique où les zones industrielles périphériques dialoguent peu avec un centre ancien structuré par un dense tissu associatif et culturel. La cartographie met en évidence une couverture territoriale quasi totale, faisant du réseau associatif une force majeure aux côtés des piliers couteliers et institutionnels.

b. Thiers, territoire apprenant ?

Dans le champ du développement territorial, le territoire apprenant constitue une catégorie analytique aux définitions plurielles (Berterreix & Chaliès, 2024). Il peut renvoyer à une reconnaissance institutionnelle, comme l'adhésion au Réseau mondial des villes apprenantes de l'UNESCO (UNESCO, 2024), ou à des démarches locales fondées sur la mobilisation des acteurs, les apprentissages collectifs et l'expérimentation (Rieutort, 2021). Thiers relève de cette seconde acception : la ville n'est ni labellisée ni spontanément désignée comme territoire apprenant par les acteurs. Le terme est mobilisé par les chercheurs pour analyser des apprentissages situés autour des coopérations, des représentations territoriales, des modes d'action collective et des outils de dialogue. Encore peu approprié localement, le concept est progressivement formalisé par la thèse, à travers les enquêtes, ateliers, expérimentations et espaces de gouvernance.

**2. *Articuler production de savoirs et action territoriale :
l'itinéraire méthodologique de la thèse cifre comme
outil d'apprentissage collectif et de réflexivité***

La thèse CIFRE, intitulée « Territoires apprenants, entre reconnaissance internationale et démarches opérationnelles territoriales d'apprentissage : Regards croisés à Clermont-Ferrand et Thiers », mobilise l'itinéraire méthodologique comme un processus itératif articulant analyse, terrain et interactions avec les acteurs (Houdart & Lardon, 2022). Déployé entre 2023 et 2026, cet itinéraire permet de suivre la construction progressive de la recherche et l'évolution des postures du doctorant-chercheur dans une démarche non linéaire, faite d'allers-retours entre immersion, action territoriale, analyse et mise à distance. Les matériaux mobilisés dans cette recherche relèvent ainsi d'une méthodologie qualitative et inductive, construite à partir de plusieurs sources recueillies entre 2023 et 2026. Ils comprennent des entretiens exploratoires avec des acteurs institutionnels, associatifs, économiques, culturels et techniques ; des observations de réunions, de COPIL et de COTECH ; des Comités de suivi individuel ; des ateliers, expérimentations territoriales et jeux de territoire ; des productions étudiantes telles que cartes, frises, diagnostics et restitutions ; ainsi que le séminaire chercheurs-acteurs organisé à Thiers en décembre 2025. À ces matériaux s'ajoutent plusieurs objets intermédiaires – cartes, itinéraire méthodologique, tableaux, frises et comptes rendus – qui permettent d'organiser les données, de mettre en discussion les représentations du territoire et d'observer les ajustements de posture. L'ensemble de ces matériaux sert à analyser les interactions, les temporalités, les tensions, les formes de médiation et les processus de co-construction des connaissances dans la recherche-action territoriale (Paillé & Mucchielli, 2016 ; Vinck, 2009). Source : jeu de données structuré par Merveille Tawab, 2023-2026.

Trois phases structurent ce parcours. La première, ouverte en mai 2023, correspond à une immersion active dans le territoire : entretiens exploratoires, cartographie des acteurs, activités et espaces, participation aux COPIL, COTECH, séminaires et journées d'études. Ces dispositifs, compris comme des agencements de discours, d'institutions, de règles et de pratiques (Foucault, 1975), permettent d'identifier les attentes, tensions, coopérations et représentations locales, tout en installant une double

posture de chercheur et d'apprenant. La deuxième phase, à partir de novembre 2024, marque un temps de retrait et de reconfiguration, lié à la réserve électorale, à l'arrêt maternité et à la suspension du groupe de travail « Territoire apprenant ». Ce moment permet de relire les matériaux collectés, de clarifier les choix méthodologiques et de déplacer le chronotope de la recherche vers une phase plus réflexive (Bemong et al., 2010). La troisième phase, engagée à partir de septembre 2025, repose sur une présence flottante et un travail de médiation, notamment lors du séminaire chercheurs-acteurs de décembre 2025 à février 2026, où balades urbaines et tables rondes permettent de confronter les représentations et d'observer la recomposition des rôles. L'itinéraire méthodologique justifie ainsi l'usage conjoint de la participation observante (Soulé, 2007) et de l'observation flottante (Pétonnet, 1982), adaptées pour saisir les interactions ordinaires, les ajustements de posture et les régimes spatio-temporels de la recherche-action territoriale. Il montre que les postures ne se succèdent pas mécaniquement, mais se combinent selon les contextes, les ressources, les objectifs et les temporalités du projet. Cette pluralité révèle des rythmes différenciés – accélérations, ralentissements, reprises et temps de maturation – compris comme des « manières de fluer » (Benveniste, 1974 ; Graff & Gwiazdzinski, 2024), à partir desquels se documente la production de savoirs situés.

IV. Résultats

1. *Quels types de postures de travail peut adopter un chercheur dans un territoire apprenant ?*

À partir de l'itinéraire méthodologique de la thèse CIFRE à Thiers (Figure 3), six postures méthodologiques sont identifiées : chercheur, apprenant, agent, encadrant, accompagnant et évaluateur. Elles ne correspondent pas à des étapes successives, mais à des positionnements mobilisés selon les situations, les objectifs opérationnels, les temporalités du terrain et les interactions avec les acteurs. Le tableau suivant en propose une lecture synthétique, en précisant pour chacune sa finalité, ses rôles principaux et ses manifestations dans l'itinéraire méthodologique.

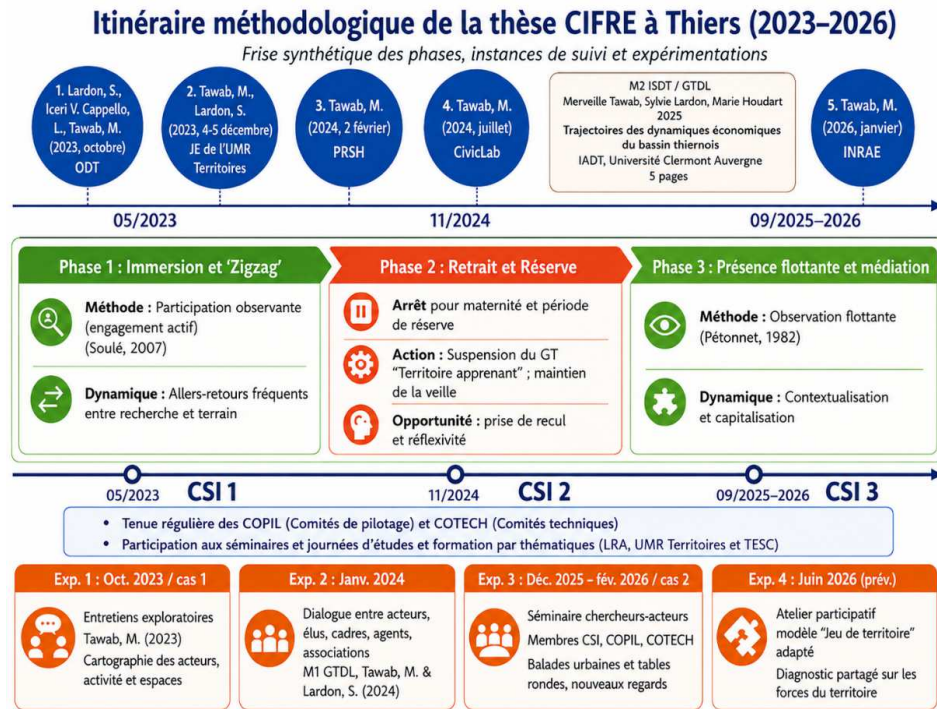


Figure 3. Itinéraire méthodologique de la Thèse CIFRE ville de Thiers/ LRA/ ANRT (Merveille Tawab, 02 /2026)

L'analyse du tableau montre que ces postures ne sont ni fixes ni exclusives. Elles s'articulent et se recomposent au fil de la recherche, selon les scènes d'action, les attentes institutionnelles et les besoins du terrain. Certaines postures relèvent davantage de la production scientifique et de la réflexivité, comme celles de chercheur, d'apprenant et d'évaluateur ; d'autres sont plus directement liées à l'action territoriale, à la médiation ou à la transmission, comme celles d'agent, d'accompagnant et d'encadrant. Leur combinaison traduit le caractère hybride de la recherche CIFRE en territoire apprenant, où le doctorant-chercheur doit à la fois produire des connaissances, accompagner des dynamiques collectives et ajuster sa place dans l'action.

Tableau 1

Tableau synthétique des postures méthodologiques

Posture	Finalité principale	Rôles et actions clés	Exemples à partir de IM
Chercheur	Produire des connaissances scientifiques	Analyse des données, des discours et des jeux d'acteurs ; valorisation académique	JE UMR Territoires (2023), CivicLab Derby (2024), articles
Apprenant	Comprendre le territoire par l'immersion	Participation observante, apprentissage par l'expérience, réflexivité	Immersion terrain, Semaine de la Recherche ENSA-LRA, formation TESC
Agent	Agir et expérimenter dans le territoire	Organisation d'ateliers, animation de dispositifs apprenants	Ateliers de restitution, expérimentations 1 et 2
Encadrant	Former et accompagner les étudiants	Suivi méthodologique, accompagnement des enquêtes	Encadrement M1 GTDL et M2 Gouvernance/Habitabilité
Accompagnant	Soutenir la co-construction collective	Facilitation, médiation, soutien aux dynamiques locales	Expérimentations 2, 3 et 4, jeu de territoire
Évaluateur	Analyser les effets et capitaliser	Synthèse, prise de recul, réflexivité	Rapports, analyse transversale des postures, rédaction de la thèse

Source : données de terrain recueillis par Merveille Tawab, 2026

2. Comment les postures se déploient-elles sur le terrain d'étude d'un territoire apprenant ?

a. Choisir une posture : enjeux chronotopiques et temporalités

Il s'agit d'analyser les logiques de choix des postures méthodologiques adoptées sur le terrain. On comprend, selon les contextes et les interactions, les raisons pour des choix de postures. Cela est en lien avec les temporalités, le cadre institutionnel, les attentes des acteurs ainsi que les marges de manœuvre inhérentes au dispositif CIFRE.

Description du cas 1 (voir figure 3) : Entretiens exploratoires

En début de thèse, le chercheur découvre le territoire et mobilise un dispositif CIFRE peu connu dans le contexte local. Cette situation impose une réflexion fine sur la posture à adopter pour combiner compréhension du territoire et intégration dans les équipes. Concrètement, comme l'illustre l'itinéraire méthodologique présenté précédemment, la phase initiale a été marquée par la réalisation d'entretiens exploratoires. Ces entretiens, réalisés au tout début de la thèse, ont constitué un moment crucial pour le choix de la posture. La posture adoptée devait permettre d'aborder les enjeux liés aux blocages institutionnels et aux dynamiques locales et atteindre les objectifs opérationnels, à savoir comprendre le fonctionnement des territoires et intégrer le chercheur dans les équipes.

Le choix d'une posture par le chercheur ne s'opère pas de manière abstraite ; il est influencé par les temporalités et les enjeux chronotopiques (Colleoni & Spada, 2021), c'est-à-dire par l'articulation sensible de l'espace et du temps de l'action. Dans ce contexte, la combinaison des postures de chercheur et d'apprenant a été privilégiée. La première garantit la rigueur scientifique et la collecte de données, la seconde favorise l'écoute et l'intégration progressive aux équipes. Cette articulation permet d'ajuster la posture d'agent aux temporalités de la thèse et aux dispositifs CIFRE.

La posture devient ainsi un outil méthodologique et un levier d'intégration territoriale, conciliant exigence scientifique et adaptation locale. Elle révèle une intelligence en situation produisant un « savoir topique » ancré dans le lieu. Selon Turco (2015), ce savoir adaptatif transforme l'expérience de terrain en connaissance relationnelle.

*b. L'Expérimentation comme espace de déploiement
et d'articulation des postures*

Le second cas d'étude analyse une expérimentation au cours de laquelle plusieurs postures méthodologiques se déploient simultanément dans un même cadre d'action. Il examine la coexistence et l'articulation des postures dans un dispositif impliquant élus, techniciens, acteurs associatifs et chercheurs. Le chercheur peut y mobiliser successivement ou conjointement des postures de chercheur, d'agent, d'accompagnement, d'encadrement et d'évaluation. Les postures ne se succèdent pas linéairement, mais s'entrelacent, révélant la complexité du travail en territoire apprenant et ses effets sur l'apprentissage collectif.

Description du cas 2 (voir figure 3) : Séminaire chercheurs-acteurs

Le second cas analyse le séminaire en tant que dispositif expérimental. Ces expérimentations s'ancrent dans la notion de territoire apprenant en ce qu'elles interrogent les pratiques établies et impulsent de nouvelles dynamiques d'action collective. À cette occasion, les membres du CSI, initialement investis d'une mission d'évaluation, ont adopté un positionnement d'apprenants. Parallèlement, les directeurs de thèse ont élargi leur périmètre en articulant évaluation, apprentissage et valorisation scientifique, tandis que les acteurs locaux, habituellement cantonnés à un rôle d'agents, se sont pleinement impliqués comme apprenants. La doctorante a, quant à elle, déployé une multiplicité de postures : chercheuse au LRA pour la valorisation scientifique, agente pour l'organisation logistique, apprenante lors des débats et médiatrice entre les chercheurs, le CSI et les partenaires locaux. Cette agilité illustre la recomposition dynamique des rôles et l'émergence de nouvelles postures au cœur de l'expérimentation.

Ce cas montre que les postures ne suivent pas une logique linéaire, mais une dynamique interactive et adaptative. Selon les objectifs, les temporalités et les cadres institutionnels, les acteurs mobilisent et transforment différentes postures – évaluateur, apprenant, chercheur ou médiateur. L'émergence de la doctorante comme médiatrice révèle ainsi de nouvelles configurations de rôles et souligne l'importance d'une réflexivité pour soutenir la production de savoirs situés et l'apprentissage collectif.

c. Analyse des postures et agencements possibles

Cette section met en évidence trois agencements : recherche d'un confort méthodologique, appropriation de l'incertitude du terrain et affirmation progressive des choix. En recherche-action, l'incertitude devient un levier heuristique : les frictions entre logiques d'acteurs produisent une trajectoire non linéaire, en « zigzag » (Souillard et al., 2007), proche de la posture du praticien réflexif fondée sur l'agilité méthodologique et l'analyse en situation (Schön, 1983).

Le schéma illustre l'évolution de la posture du chercheur à travers trois agencements. Le premier correspond à une situation de forte incertitude, marquée par des enjeux spatiaux, temporels et interactionnels, où le confort méthodologique reste fragile. Le deuxième montre comment l'adoption de méthodologies intégratives — participation observante et itinéraire en zigzag — permet de mieux comprendre le terrain tout en assumant l'incertitude. Le troisième traduit une navigation plus stabilisée : grâce à l'observation flottante, l'incertitude n'est plus seulement source d'inconfort, mais devient une ressource pour l'analyse.

Cette évolution montre que les postures du chercheur ne relèvent pas d'un choix abstrait, mais d'une articulation entre trois dimensions : la posture adoptée — chercheur, apprenant, agent, accompagnant, encadrant ou évaluateur —, les objectifs opérationnels liés au contexte et aux acteurs, et les résultats visés, qu'il s'agisse de produire des connaissances, d'accompagner une dynamique ou d'expérimenter une action. Ainsi, dans le premier cas étudié, l'objectif d'intégration et de compréhension du territoire conduit à privilégier les postures de chercheur et d'apprenant plutôt que celle d'agent. La démarche s'inscrit alors dans une logique réflexive et itérative : choisir une posture, la déployer, puis l'évaluer au regard des effets produits. Cette dynamique renvoie à une rationalité située, dépendante du contexte et des ressources (Crozier & Friedberg, 1977), et montre comment l'analyse des postures permet de comprendre la transformation progressive des pratiques, des rôles et des savoirs situés.

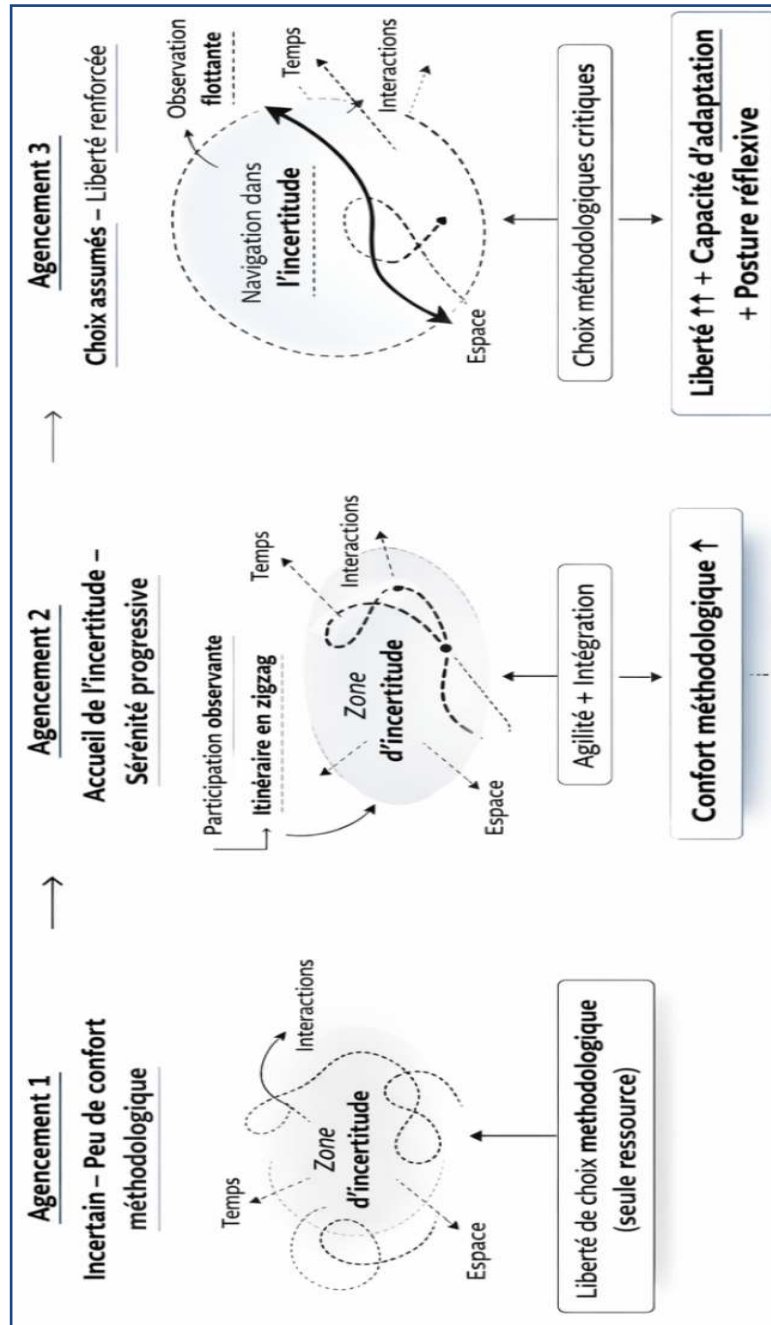


Figure 4. Dynamique des agencements méthodologiques
(Merveille Tawab, 2026)

V. Discussion

1. Complémentarité et hybridation des postures

La diversité des postures confirme la complexité du positionnement du chercheur en contexte participatif. Les travaux de Gwiazdzinski (2019 ; 2021) montrent que porter ou non le gilet jaune matérialise la tension entre engagement et observation. Cette autre expérience révèle une timidité initiale, un double statut entre implication et distance, une participation aux tâches quotidiennes et une mise à distance nécessaire à l'analyse. Face au risque de confusion entre statuts et postures, le chercheur s'est recentré sur les résultats et le sens de sa démarche : pourquoi mener cette recherche et dans quelle finalité ? La clarification réduit l'incertitude et l'inconfort propres à une recherche engagée. Six rôles émergent en immersion : observateur, acteur, pédagogue, chercheur, formateur et performateur. Cette figure évoque « l'intellectuel organique » (Castoriadis, 1975).

Ces postures se déploient dans plusieurs dispositifs : collectivité, laboratoire, CSI et médias. Cinq dimensions principales se dégagent. La posture disciplinaire s'ancre en géographie et mobilise ses cadres méthodologiques. Elle s'articule à une posture éthique, attentive aux limites dans la relation aux acteurs. S'y ajoute une posture intellectuelle, soucieuse de cohérence entre recherche et société. La posture professionnelle répond aux attentes institutionnelles. Enfin, une posture citoyenne renvoie au « devoir de cité » (Febvre, 1953). Il est nécessaire de rendre explicites les positions adoptées, tout en reconnaissant leur hybridation et la nécessité de « ruser » (Certeau, 1990). Selon les contextes, une posture peut dominer, d'où l'importance de s'immerger dans les temporalités du collectif pour en saisir les rythmes et entretenir une confiance renouvelée au sein de collectifs en recomposition. Les travaux de Sylvie Lardon et al. (2023) à Clermont-Ferrand montrent que les postures d'« apprenant » et d'« accompagnateur » se décomposent, s'articulent et se complètent dans la démarche participative. Leur hybridation apparaît ainsi comme une condition centrale de la dynamique apprenante du territoire, ainsi le tripode Postures-Objectifs opérationnels-Résultats est constaté.

Cette pluralité de postures exige une forte polyvalence : entretiens, animation, médiation qui, concentrée sur une seule personne, expose à la surcharge. Elle dépend aussi de l'ouverture des acteurs et demeure vulnérable aux conflits et aux déséquilibres de pouvoir, tout en requérant un investissement temporel important, constitutif d'un « savoir en situation ». Le recours à une méthodologie rigoureuse constitue toutefois un garde-fou, limitant les risques sans exclure l'inventivité. La tension confort et inconfort devient ressource d'adaptation.

2. Opérationnalités et temporalités

La posture des acteurs constitue un levier central des territoires apprenants : elle peut favoriser ou freiner la co-construction et suppose un déplacement des rôles institutionnels. Les profils hybrides, à l'interface des sphères politique, institutionnelle, associative et académique, facilitent la circulation entre action et production de savoir, en soutenant des partenariats plus horizontaux. L'atelier (Rojas Arias, 2022) apparaît comme un espace d'expérimentation favorisant la transformation des postures et la construction de la confiance. En instaurant une posture d'apprenant partagée, il atténue les hiérarchies et soutient l'ajustement des positions. Il est défini comme un travail collectif dans un temps et un lieu dédiés (Ander-Egg, 1999), et matérialise un moment apprenant propice à l'adaptation des postures.

La Recherche-Action transforme le rapport au savoir en faisant du temps un moteur de changement (Colleoni, 2025). Le chercheur devient médiateur de temporalités, articulant réflexion théorique et action de terrain. Cette posture favorise une collaboration horizontale entre savoirs scientifiques et locaux, substituant à la linéarité un processus dynamique où connaissance et intervention se répondent. Cette dynamique repose sur des cycles d'action et de réflexion, s'inscrit dans une présence durable et respecte les rythmes des acteurs. Le temps est conçu comme un flux en transformation, où savoirs et pratiques évoluent conjointement. Ces temporalités éclairent l'analyse des postures et expliquent la modulation des rôles selon les cycles territoriaux. Le prisme chronotopique permet de comprendre comment temps et espaces façonnent les ajustements et reconfigurations au fil du dispositif CIFRE.

VI. Conclusion

Cette analyse met en évidence la nécessité d'un recul réflexif sur les postures en recherche-action. Celles du doctorant-chercheur, des chercheurs et des acteurs ne sont ni homogènes ni stabilisées : elles évoluent selon les phases de la recherche, les configurations d'acteurs, les situations rencontrées et les temporalités du projet. Elles se construisent ainsi de manière située et relationnelle, dans l'ajustement entre attentes institutionnelles, contraintes organisationnelles, exigences scientifiques et dynamiques participatives. Au regard de l'état de l'art, l'analyse confirme que les territoires apprenants ne relèvent pas seulement de dispositifs formels ou d'une labellisation institutionnelle, mais se construisent dans des situations concrètes de coopération, de circulation des savoirs et d'apprentissage collectif (Bier, 2010 ; Rieutort, 2021 ; Gwiazdzinski & Cholat, 2021). Elle prolonge également les travaux sur la recherche partenariale en montrant que la production de connaissances dépend des postures adoptées, négociées et ajustées dans l'action (Soulard et al., 2007 ; Vinck, 2009). L'apport de l'article est triple : théorique, en proposant une lecture des territoires apprenants par les postures ; méthodologique, en montrant l'intérêt de l'itinéraire méthodologique, de la participation observante et de l'observation flottante pour saisir ces ajustements (Pétonnet, 1982 ; Soulé, 2007 ; Houdart & Lardon, 2022) ; et opérationnel, en soulignant le rôle des objets intermédiaires – cartes, frises, comptes rendus, ateliers, tableaux et jeu de territoire – comme supports de réflexivité collective. Comprendre les postures permet ainsi d'éclairer les conditions qui rendent possibles les apprentissages collectifs, sans prétendre en mesurer directement les effets.

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All links were verified by the authors and found to be functioning before the publication of this text in 2026.

AI AND SCIENTIFIC INTEGRITY⁸

Data collection, analysis, and the scientific structuring of the article were carried out by the authors. Artificial intelligence was used as a support tool to transcribe certain exchanges, reformulate ideas from meetings, and improve the clarity of the writing. It did not replace the work of analysis, interpretation, or scientific validation performed by the authors. Sources, references, and bibliographic choices were verified and validated by the authors, in accordance with the academic integrity requirements related to the use of AI (Moscarola & Kalika, 2025).

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⁸ J. Moscarola, M. Kalika, 'Promoting the uses of artificial intelligence (AI) while respecting academic integrity: the case of the Business Science Institute', in M. Bergadaà & P. Peixoto (eds.), *Reinventing Academic Integrity in the Age of Artificial Intelligence*, EMS Éditions, 2025, pp. 146-159, <https://doi.org/10.3917/ems.berga.2025.01.0146>

Elena-Codina DUȘOIU¹

MINING HERITAGE: CHARACTERISTICS. VALUE. POTENTIAL. ROMANIAN TRADITION AND EUROPEAN EXPERIENCE

Abstract. The paper proposes a comparative analysis between different categories of industrial heritage dedicated to mining, concluding on some invariants of these artifacts, which by definition link the underground to the aboveground. Depending on the raw material extracted, mines present specific characteristics, which lead to a specific pattern for each type of extraction. The paper is equally based on the study of international bibliography regarding mining heritage and on personal studies of the author (in-site research and conducted projects). The study presents both unique mining sites from Romania, currently abandoned (gold galleries and mine shafts from the Bucium commune in Apuseni, the Anina coal mine in Banatul Montan), as well as extractions that have benefited from remarkable interventions for the purpose of integration into a tourist circuit (Turda salt pan). The paper also collects strategies for the adaptive re-use of mining sites, based on international examples of good practice, such as mining sites and geoparks in Northern Spain (for example Las Médulas – gold mining), Italy (Sardinia – metal mineral extraction), Belgium (Genk region – former coal mine transformed into a cultural center). These cases are fundamentally similar to Romanian mining sites. The creation of a common database may become a valuable element for the preservation of these sites and their integration into the life of communities and landscape.

Keywords: industrial heritage, extraction, geopark, UNESCO mining site, good practice example

1. Introduction. Argument for preserving mining heritage

The paradigm of the information age has generated the imperceptible replacement of the model of society based on resource exploitation, with

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digital development and the exponential expansion of communication. Industrial artifacts have become vestiges of the past, constituting the multidisciplinary field of industrial archaeology, which aims to preserve and, eventually, revitalize complex industrial sites (buildings, infrastructure, equipment), as well as the knowledge brought by the evolution of technological processes. The mining industry is special as object of study for industrial archaeology, involving direct interaction with natural resources, in the territory, which requires specific approaches and equipment, but also the building of strong, distinctive communities.

Stefan Berger identifies no less than eleven features making mining heritage worth to be preserved. The first three refer to the value of mining archaeology and “how the extraction of raw materials from the earth has been an activity shaping human existence for tens of thousands of years” (Berger 2020: 2-4), to the millenary technological progress obtained through mining industry and to the role brought by the science of mining in the organization of work processes. The author identifies key dates, such as the Xth century, when the blast furnace was invented under the Sung dynasty in China and 1556, the date of the iconic early publication dedicated to mining *De Rerum Metallica* by Georg Agricola. The next four arguments refer to community: mining as generator of large scale migration (as in the case of the discovery of the first major diamond in South Africa, the ‘Eureka Diamond’ in 1866), as producer of «particular forms of working-class culture» (such as happened in 1900, “when Cornish miners in Mexico played, for the first time in Mexico, a game of football”), as a subject of gender (women and children were generally prohibited to work in mines, as happened in 1933 in Japan) and as the need to remember the saddest events related to mining: underground accidents, etc. which happened all over the world. The next three analyzed items are: the importance of the state in the administration of mining industry, the visual history of mining, which became a study field in itself and the consequences of mining exploitation on the environment (and remediation of former extraction sites), an important approach to be analyzed for all types of mining industries. The last approach (11th) refers to the persistence of mining sites in the collective memory, even long after the actual mining activity has ceased. Mining sites are an integral part of the spirit of place and induce the transformation of the territory.

Basing on this Berger's general perspective, the paper moves to a specific view for the situation of mining sites in Romania. The questions guiding the research are: can we talk about a series of invariants in the analysis of mining industries? Do these invariants give us solutions for the future preservation of mining sites? Can we apply in the intervention strategies a series of rules determined by the characteristics of the extracted material?

2. Methodology

The work follows an approach from general to particular, correlating the exploitation of basic underground resources with the evolution of settlements in the territory and with the millenary history and culture of our continent. Three extractive branches are particularized (coal, gold and salt mining), all of which fundamentally generate a way of life and a local culture. The general documentation was carried out by studying reference publications, both books and periodicals, mentioned in the bibliography. The field applied in Romania comes naturally in the continuity of the European situation. The information is extracted both from reference publications, and from the author's personal experience, materialized both through her own research and *in situ* observations, by visiting various mining sites in the country and abroad, by coordinating projects etc. The intention is to provide an overview of the characteristics and values of the mining heritage, as well as the possibilities for its preservation and revitalization in the context of the current community.

3. Results

3.1. Mining in Romania: from underground resources to cultural landscape and location in the territory

It is archaeologically attested that mining activity on the territory of present Romania dates back to Antiquity, before the period of ancient Dacia and its conquest by the Roman Empire (106 AC) (Wollmann 2007: 7). Important

evidence of early mining activity has been identified at several sites in present-day Romania: Căraciu (Hunedoara) for gold (ca. 3800–3700 BC), Corna (Severin) for iron (3000–2600 BC), and the Pianului Valley for copper (3500–2200 BC). During this period, mining developed in a particularly distinctive way across the Romanian territory, especially in relation to gold extraction. The abundance of gold in Dacia was undoubtedly one of the main reasons for the Roman conquest of the region. Even if not all the gold brought by Trajan from Dacia came from local deposits, historical data still highlight the significant development of gold mining in the region. The Roman period introduced the most advanced techniques of the time, marking a true flourishing of the mining industry. Over the 166 years of Roman administration, it is estimated that approximately 500 tons of gold and 950 tons of silver were extracted from the province (Kovacs et al. 2018 41-50).

Mining in Transylvania developed continuously during the Habsburg Empire, the resources here being considered strategic. After the Great Union of 1918, the Romanian state continued investments in this rich region (Rusu Abrudeanu 1933: 292, 303). Technical progress was quickly incorporated to the extraction process. In Transylvania and Maramureș, steam engines and their early prototypes were employed in the mining and metallurgical industries during the nineteenth century, particularly in the areas of Zlatna and Baia Mare.

After World War II, a key moment was the nationalization of the means of production in 1948. During the communist period, the country's industrialization continued, especially in the 1980s, when the industrial infrastructure grew inversely proportional to the efficiency of production. The reference point for evaluating the patrimony is the year 1984, a period marked by peak development in the extractive industry. This moment reflects the significant accumulation of useful mineral resources, with substantial reserves officially approved at that time. For the assessment of the current mining patrimony, the starting point was the most comprehensive and widely recommended database on the subject, titled "Harta Substanțelor Minerale Utile" (Map of Useful Mineral Resources), 2nd edition, published by the Geological Institute of Romania in 1984. Three main categories of accumulations were considered: metallic, non-metallic, and coal (Kovacs et al. 2018: 41-50).

3.2. Coal mining in Europe and in Romania.

Characteristics, problems, opportunities

Coal holds a distinctive place in European energy history, as it was the only fuel to develop a dynamic continental market well before supplies became globalized. In this sense, European coal transnationalism preceded coal colonialism. Early on, Britain became a major exporter, supplying coal to most European countries. British coal powered industrial steam engines, locomotives, and urban gas works across a wide range of cities, from St. Petersburg and Stockholm to Milan and Athens (Bluma et al. 2023: 7).

Subsequently, Germany also rose as an important coal exporter. After gaining independence following the First World War, Poland entered the market as well, further increasing the complexity of intra-European coal trade. In several regions, including the Netherlands and the port cities of northern Germany, strong competition developed between British and Ruhr coal. European coal was so plentiful and inexpensive that, prior to 1914, imports from outside the continent could not compete. As a result, European coal transnationalism prevailed. German coal was desperately needed on the European market after WWII (especially in France), which played a key role in motivating the creation of the European Coal and Steel Community (ECSC) in 1950, which not only reinforced European coal transnationalism but also laid the groundwork for broader political and economic integration in (West) Europe.

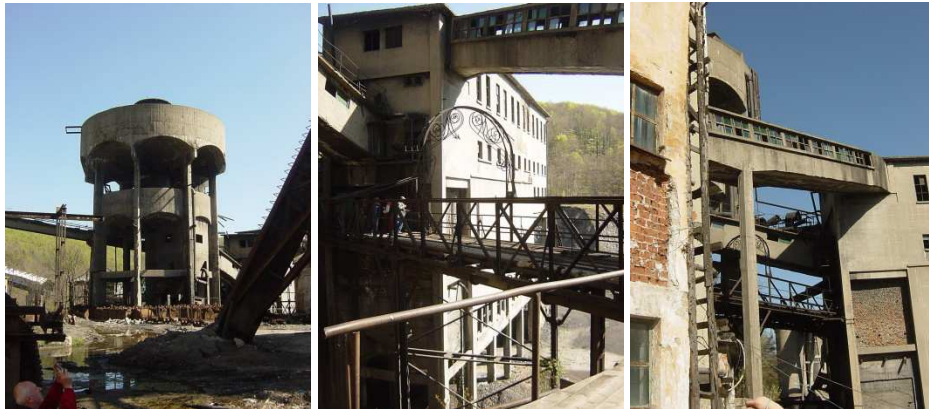
However, by 1956, German coal production had reached its peak, and, unsurprisingly, the cost of intra-European coal began to rise steadily in the following decades. At the same time, transportation costs dropped sharply due to the advent of oil-powered ships, while evolving institutional conditions in the global economy encouraged trade. As a result, coal from distant regions (such as Colombia, South Africa, Australia and the United States) began to compete effectively in European markets (Högselius in Bluma et al. 2023: 38-39).

On the present territory of Romania, in the 19th century, especially in the Western part of the country, coal began to be intensively exploited, together with other mineral resources. At the beginning of the 20th century, Romania had significant coal reserves (even if not the best quality), mainly in the Hunedoara Basin and the Jiu Valley. After World War II, the Romanian

mining sector experienced a period of massive development, accentuated by the economic policies of the communist period.

In Europe coal production was dominated by Britain and Germany, which exported massively to other European countries. Before 1914, European coal was so abundant and cheap that resources from other parts of the world could not compete.

Romania was not a major exporter at the European level, but domestic coal was essential for the development of local industry and electricity. After 1948, with the establishment of the communist regime, coal mining in Romania went through a period of intense industrialization and centralized planning. Coal became the main energy resource, essential for the functioning of heavy industry, the production of electrical and thermal energy, as well as for the metallurgical and chemical industries. The mines in Valea Jiului, Petroșani, Petrila, Lupeni, Vulcan and Anina (Figs. 1, 2, 3) were expanding.



*Figures 1,2,3. The site of the coal mine from Anina, Banatul Montan, Romania, closed in 2006
(Source: photo by the author, 2007)*

However, rapid wear of infrastructure and intensive mining leading to depletion of some deposits. Difficult and dangerous working conditions for miners led several time to tragic accidents, several methan explosions being documented in Valea Jiului between 1960-1980 (Jujan& Svoboda., 2009: 146-48). In the 1990s–2000s, the Romanian government, under pressure from international bodies and due to the energy deficit,

began closing unprofitable mines and gradually reducing the mining workforce. Accession to the EU (2007) brought strict environmental regulations, and polluting coal became less competitive compared to other energy sources. Mine closures continued progressively in the 2010s–2020s, especially in the Jiu Valley, in Petroșani, Petrila and Lupeni.

Today Europe faces the paradigm of “decarbonisation”, in the attempt to protect our environment. “Deep decarbonisation,” or the substantial reduction of carbon dioxide emissions, primarily entails a fundamental transformation of energy systems, expected to take place by the middle of the 21st century. As early as 1990, the German Bundestag’s Enquete Commission on “Protection of Man and the Environment” advocated for an 80 percent reduction in Germany’s greenhouse gas emissions by 2050. In contrast, many other economies continue to depend on coal as an energy source, where it remains a key component of the global energy supply (Bluma et al. 2023: 1).

3.3. Gold Sites in Romania. The complexity of the heritage generated by gold mining

“Just as for thousands of years humanity has been searching for the Fountain of Youth – this eternal dream of people, in order to extract from it a new sap at the expense of a body tired of diseases and numerous wounds – so for thousands of years the same humanity has been working, fighting and toiling to accumulate as much gold as possible, which, having been consecrated since ancient times as the most suitable element of exchange, thanks to its inalterability, uniformity and small volume in relation to its weight, can give man the possibility of satisfying the various needs and desires of life.” (Rusu Abrudeanu 1933: 7). This poetic quotation is extremely significant for the power of gold and the way it changed settlements and communities.

In Europe, native gold has been known since ancient times, initially discovered in Transylvania and later in Salzburg and Carinthia but also in the western part of the continent. An iconic golden exploitation is the one from Las Médulas, El Bierzo region, Spain, dating from Roman times, that is preserved today as a national park (Figs. 4,5).



Figures 4,5. The Roman gold exploitation from Las Medulas, El Bierzo, Spain
(Source: photos by the author, 2013)

Significant amounts of gold can also be found in river sediments. In Europe, rivers such as the Elbe, Danube, Inn, and Rhine (especially the stretch between Basel and Mainz) carry gold, as do Transylvanian rivers like the Mureș, Olt, and Arieș, along with many larger and smaller valleys in the Apuseni Mountains (Rusu Abrudeanu 1933: 7-12).

The Apuseni Mountains, located in present-day Romania, represent the oldest gold-bearing region of Dacia. This area forms a roughly trapezoidal zone with corners at Săcărâmbu (Hunedoara County), Zlatna-Roșia Montană-Abrud (Alba County), and Ofenbaia or Baia de Arieș (Turda County). Gold deposits in this region are primarily associated with secondary and tertiary eruptive rocks, which occur here in abundant quantities (Rusu Abrudeanu 1933: 42). Within the territory of Bucium commune, clear evidence of Roman mining activity can be seen on Frasinul Mountain, which separates the villages of Bucium-Șeasa and Bucium-Muntari, rising prominently near Detunata and the Corabia-Vulcoiu-Boteș massif, east of Bucium-Izbita and south of Bucium-Poeni. The Frasinul workings, after those at Cetatea Mare and Cetatea Mică in the Roșia Montană massif, represent some of the most impressive and extensive underground Roman mining operations (Rusu Abrudeanu 1933: 121-122). The miners' corporation (Collegium Aurorarium) was headquartered in Zlatna.

According to an old local mining law, characterized by small perimeters, in the beginning of the XXth century there were still hundreds of such

exploitations, tiny and primitive, grinding the ore, which they transported downhill on the backs of horses, with the help of stamps that have remained in use (Fig. 7), almost unchanged, since Roman times (Rusu Abrudeanu 1933: 239). On the other hand, mine owners fought to stimulate the insertion of local capital and mining associations were actively involved in the social and cultural life of miners.

Roșia Montană is the most famous mining site of the Apuseni mountains, still preserving a significant quantity of gold and providing great interest for its value as cultural landscape, industrial heritage dating from Antiquity, specific architectural settlement and natural area. Trapezoidal underground galleries are still well preserved today, with a length of 15 km. (Merciu, F.C.&all, 2015: 5-19)

A project of aggressive exploitation by surface mining that producing devastating effects on the environment has been stopped due to civic protests several years ago, now the site of Roșia Montană having achieved the recognition as an UNESCO site (2021). In the last 20 years, several summer schools have been organized in the area of Roșia Montană, studying the complex layers of patrimony of the region.

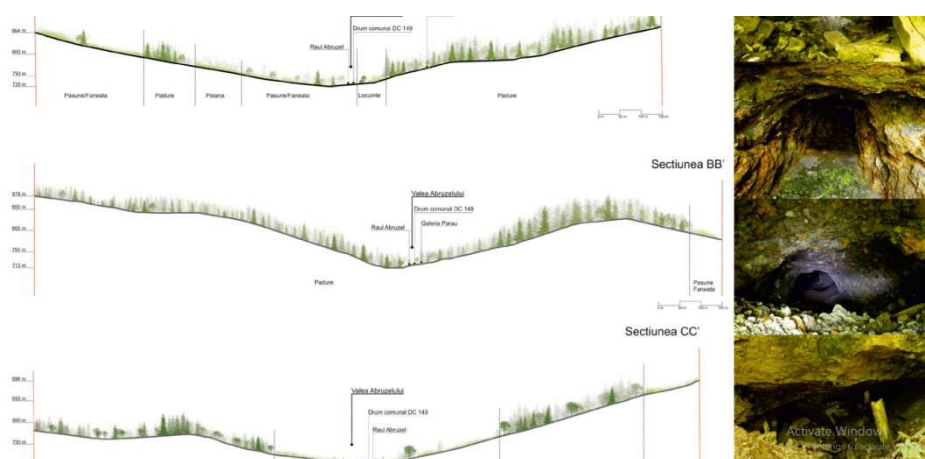


Figure 6. Study of gold mine mouths in the Abruzel valley, Bucium
(Source: study realized at Summer University Bucium, 2015, guided by author)



Figure 7. Domestic gold ore mill (*șteamp*), XIXth century, Bucium, Alba county, Romania
(Source: photo by the author, 2019)



Figure 8. Traditional objects used in mining – *corfă*, basket for carrying ore pieces, *lămpaș* (miner's lamp)
(Source: photo by the author, 2019)

The commune of Bucium, in the neighbourhood of Roșia Montană, is an authentic place in the Apuseni Mountains, privileged for preserving the many layers of mining traditions practiced for millennia. Numerous annual events, called "Summer Universities", have been held in Bucium over the years, since 2009. Within this occasions, numerous components of the local heritage have been inventoried, such as mine shafts, mining galleries (Fig. 6) and interventions in the landscape, to households, gold mills (Fig. 7), furniture, household items (Fig.8), etc. (Dușoiu 2020: 89-92).

3.4. Salt resources. Romanian salt pans

Salt mining in Romania dates back to prehistoric times. Archaeological evidence shows that salt was mined as early as the Neolithic period. During the Dacian and then Roman times, salt mining intensified, as salt was a strategic resource. In the Middle Ages, salt mines were controlled by rulers or royal authorities and represented an important source of income for the state (Albinetz et al. 2018: 5-8). It is known that the term "salary" comes from salt mines, where payment was given in kind. In Transylvania, the mines were administered by the royal authorities of the Kingdom of Hungary, and later by the Habsburg Empire (Albinetz et al. 2018: 5-8). In modern times, mining techniques have developed, and many salt mines have become industrial operations. Today, most are administered by the state-owned company Salrom, and some of them have also been transformed into important tourist and spa sites.

The main salt mines in Romania are located all over the country, the most important exploitations being: Turda Salt Mine – one of the most famous ones, dating from Antiquity, today an important tourist attraction, due to its renovation and architectural setting dating from 2010, Praid Salt Mine – the largest salt mine in Romania and one of the largest in Europe (unfortunately flooded recently following a natural disaster in 2025), Slănic Prahova Salt Mine – known for the Unirea Salt Mine, one of the largest salt mines in Europe, Târgu Ocna Salt Mine – important mine and treatment place for respiratory diseases, Ocna Dej Salt Mine – traditional mine in Transylvania and Ocnele Mari Salt Mine – old mine in the Getic Subcarpathian area.

3.5. Preservation of mining sites. Good practice examples

The mining industry is widely regarded as an important sector; however, the remnants of mining activities – especially those from the industrial era – have long been viewed as unattractive features of the landscape. As a result, efforts have more often focused on removing traces of mining rather than preserving and repurposing them. Nevertheless, these remains frequently embody significant historical and cultural values, reflecting

the technological achievements of past generations as well as the lives, traditions, customs, and beliefs of mining communities. When considered as heritage, however, they present clear contradictions, particularly regarding the definition of heritage values, as well as the economic and environmental risks associated with their use.

Cultural tourism that centers on mining heritage – along with the presentation, preservation, and interpretation of its values and meanings for visitors – is often referred to as mining tourism and can also be viewed as a form of geotourism. However, geotourism differs in that it primarily emphasizes geological and geomorphological features, whereas mining tourism focuses more on the physical remains of mining activities and related heritage. It seems that visitors are mainly attracted by opportunities to take guided tours through underground passages in former or still operational mines, as well as to explore their technical equipment and surface structures. This perspective, however, overlooks many important elements – especially intangible aspects that are also part of mining heritage – making such a definition incomplete. (Jelen 2018: 93-105)

Bianca Radu observed particular features of mining heritage, such as mono-industrial character, location in remote areas and overdependence of the mining company. "Mining communities need to develop projects that strengthen the solidarity among people who originate from different regions. Restructuring strategies should be planned well in advance, even during the profitable stage of the mining activity, to minimize the social impact of mine closure and to prevent migration of young people out of the community." (Radu, 2018: 39-51).

Europe has tried to preserve the memory of its mining sites, if possible, considering the integrality of their values (from connection and relation with landscape to underground systems of galleries, shafts etc. to different types of industrial constructions and infrastructures and to annex buildings and facilities (houses for workers, cultural buildings etc.). Mining regions from Germany, Belgium, France, Scandinavian countries, Spain or Italy have found a new perspective for their future by their transformation into geomineral parks or natural parks, into cultural centers, creative hubs or museums. Some outstanding examples of European mining parks are: the Sardinian Historical and Environmental Geomineral Park (UNESCO site), a huge territory that groups together and identifies eight

areas of Sardinia, Italy, covering a total of 3,500 km² (belonging to 81 different municipalities), presenting a mining tradition coming from the Roman Empire, the natural Park from Las Médulas (UNESCO site), Ponferrada, El Bierzo, Spain (Figs. 4,5), the Cabárceno Natural Park, from Penagos, Santander, Spain, where the mining geopark is combined with a zoological garden, Parque Miniero del Rio Tinto, Huelva, Andalusia, Spain or Geoparkea – the Basque Coast Geopark, situated in Bizcaya, comprising the municipalities of Mutriku, Deba and Zumaya.

Other successful conversions of mining sites, conceived following the concept of adaptive re-use, are the cultural center, creative hub and design academy C-mine, organized in a former coal mine in Genk, Belgium (Figs. 9, 10, 11) and the Museum of Energy from Ponferrada, Spain (Fábrica de la Luz), an exemplary approach showing all the aspects concerning energy : extraction of raw materials, transport, production, distribution, use, maintenance, workers community etc. The arrangement of the Energy Museum in Ponferrada in a former thermal power plant includes media testimonies through which former workers, engineers, administrators, but also former operating equipment are present in the current exhibition space (figs. 12, 13).



*Figures 9,10,11. C-mine Creative Hub, conversion of a former coal mine Genk, Belgium
(Source: photos by the author, 2015)*

Such rehabilitations allow us to draw comparisons of the re-used industrial buildings with sites from other country, still in an abandoned shape (Figs. 14,15,16,17). Such associations are often amazing, showing the extraordinary qualities of unity and coherence that mining sites have worldwide. We discover that industrial heritage (and mining in particular) have developed an own language and a proper message, recognizable everywhere.



Figures 12,13. The Museum of Energy (Fábrica de la Luz), Ponferrada, Spain, in a former central thermal plant, exterior views (Source: photos by the author, 2013)



Figures 14,15. A comparison between the interior space of Fábrica de la Luz (Ponferrada, Spain) and the electric plant of the Anina mines ensemble (Source: photos by the author, 2013/2007)



Figures 16,17. A comparison between the control board of Fábrica de la Luz (Ponferrada, Spain), former plant and control board of the electric plant of the Anina mines ensemble (Source: photos by the author, 2013/2007)

In conclusion, the numerous ingenious architectural and landscape intervention solutions show the potential of former mining sites to regenerate, following and applying the concept of adaptive re-use. In all successful interventions, the tradition and evolution of the community, which is actively involved in the functioning of the new ensemble, are taken into account.

4. Conclusions. Romanian mining heritage – where to?

During a period of more than 15 years dedicated to guiding diploma projects at the Faculty of Architecture and the Faculty of Interior Architecture of UAUIM Bucharest, I had the opportunity to observe the special interest of students in abandoned industrial sites, whose importance in defining the urban fabric and its development, as well as whose regeneration potential they intuitively perceive. In the vast collection of proposals for the regeneration of urban sites throughout Romania, a significant part was dedicated to mining sites: interventions on the Anina mines complex, the Moreni oil platform, the Moinești oil area (Bacau), interventions in the gold-bearing area of the Apuseni Mountains (Roșia Montana, Bucium) etc.

Probably, at this moment the range of reference models for interventions in mining sites on the territory of Romania is limited, the salt mines being perhaps the most attractive spaces of this type from a tourist point of view. Turda Salt Mine, designed around the 2010s by a team of young architects, remains emblematic for the spectacular scenography that can be achieved in the underground space.

We can now turn back to the initial questions dropped by this research: can we talk about a series of invariants in the analysis of mining industries? Definitely, considering the strong personality and identity of this entities of aboveground and underground landscape.

As for the second initial question: do these invariants give us solutions for the future preservation of mining sites?, we should consider the variety of approaches and intervention strategies that we can be found at European level. This multitude of solutions is applicable to sites in Romania: from mining geoparks to thematic museums or conversions that propose a diversity of activities that can highlight industrial spaces

with a strong identity, underground or above ground. Creativity has no limits in choosing the new functions: concerts are organized underground within the Mining Geopark in Sardinia, Italy, where musical events benefit from the special acoustics of the millenary excavated spaces.

An answer to our third research question is needed as well: can we apply in the intervention strategies a series of rules determined by the characteristics of the extracted material? We may consider here technical aspects, in terms of preservation, consolidation and accessibility, but also tradition and communities, who have been constructing their life for centuries around the resources extracted

Dr. Luciano Otelli, director of the Geological-Mining Park of Sardinia, was an engineer with a vast experience in the extraction process of mining and a deep connoisseur of the miner's community. During the 5th International Workshop on Industrial Archaeology held in the Mountain Banat region, Romania, 2007, after presenting the outstanding good practice example generated by the Sardinian experience, he finished his presentation, therefore, with a sad thought:

“Closing a mine is a tragedy because it means the end of an entire culture, a way of life, a way of being.”

We have to keep in mind the responsibility to preserve somehow this culture, way of life and way of being and integrate them into our present reality.

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ÉVALUATION DU BILAN HYDRIQUE DU BASSIN D'AL BARED (2011-2020), LIBAN NORD : UNE APPROCHE COMBINANT DIFFÉRENTES MÉTHODES D'INTERPOLATION PLUVIOMÉTRIQUE ET D'ÉVAPOTRANSPIRATION RÉELLE

Résumé. Cet article vise à l'identification d'une méthode pour caractériser l'évolution du bilan hydrique du bassin versant de la rivière Al Bared (Liban Nord) sur une période qui s'étend de l'année 2011 jusqu'à l'année 2020. Cette étude s'appuie sur trois méthodes d'interpolation (isohyètes, Thiessen et IDW) pour la détermination de l'élément d'entrée (la pluviométrie) et trois modèles empiriques (Turc, Thornthwaite et Coutagne) pour le calcul l'évapotranspiration. Le bassin reçoit annuellement en moyenne 1216 mm de précipitations selon la méthode des isohyètes. L'analyse des résultats de l'évapotranspiration (ETR) a montré une différence significative entre les valeurs obtenues des trois modèles. La valeur de l'ETR qui constitue la frange d'eau qui retourne vers l'atmosphère sous forme de vapeur d'eau atteint 580.58 mm, soit près de 47.7% de la lame d'eau précipitée en appliquant la méthode de Thornthwaite pour l'évapotranspiration réelle. La quantité d'eau ruisselée est de l'ordre de 469.50 mm, soit 38% de la lame d'eau précipitée pour enfin estimer la lame d'eau infiltrée de 279.14 mm, soit 23 % de la lame d'eau précipitée.

Mots-clés : bilan hydrique, BVB El-Bared, isohyètes, évapotranspiration

1. Introduction

Le Liban apparaît comme l'exemple d'un pays qui reçoit des quantités de pluie importantes de 8.2 milliards m³ par an en moyenne (Comair, 2008),

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mais qui se trouve devant des grandes difficultés financières et techniques pour les récupérer (Charbel, 2012). Cela pourra avoir comme effet de retarder relativement son développement du domaine agricole dont les surfaces irriguées représentent à peine 40% des superficies cultivées (Ministère de l'Agriculture, 2020). Les secteurs secondaires et tertiaires présentent une demande accrue en eau (Comair, 2005). Au Liban, les problématiques de l'eau, de l'énergie et de l'environnement influent sur le développement durable. Ces facteurs constituent les principaux défis auxquels fait face la population libanaise.

Connaissant que la grande majorité de l'approvisionnement en eau prend ses sources des aquifères du Mont-Liban dont le bassin versant du Nahr El-Bared (Liban-Nord) fait partie. Dans beaucoup de domaines, le bassin montre des caractéristiques similaires à celles des régions karstiques de la montagne libanaise. La fissuration des couches géologiques du bassin favorise l'infiltration rapide vers le souterrain (Akkari, 2024). Le cours d'eau d'Al Bared apporte en moyenne 72 Mm³ (moyenne de 20 ans allant de l'année 2000 jusqu'à l'année 2020) selon les données livrées par l'Office National du Litani – Liban (ONL)) et prend naissance des hautes altitudes (2800 m) du Mont Liban.

Le bassin versant du Nahr Al Bared constitue un système complexe dont le bilan hydrique, résultant de l'interaction entre les précipitations, l'écoulement et les paramètres morphométriques, exprime l'aspect central de cette complexité, connaissant que le bilan hydrique est l'une des sources d'informations les plus importantes sur le bassin versant. Le bilan hydrique est une approche majeure pour valider les limites du système karstique, ainsi que ses conditions de recharge et de décharge (El Hakim, 2005). Malgré les précipitations appréciables (allant de 1000 mm sur la cote à plus 1400 mm en hautes altitudes), la robuste diminution du débit d'étiage soulève des interrogations quant à la compréhension de la relation entre les composantes du bilan et en second lieu la manifestation des détails morphométriques dans le bassin.

Dans le but d'explorer les possibilités du bilan hydrique en tant qu'outil d'analyse de la durabilité de l'eau, cet article utilise l'équation du bilan hydrique pour évaluer les ressources disponibles dans le bassin d'Al Bared. L'objectif principal est de mettre en place un cadre dans lequel les apports et les sorties d'eau dans le bassin sont déterminés et

utilisés pour définir la capacité du bassin à répondre à la demande totale en eau à partir de ses propres ressources. En outre, l'étude discute de la manière d'estimer les données hydrologiques, même si elles sont incertaines.

Certains des éléments du bilan hydrique (précipitations et débit) sont mesurés par le secteur public (Direction Générale de l'Aviation Civile – Département météorologique et l'Autorité Nationale du Fleuve Litani au Liban (ONL), et autres éléments sont calculés à partir de formules empiriques. L'interpolation spatiale devient nécessaire en terme du bilan pour prédire les précipitations, en surmontant les données limitées, l'environnement et d'autres conditions physiographiques, afin que la modélisation des autres composantes puisse toujours être réalisée.

Comme le montre Rösler (2010), les valeurs mesurées des précipitations sont inférieures de 6 à 20 % aux valeurs réelles. D'un autre côté, une connaissance détaillée de tous les éléments et de leurs valeurs est importante pour l'évaluation du bilan hydrique. Chaque élément peut être calculé à l'aide de méthodes indirectes, en utilisant des données provenant de bassins versants analogiques ou de formules empiriques qui ne sont qu'une approximation des conditions réelles. L'un des éléments les plus problématiques est l'évapotranspiration, qui n'est pas mesurée sur le réseau régulier. Ce paramètre est calculé à partir de formules qui permettent de déterminer l'évapotranspiration potentielle ou de référence ou réelles.

2. Problématiques

L'acquisition de données pluviométriques plus précises est donc cruciale pour améliorer les résultats de prévision de l'hydrogramme. Uniformément réparties sur la zone d'étude en raison de la variabilité topographique des bassins versants, il est préférable d'avoir autant de stations pluviométriques que possible pour estimer les précipitations surfaciques qui représentent les précipitations réelles sur le bassin. Malheureusement, il n'est pas possible d'installer des stations pluviométriques dans autant d'endroits qu'espéré en raison de facteurs limitants tels que les contraintes budgétaires, l'inaccessibilité de certaines zones ou le manque de personnel disponible. Plusieurs techniques d'estimation des précipitations surfaciques sont

actuellement utilisées pour effectuer la moyenne des précipitations collectées aux stations. Les techniques isohyètes et polygonales de Thiessen sont des techniques conventionnelles qui sont généralement appliquées pour estimer les précipitations surfaciques sur l'ensemble du bassin (Taesombat, 2009). Cependant, les principes fondamentaux d'application de ces techniques peuvent produire des résultats différents en raison des effets de la variation topographique et du nombre limité de stations pluviométriques disponibles. Étant donné que les précipitations sont spatialement variables et que leur distribution spatiale varie d'un événement à l'autre, les précipitations ponctuelles ne fournissent pas une estimation ou une représentation précise des précipitations dans une zone. La pluviométrie surfacique sera toujours une estimation et non la véritable profondeur des précipitations, quelle que soit la méthode.

Toutes ces méthodes d'estimation des précipitations moyennes au niveau d'une zone calculent la moyenne pondérée des valeurs ponctuelles des précipitations ; la différence entre les différentes méthodes réside uniquement dans l'attribution de poids à ces valeurs de précipitations ponctuelles individuelles. Les poids étant principalement basés sur la superficie proportionnelle représentée par une jauge ponctuelle.

Une quantification précise de l'évaporation réelle (ETR) est élémentaire pour la planification et la conception des systèmes d'approvisionnement en eau et l'utilisation durable de ces ressources. Cependant, la rareté du réseau de stations d'observation limite la compréhension de l'évapotranspiration à l'échelle de certains grands bassins

L'ET en moyenne spatiale à l'échelle du bassin peut être estimée à l'aide de l'équation du bilan hydrique : $ETR = P - Q - \Delta S$. Ceci calcule l'évapotranspiration comme le résidu entre les précipitations (P) et la somme du débit fluvial (Q) et du changement de stockage d'eau terrestre (ΔS). En effet, le stockage terrestre de l'eau revient directement à tous les facteurs d'influence, y compris les activités humaines telles que l'agriculture, l'irrigation et la retenue par des réservoirs.

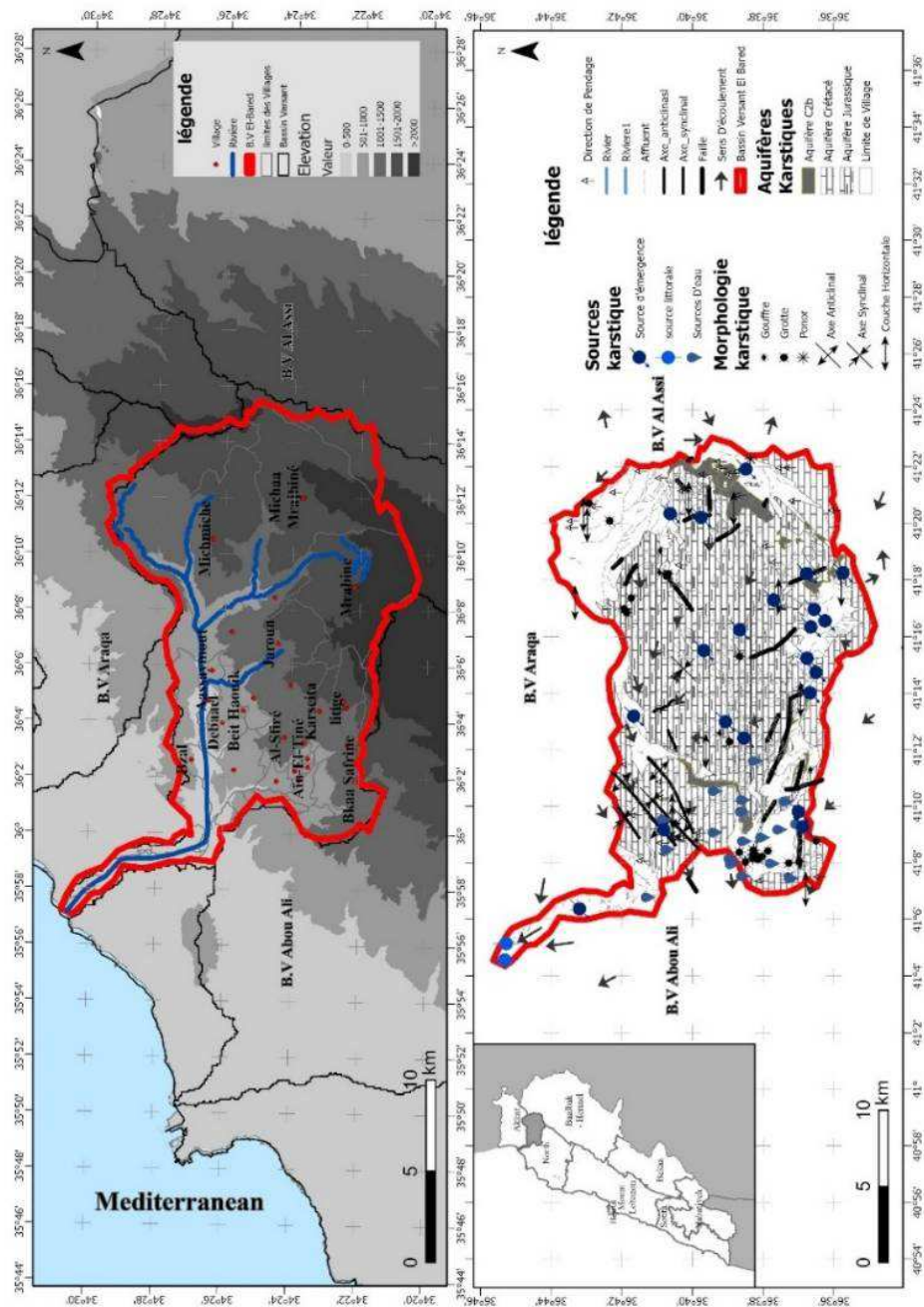
Dans ce contexte, la problématique centrale de cette étude réside dans la nécessité de déterminer les paramètres influençant le bilan hydrique du bassin versant du Nahr Al Bared. Dans ce domaine, se soulèvent plusieurs emplois de recherche :

- La circonspection de trois méthodes d'interpolation des précipitations rend-t-elle des résultats similaires avec les trois méthodes pour la fonction d'entrée du bilan ?
- Dans quelle mesure l'application des formules de Turc, Coutagne et Thornwaite offre-elle des perspectives convergentes ou divergentes sur le bilan hydrique du bassin versant. En un autre volet, la question se pose sur l'interprétation des résultats à la lumière des paramètres morphométriques ?

3. Cadre de l'étude

La région étudiée superficie de 283.24 km² (Akkari, 2023) se situe au Liban-Nord, entre les latitudes Nord 34°19 '59'' et 34°30'20'' et les longitudes Est 36°15'25'' et 35°56'14''. Le Caza El-Miné Ed Danniyé et Mohafazat Akkar englobent la majorité de la superficie du bassin (81.23% ; fig. 1) ; la minorité du bassin s'étend dans le Caza El Hermel. Le bassin présente une grande importance surtout qu'il englobe 54 villages en pleine extension démographique et agricole.

Nahr Al Bared récolte les eaux des hautes altitudes aboutissant les 2800 m (Jabal el Makmel, Jabal El Arbain, Jabal Masrah El Diab et Jabal Jouret EL Qbabit), de la source Es-Soukkar et puis rencontre l'affluent Nahr Abou Moussa venant de Qamouaa à Ayoun El Samak pour passer après dans les vallées du Caza du Sir Ed Danniyé pour enfin se jeter dans la mer Méditerranée. La zone étudiée se trouve limitée à l'Ouest par la mer Méditerranée, au Nord par le bassin versant de la rivière Araqa, à l'Est par le bassin versant de Nahr El Assi et au Sud par le bassin versant du Nahr Abou Ali.



4. Matériels et méthodes

La précision de l'estimation du ruissellement et des crues est importante pour atténuer les problèmes liés à l'eau. La précision dépend des méthodes utilisées pour l'approximation des précipitations surfaciques. Plusieurs méthodes sont utilisées pour traduire une image précise du bilan hydrologique. Ces méthodes concernent la détermination de la pluviométrie, de l'évapotranspiration et de l'infiltration selon diverses procédés et formules. Notre étude se base sur la détermination du bilan hydrologique qui est l'issue des quantités d'eau entrant et sortant du système dans l'espace et dans le temps. Une comparaison entre ces méthodes sera établie afin de déceler la fiabilité de chacune dans le bilan dont la période s'étend de l'année 2011 jusqu'à l'année 2020.

La méthodologie du travail divisée en deux parties :

A. Collection du données : Les données climatiques utilisées dans cette étude reposent sur des séries de précipitations journalières issues des 13 stations situées au sein de la zone d'étude, notamment Abdeh, Fnaydeq, Es Sfiré, Sir Ed-Danniyeh, Bcharreh, Amioun, Chekka, Batroumn, Akkar Al Atiq, Berbara, Halba et Tourzaya, couvrant la période allant de 2011 à 2020. Ces données ont été fournies par l'IRAL (Lebanese Agricultural Research Institute) et constituent une base essentielle pour l'analyse de la variabilité spatio-temporelle des précipitations.

Par ailleurs, les données hydrologiques correspondent aux chroniques de débits journaliers du Nahr El-Bared. Ces informations, obtenues auprès de l'ONL (Office National du Litani), couvrent une période allant de 2011 à 2020 et permettent d'analyser la dynamique hydrologique et les réponses du bassin versant aux événements pluviométriques.

Enfin, les cartes géologiques à l'échelle 1/50 000, élaborées par Dubertret, ont été utilisées comme référence de base pour la caractérisation lithologique de la zone d'étude. Elles ont notamment servi à l'élaboration de la carte d'infiltration, en intégrant les propriétés géologiques influençant les processus de percolation et de stockage des eaux.

B. Composantes du bilan hydrologique : Le bilan hydrologique du bassin versant s'exprime schématiquement par la formule suivante :

$$P = E + Q + I + U + dR$$

P précipitation, E évapotranspiration, Q écoulement, I infiltration, U utilisation humaines et dR variation des réserves de surface et souterraines.

Chacun des termes du bilan hydrologique est naturellement pondéré par divers paramètres climatiques et géographiques ; par exemple la température est l'un des facteurs principaux du pouvoir évaporant de l'atmosphère, le relief conditionne les précipitations des masses nuageuses et la nature de la couverture végétale influe sur le phénomène d'interception et de transpiration (Morell, 1999).

Choix des formules impliquées dans le calcul du bilan

Les composantes du bilan hydrologique sont divisées en éléments d'entrée représentés par la pluviométrie et les éléments de sortie figurés par l'évapotranspiration, le ruissellement et l'infiltration; chacun de ces paramètres est calculé à partir des méthodes directes (mesures in situ) et empiriques par l'utilisation des diverses formules.

a. Méthodes d'interpolation de la pluviométrie

Des données pluviométriques annuelles ont été collectées entre 2011 et 2020 à partir des stations pluviométriques situées à l'intérieur et autour du bassin de la rivière Al Bared. La cohérence des données pluviométriques a été vérifiée à l'aide de la méthode de la courbe de double masse. Les données pluviométriques se sont révélées fiables et ont donc été utilisées pour une analyse plus approfondie.

Connaissant la nature et les caractéristiques des précipitations, nous pouvons conceptualiser leurs effets sur le ruissellement, l'infiltration, l'évapotranspiration et le rendement en eau. Elles sont en règle générale mesurées ponctuellement à l'aide d'instruments (pluviographe et pluviomètre) installés dans des stations météorologiques. Pour effectuer l'estimation rigoureuse de la pluie globale sur le bassin, il est nécessaire de prendre

en compte l'hétérogénéité spatiale de cette variable. Le nombre limité des stations situées sur le site d'une part, et l'influence du relief d'autre part font l'aspect particulièrement difficile à assembler. Dans ce contexte et pour conformément interpoler la pluviométrie, plusieurs méthodes sont proposées telles que les polygones de Thiessen, les isohyètes et la moyenne arithmétique (Tab 1). Pour permettre cette estimation, l'emploi des méthodes déterministes en fonction de l'aire du bassin, se voit indispensable pour déterminer la pluie globale correspondante.

Tableau 1

Méthodes d'interpolation des précipitations selon Cosandey et Robinson (2000)

Méthodes	Caractéristiques	Domaines d'emploi
IDW (Inverse Distance Weighting)	– Pondération des valeurs selon la distance (plus proche = plus influent) – Surface continue (raster) – Variable selon la distance – Bonne si les points sont bien repartis	Plus couramment utilisée
Isohyètes	– Prendre en compte du relief – $P_{(bassin)} = P_1 \times S_1 + P_2 \times S_2 + \dots + P_n \times S_n$	Plus rigoureuse
Thiessen	– Simplification des Isohyètes – Se base sur les polygones – Affecte à chaque pluviomètre une zone d'influence dont l'air exprimée en % représentant le facteur de pondération de la valeur locale – La quantité d'eau est proportionnelle à la surface du polygone	Plus couramment utilisée

b. Méthodes empiriques pour le calcul de l'évapotranspiration réelle

Evapotranspiration. Contrairement aux pluies ou aux écoulements qui peuvent faire l'objet d'une approche quantitative satisfaisante bien que précise, il est actuellement très difficile de mesurer directement le flux de vapeur d'eau dans l'atmosphère (Youssef , 2015).

L'évapotranspiration est calculée à partir de mesures directes in situ, méthodes analytiques basées sur le bilan hydrique ou bilan énergétique et méthodes empiriques basées sur l'analyse statistiques des observations (Tab 2).

L'ETR est la somme des quantités de vapeur d'eau évaporées par le sol et par les plantes. À partir des observations faites sur 254 bassins versants situés sous tous les climats du globe M. Turc (1961) proposa la formule empirique suivante qui estime l'évapotranspiration réelle annuelle d'un bassin en fonction de la pluie annuelle et sa température annuelle moyenne :

$$ETR = \frac{P}{\sqrt{0.9 + \frac{P^2}{L^2}}}$$

Avec $L = 300 + 25 t + 0.05t^3$; P : hauteur annuelle de pluie (en mm);
 t : température annuelle (en °C).

Cette formule est d'un emploi aisé et ne se rapproche de l'évapotranspiration réelle que pour des bassins versants relativement étendus, sans échanges à la frontière et pour des durées d'observation assez longues pour que l'on puisse négliger les variations de réserves souterraines (Awad, 2011).

Formule de Thornthwaite, déjà ancienne (1944), est basée sur de nombreuses expériences effectuées sur des cases lysimétriques. L'évaporation potentielle est donnée par la formule :

$$ETP = C T^a$$

ETP : est l'évapotranspiration mensuelle en centimètres pour un mois fictif de 30 jours et une durée théorique d'ensoleillement de 12 heures sur 24 ; T : la température en °C pour le mois-considéré ; (C) et (a) sont des fonctions de l'indice thermique annuel, (a) est calculé à partir d'un indice thermique mensuel donné par la formule :

$$I = (T/5)^{1.514}$$

Si l'on appelle I l'indice annuel égale à la somme de 12 indices mensuels et en adaptant certaines simplifications, la valeur de (a) est donnée par l'expression :

$$a = (1.6/100)I + 0.5$$

Le terme C varie en sens inverse de I et en définitive l'équation peut s'écrire:

$$(ETP) = 1.6 (10. T/I)^a$$

En coordonnées logarithmiques, les courbes représentatives de cette dernière équation sont des droites correspondant à des lieux et des climats différents. L'expérience Montre que ces droites concourent vers le point de coordonnées ETP = 135mm et T = 28.5 c (Morell, 1999).

La comparaison des valeurs mensuelles de l'évapotranspiration potentielle (ETP) et des hauteurs des précipitations mensuelles (P) permet de calculer l'évapotranspiration réelle mensuelle (ETR).

Tableau 2

Fiabilité des formules d'évapotranspiration

Méthodes	Formule	Caractéristiques	Domaines d'emploi
Turc	$ETR = \frac{P}{\sqrt{0.9 + \frac{P^2}{L^2}}}$	Prend en compte le rayonnement solaire. Plus complexe à appliquer que la formule de Coutagne. Moyennement employée dans les situations nécessitant une prise en compte du rayonnement solaire, comme l'irrigation et la gestion des ressources en eau.	Utilisation modérée
Thornthwaite	$ETP = C T^a$	Prend en compte la température et la latitude Plus complexe à appliquer que la formule de Coutagne La complexité des calculs et la nécessité de données supplémentaires la rendent peu utilisée en pratique. Elle est plutôt réservée aux recherches approfondies.	Utilisation rare
Coutagne	$\lambda = \frac{D - p - \lambda \cdot p^2}{0.8 + 0.14 \cdot t}$	La plus simple, mais elle peut être la moins précise. Empirique, ne reflète pas les processus physiques complexes. Simple et facile à appliquer Assez courante dans les études préliminaires.	Fréquemment utilisée

Les méthodes développées ne peuvent donner qu'un ordre de grandeur approximatif de l'ETR puisqu'elles sont basées, pour la plupart, sur l'emploi de relations empiriques qui ne tiennent pas compte spécifiquement du contexte climatique et du type de végétation rencontrés sur le bassin étudié (Youssef , 2015).

c. Méthodes et formules concernant la détermination du débit

L'écoulement. Les méthodes et formules concernant la détermination du débit offrent un aperçu précieux de la dynamique hydrologique des cours d'eau, contribuant ainsi à une gestion plus efficace des ressources en eau et à une meilleure préparation aux événements hydrologiques extrêmes. Il constitue le troisième paramètre essentiel du bilan hydrologique.

Le débit mesuré est obtenu d'après les mesures limnimétriques effectuées par l'ONL (Office National du Litani) à l'embouchure du Nahr Al Bared. L'écoulement dans le bilan hydrologique d'un bassin versant est caractérisé par le coefficient d'écoulement total « C », défini par le rapport entre les quantités d'eau écoulées et celles précipitées : $C = E(t)/P$.

d. Méthodes de détermination de l'infiltration

L'infiltration représente le processus de passage de l'eau à travers les couches superficielles du sol lorsque celui-ci reçoit une averse ou est exposé à une submersion. L'eau d'infiltration remplit en premier lieu les interstices du sol en surface et pénètre par la suite dans le sol sous l'action de la gravité (Musy , 1998). L'infiltration est nécessaire pour renouveler le stock d'eau du sol, alimenter les eaux souterraines et reconstituer les réserves aquifères. Elle peut aussi réduire les débits de ruissellement (Youssef , 2015).

L'infiltration est déterminée d'après la soustraction des paramètres de sortie des paramètres d'entrée comme suit : $I = P - (Q + E + \Delta S)$.

La quantité d'eau stockée est définie aussi selon l'approche empirique d'Horton qui s'écrit :

$$i(t) = i_f + (i_0 - i_f) * e^{-\alpha t}$$

$i(t)$: capacité d'infiltration au cours du temps (cm/s) ; i_0 : capacité d'infiltration initiale (cm/s) ; i_f : capacité d'infiltration finale (cm/s) ;
 g : constante fonction de la nature du sol (min^{-1}).

L'utilisation de ce type d'équation, quoique répandue, reste limitée, car la détermination des paramètres, i_0 , i_f , et g présente certaines difficultés pratiques (Musy, 1998).

5. Résultats et discussion

L'examen complet se penche sur l'interaction complexe des précipitations, du ruissellement, de l'évapotranspiration et d'autres facteurs qui façonnent l'équilibre hydrologique du Nahr l Bared.

Éléments d'entrée. Les précipitations révèlent les principaux éléments d'entrée du bilan hydrologique. Pour l'étude du bilan, une estimation correcte de la lame d'eau sollicite l'adoption de l'une des méthodes d'extrapolation de la pluviométrie : Thiessen, Isohyètes et IDW.

Pluviométrie estimée selon la méthode du IDW. La carte de répartition spatiale des précipitations obtenue par la méthode d'Inverse Distance Weighting (IDW) met en évidence une structuration nette du champ pluviométrique à l'échelle du bassin versant d'El-Bared (Fig. 2). Cette approche, fondée sur le principe de décroissance de l'influence avec la distance, génère une surface continue dominée par les stations les plus proches, ce qui se traduit par des gradients concentriques autour des points d'observation. Les résultats montrent que les précipitations varient globalement entre moins de 737 mm et plus de 1550 mm, traduisant une forte hétérogénéité spatiale. Un noyau de fortes précipitations, atteignant 1283 à 1550 mm, se localise dans la partie centro-occidentale du bassin, principalement sous l'influence des stations de Es Sfireh et Sir Ed Danniye, ce qui suggère un effet orographique marqué. Autour de ce noyau, une zone de transition comprise entre 1072 et 1283 mm illustre l'atténuation progressive de l'influence des stations les plus arrosées.

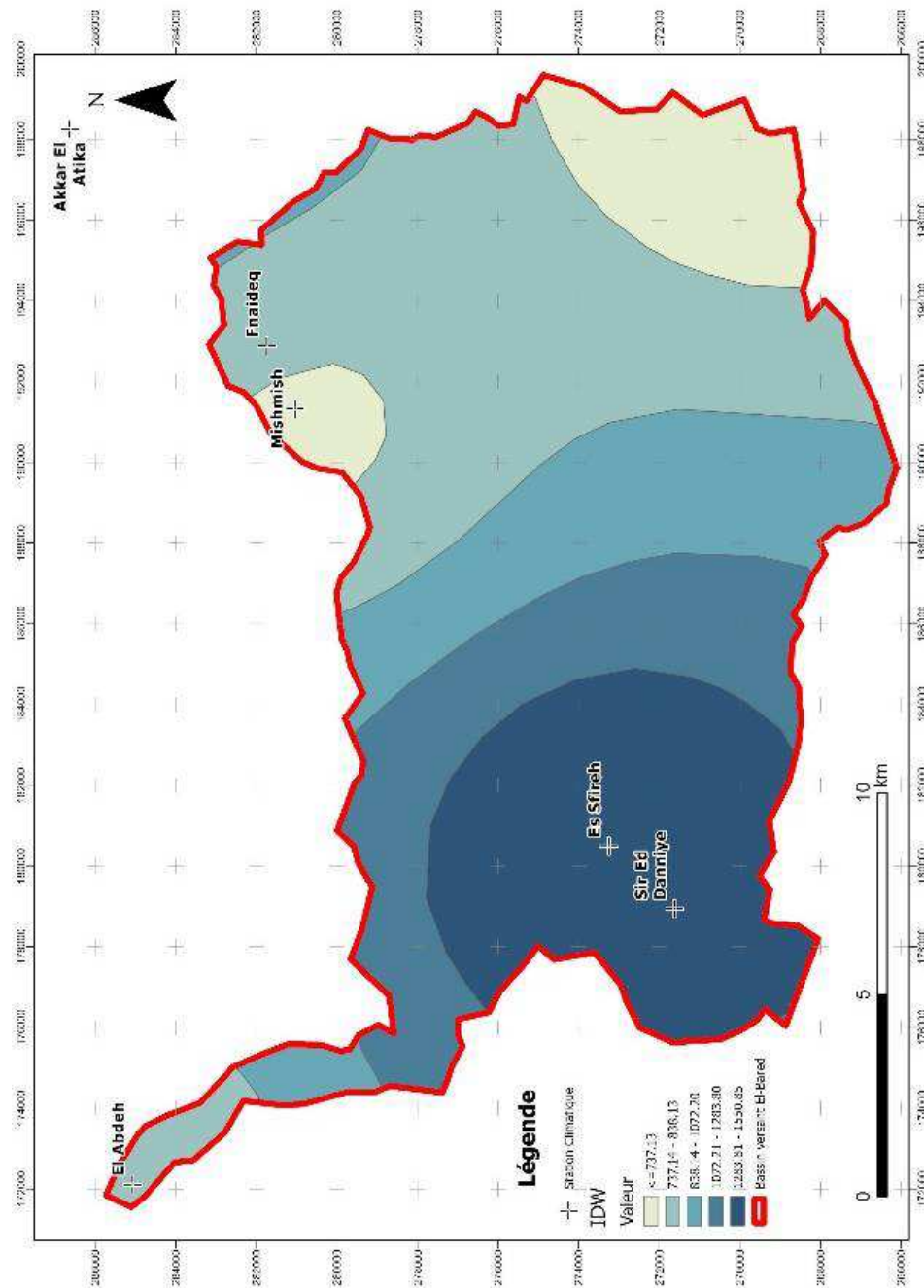


Figure 2, Pluviométrie estimée selon la méthode du IDW

À l'inverse, les marges orientales et nord-occidentales présentent des cumuls pluviométriques plus faibles, généralement compris entre 737 et 838 mm, voire localement inférieurs à 737 mm, en relation avec l'influence des stations de Mishmish, Fnaideq et El Abdeh. Cette distribution traduit un gradient pluviométrique global décroissant d'ouest en est, avec une diminution pouvant dépasser 700 mm entre les zones les plus humides et les plus sèches. Toutefois, cette structuration doit être interprétée avec prudence. La méthode IDW tend à produire des artefacts spatiaux qui reflètent davantage la position des stations que la variabilité réelle du phénomène climatique. De plus, l'absence de prise en compte explicite des facteurs topographiques limite la capacité du modèle à reproduire fidèlement les mécanismes contrôlant les précipitations. Ainsi, bien que l'IDW fournisse une approximation quantitative utile, son interprétation dans un cadre scientifique nécessite une validation croisée avec d'autres méthodes d'interpolation ou des approches intégrant des variables explicatives.

Pluviométrie estimée selon la méthode de Thiessen. La méthode du polygone de Thiessen est couramment utilisée, parce que son application s'adapte bien, et parce qu'elle donne en général de bons résultats. Elle convient notamment lorsque le réseau pluviométrique n'est pas spatialement homogène. Les différentes zones d'influence sont déterminées par le découpage géométrique du bassin du Nahr El-Bared. Dans chaque polygone, la hauteur de précipitations est celle relevée à la station située à l'intérieur de celui-ci. Les côtés des polygones représentent les limites de l'aire accordée à chaque station (Youssef , 2015). L'aire de chaque polygone (A_i) est déterminée à travers le logiciel ARCGIS Pro 3.5 (Fig. 3).

Tableau 3

Précipitations selon la méthode de Thiessen (2011-2020)

Station	Altitude en m	Superficie Km ²	% de la superficie	Ai km ²	Pi mm	P moy
El-Aabdé	40	9.15	3.2	9.15	706	22.80
Sir Ed Danniyé	915	23.5	8.28	23.5	1286	106.75
Es-Sfiré	1020	114.12	40.29	114.12	1550.64	624.76
Mishmish	1800	75.54	26.66	75.54	470	125.34
Fnaideq	1130	60.88	21.49	60.88	812	174.54
Totale		283.24	100	283.24		1054.19

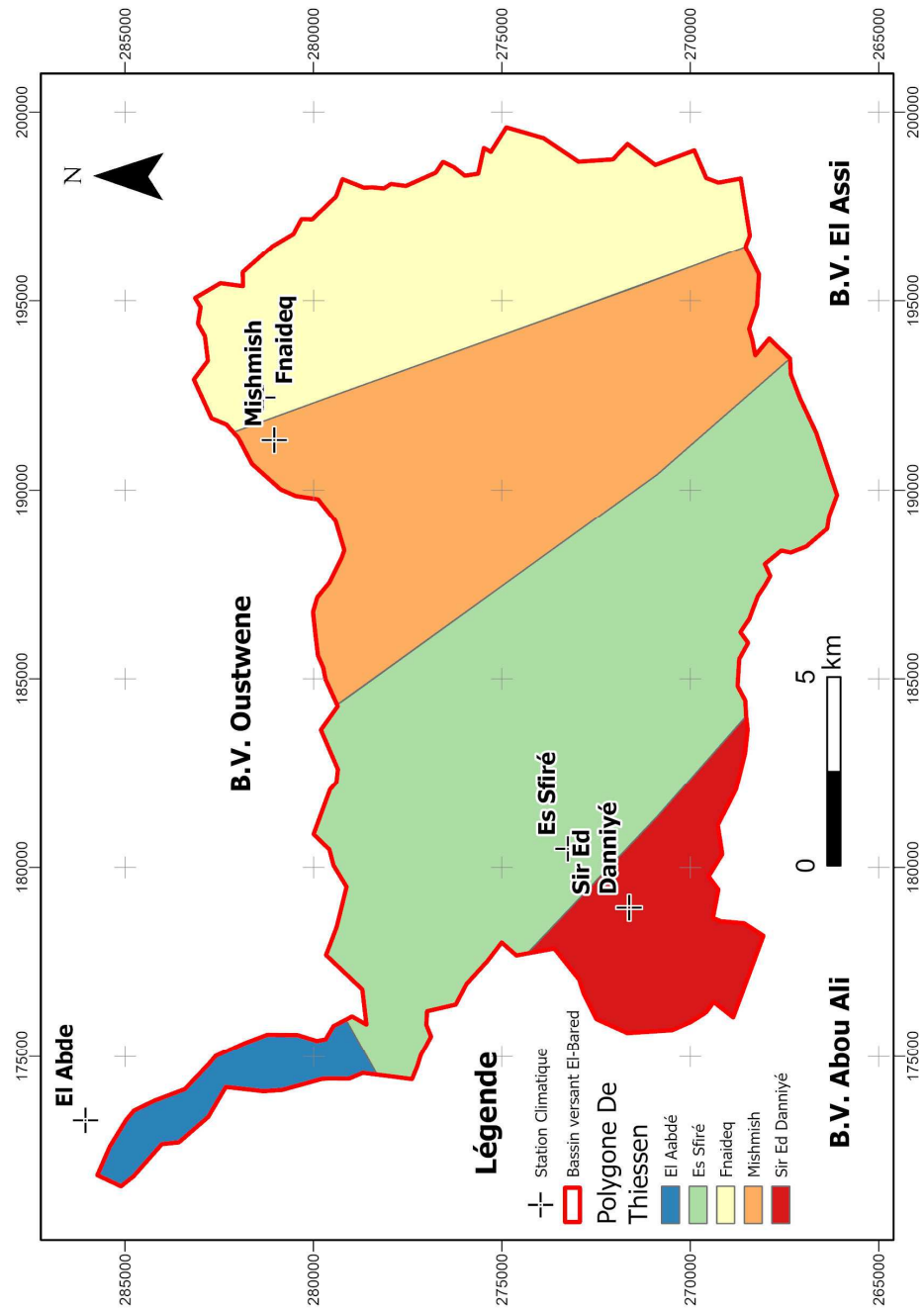


Figure 3. Stations pluviométriques adoptées selon la méthode de Thiessen

La pluviométrie établie selon la méthode de Thiessen s'écrit :

$$P_{\text{moy}} = \frac{\sum A_i \cdot P_i}{A}$$

P : Pluviométrie, *A* : Aire totale du bassin ($=\sum A_i$) ; *P_i* : Précipitation enregistrée à la station *i*; *A_i*: Superficie du polygone associée à la station *i*.

L'extrapolation selon Thiessen montre une pluviométrie annuelle moyenne de 1054.19 mm. En fait, la station d'Es Sfiré présente la plus haute quantité de pluies tombée (1550.64 mm) (Tab 3) parmi les autres stations du bassin. Selon la méthode de Thiessen, une seule station « Es-Sfiré » a une superficie très élevée si non exagérée, car elle seule occupe plus que 40.29 % (114.12 km²) de la superficie étudiée.

Pluviométrie selon la méthode des Isohyètes. Les isohyètes sont des lignes de même pluviosité. Cinq stations (Al-Aabdé, Halba Amioun, Sir Ed Danniyé, Fnaideq-Mishmish, Akkar Atika-Bchareé) ont été adoptées (Fig. 4).

Lorsque les courbes isohyètes sont tracées, la pluie moyenne peut être calculée de la manière suivante (Tab 4):

$$p_{\text{moy}} = \frac{\sum_{i=1}^K A_i \cdot P_i}{A} \quad \text{avec} \quad P_i = \frac{h_i + (h_{i+1})}{2}$$

P : précipitation sur le bassin ; *K* : nombre total d'Isohyète ; *A* : surface totale du bassin ; *P_i* : moy des hauteurs *h* de précipitations entre deux Isohyètes *i* et *i*+1 ; *A_i*: surface entre deux Isohyètes *i* et *i*+1.

Tableau 4

Précipitations reçues selon la méthode d'isohyètes (2011-2020)

Station	Superficie Km ²	% par rapport à tout le bassin	Pi mm	P moy
Al-Aabdé	0.59	0.20	706	1.4
Halba Amioun	4.81	1.69	741	12
Sir Ed Danniyé	49.97	17.64	1286	227
Fnaideq- Es-Sfiré	122.25	43.16	1181	509
Akkar Atika- Bcherré	105.6	37.28	1248	465
Totale	283.24	100		1216

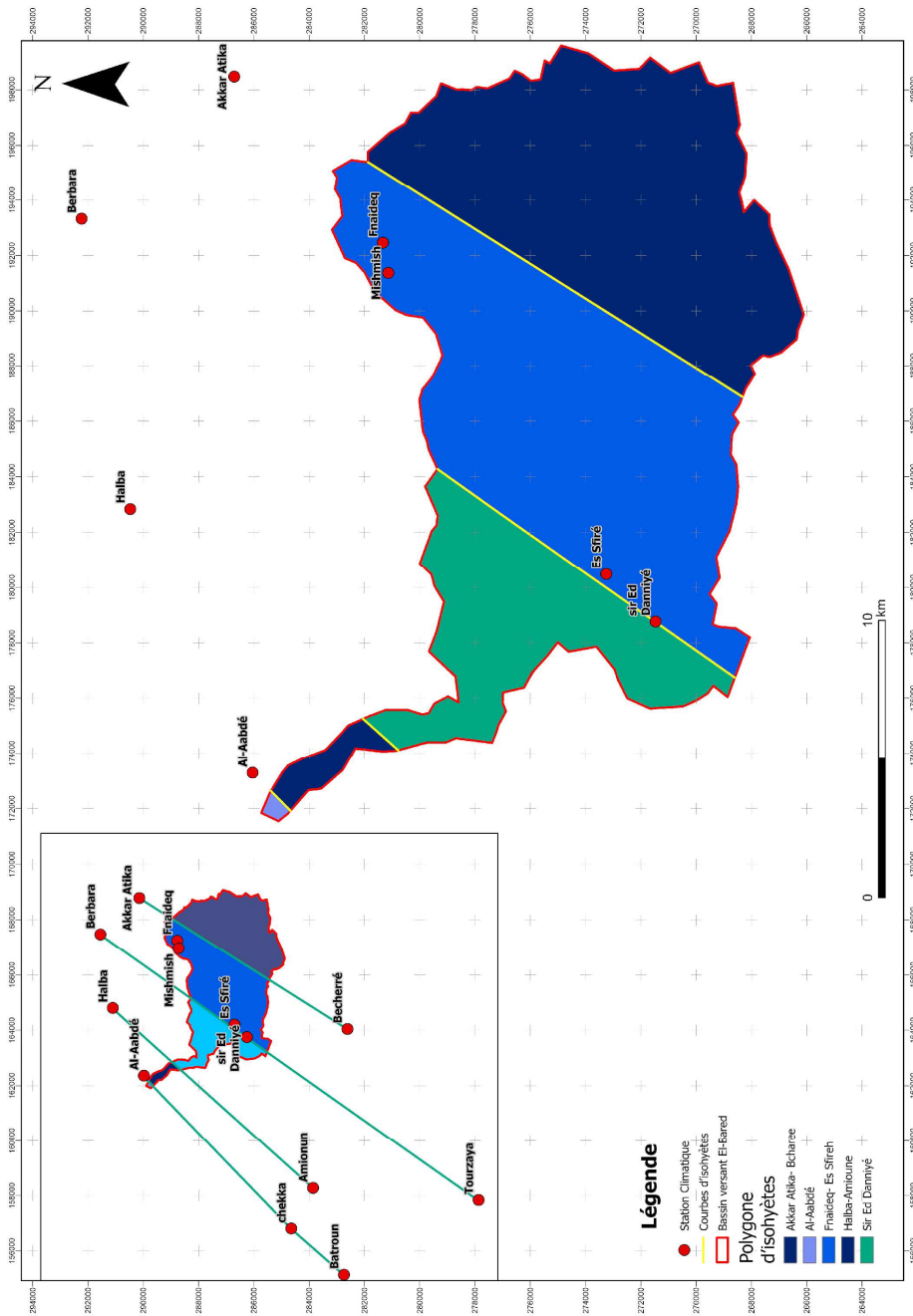


Figure 4. Stations pluviométriques adoptées dans la méthode d'isohyètes

L'extrapolation selon la méthode des Isohyètes, montre une pluviométrie annuelle moyenne de 1216 mm supérieur à celle obtenue selon Thiessen (1054 mm).

Pour se rassurer de la consistance des résultats, on a recours à l'analyse statistique One way Anova³ en utilisant le logiciel SPSS. Le Tableau 5 montre qu'il n'y a pas une différence significative entre les deux méthodes utilisées pour la mesure des précipitations. En outre, ces deux méthodes sont applicables pour le calcul des précipitations dans le bassin du Nahr Al Bared. Ainsi, on s'assure que la méthode des Isohyètes est représentative car elle prend en considération l'effet d'altitude. On note que cette méthode est largement utilisée dans les études d'interpolation des précipitations.

L'analyse de variance à un facteur (ANOVA) a été réalisée afin de comparer les moyennes des précipitations estimées par les méthodes des isohyètes, des polygones de Thiessen et de l'IDW. Les résultats montrent que la variance inter-groupes (SS = 45 722.00) est très faible par rapport à la variance intra-groupes (SS = 1 539 823.00), ce qui se traduit par une statistique F faible (F = 0.18). La valeur de significativité associée (p = 0.836) est largement supérieure au seuil de 0.05, indiquant l'absence de différence statistiquement significative entre les méthodes. Ces résultats suggèrent que les trois approches produisent des estimations globalement comparables dans le cadre de cette étude.

Tableau 5

Analyse statistique des résultats des méthodes : Isohyètes, Thiessen selon le logiciel SPSS⁴

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2566.724	1	2566.724	.045	.838
Within Groups	458178.964	8	57272.371		
Total	460745.688	9			

La comparaison des trois méthodes d'estimation des précipitations (IDW, Thiessen et isohyètes) met en évidence des différences dans la représentation

³ Analyse de variance (ANOVA) à un facteur.

⁴ Between groups: Inter-groupes; Within groups: Intra-groupes; Sum of Squares: somme des carrés; df (degree of freedom): degré de liberté; Mean Square: moyenne des carrés; F: Test du F (de Fisher-Snedecor); Sig.: Signification.

spatiale du champ pluviométrique, malgré des résultats globalement cohérents (Fig. 5, Tab 6).

Tableau 6

Analyses statistiques des résultats des méthodes: Isohyètes, Thiessen et IDW effectuées à travers le logiciel SPSS⁵

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	45 722.00	2	22 861.00	0.18	.886
Within Groups	1 539 823.00	12	128 318.58		
Total	1 585 545.00	14			

La méthode IDW produit une surface continue marquée par l'influence locale des stations et des gradients spatiaux prononcés, tandis que la méthode de Thiessen propose une répartition discrète basée sur des zones d'influence géométriques, sans transition progressive. En revanche, l'approche des isohyètes offre une représentation plus réaliste en intégrant implicitement les variations topographiques, ce qui explique des valeurs moyennes légèrement plus élevées. Toutefois, l'analyse statistique (ANOVA) confirme que ces écarts restent non significatifs ($p > 0.05$), indiquant que les trois méthodes fournissent des estimations comparables à l'échelle du bassin, bien que leurs logiques de modélisation diffèrent.

Éléments de sortie. Pour évaluer le bilan hydrologique, l'estimation délicate ou la mesure directe des divers paramètres de sortie (évapotranspiration réelle (ETR), ruissellement et infiltration) est indispensable. La détermination de ces paramètres reste toutefois empirique sauf pour le ruissellement. Notre travail consiste à traiter différentes formules et méthodes élaborées par les chercheurs.

Évapotranspiration réelle. Elle est généralement le terme le plus contraignant sur un bassin lors de l'établissement du bilan hydrique. Contrairement

⁵ Between groups: Inter-groupe ; Within groups: Intra-groupes; Sum of Square: somme des carrés; df (degree of freedom): degré de liberté; Mean Square: moyenne des carrés; F: Test du F (de Fisher-Snedecor); Sig.: Signification.

aux pluies ou aux écoulements qui peuvent faire l'objet d'une approche quantitative satisfaisante bien que précise, il est actuellement très difficile de mesurer directement le flux de vapeur d'eau dans l'atmosphère.

On note l'absence des données relatives à plusieurs facteurs, pour cela, on s'appuie dans ce travail sur des formules qui utilisent les paramètres disponibles aux stations étudiées.

La pluviométrie et la température sont utilisées pour estimer le pouvoir évaporant de l'atmosphère. Notre recherche consiste à analyser les résultats obtenus avec les trois formules : Turc, Thornthwaite et Coutagne.

A – Formule de Turc

La formule de Turc permet d'évaluer directement l'ETR annuelle moyenne d'un bassin à partir de la hauteur annuelle de pluie et de la température moyenne annuelle:

$$ETR = \frac{P}{\sqrt{0.9 + \frac{P^2}{L^2}}}$$

Avec $L = 300 + 25t + 0.05t^3$; P : hauteur annuelle de pluie (en mm);
 t : température annuelle (en °C).

Tout en s'appuyant sur la méthode des Isohyètes pour les précipitations, la formule de turc pour l'estimation de l'ETR montre les résultats suivants.

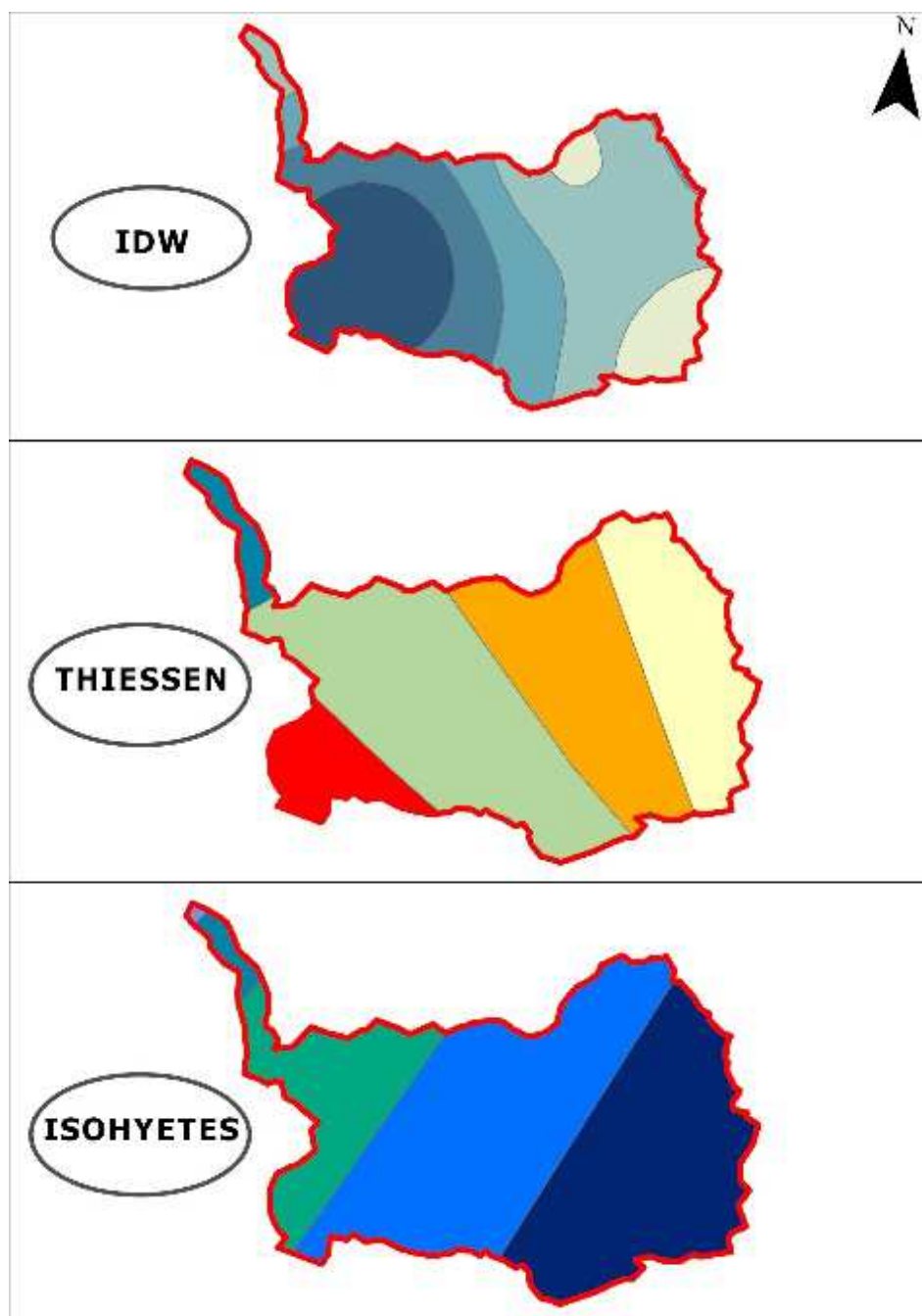


Figure 5. Résultats des méthodes: Isohyètes, Thiessen et IDW

Tableau 7

**Proportion de l'ETR (formule de Turc) dans les stations météorologiques adoptées
dans le bassin versant du Nahr El-Bared durant 9 années (2011-2020)**

Années	Abdeh (0-40 m)			Sir Ed-Dannieh (40-915 m)			Es-Sfieh (915-1020 m)			Mishmish (1020-1800m)		
	Pluvi. mm	ETR mm	%ETR	Pluvi. mm	ETR mm	%ETR	Pluvi. mm	ETR mm	%ETR	Pluvi. mm	ETR mm	%ETR
2011-2012	1161	822.71	70.86	428.6	289	67.42	1914.2	756.68	39.52	1007.2	553.22	54.92
2012-2013	858.6	607.40	70.74	1279.8	571.25	44.63	1642.2	777.22	47.32	996.2	627.56	62.99
2013-2014	358.2	352.06	98.28	316	308.20	97.53	361.6	334.10	92.39	348.6	303.59	87.08
2014-2015	702.4	580.64	82.66	1216.8	664.50	54.61	600	356.3	59.3	1081.4	515.80	47.69
2015-2016	802.40	695.04	86.62	927	651.89	70.32	313.38	309.59	98.48	626.8	440.56	70.29
2016-2017	577.00	554.77	96.15	682.40	550.14	80.62	396.00	374.14	94.48	629.80	475.94	75.57
2017-2018	557.10	532.34	95.56	728.71	632.60	86.81	778.13	609.61	78.34	974.20	628.29	64.49
2018-2019	954.20	766.32	80.31	1761.60	906.79	51.46	1595.80	777.91	48.75	1086.40	630.51	58.04
2019-2020	1019.60	798.07	78.27	1213.00	988.39	81.48	882.60	643.48	72.91	652.00	514.61	78.93
Somme	6990.50	5709.37	/	8553.91	5562.75	/	8483.91	4939.03	/	7402.6	4690.08	/
Moyenne	776.72	634.37	84.39	950.43	618.08	70.54	942.65	548.78	70.16	822.51	521.12	66.66

L'analyse des données présentées dans le Tableau 7, portant sur la proportion de l'ETR estimée selon la formule de Turc dans le bassin versant du Nahr El-Bared entre 2011 et 2020, met en évidence une variabilité spatiale marquée en fonction de l'altitude. Les résultats montrent que les zones de basse altitude (0–40 m) enregistrent le taux moyen d'ETR le plus élevé, atteignant 84.39 % des précipitations reçues, contre seulement 66.66 % dans les zones de haute altitude (1020–1800 m). Cette tendance reflète l'influence directe de l'altitude sur le processus d'évapotranspiration, celle-ci étant favorisée en basse altitude par des températures plus élevées et une exposition plus importante aux rayonnements solaires. Parallèlement, les précipitations moyennes annuelles apparaissent plus importantes dans les zones de moyenne altitude (40–915 m), atteignant 950.43 mm, contre 776.72 mm dans la zone côtière (0–40 m) et 822.51 mm dans la zone de haute altitude. Malgré cette pluviométrie favorable à l'étage médian, le taux d'ETR y reste inférieur à celui des basses altitudes, ce qui indique une plus grande disponibilité potentielle en eau pour le ruissellement et la recharge hydrogéologique dans les zones en altitude. En définitive, ces résultats soulignent l'importance de l'altitude comme facteur déterminant dans la répartition de l'ETR et des ressources hydriques au sein du bassin, et mettent en évidence la nécessité d'une gestion différenciée et adaptée des ressources en eau selon les étages altitudinaux.

Tableau 8

Résultats du bilan hydrologique pour 9 années (2011-2020) selon la formule Turc

Années	Pluviométrie	ETR		Débits (data sources : ONL)		Stockage [pluviométrie – (ETR + Débits)]	
	mm	mm	%	mm	%	mm	%
2011-2012	1127.75	605.40	53.68	590	52.31	-67.65	-5.99
2012-2013	1194.2	645.85	54.08	610	51.08	-61.65	-5.16
2013-2014	346.1	324.48	93.75	301	86.96	-279.3	-80.72
2014-2015	900.15	529.31	58.80	516	57.32	-145.16	-16.12
2015-2016	667.39	524.27	78.55	322	48.24	178.88	-26.80
2016-2017	571.3	488.74	85.54	278.80	48.80	-196.24	-34.34
2017-2018	759.53	600.71	79.08	213.14	28.06	-54.32	-7.15
2018-2019	1349.5	770.38	57.08	202.31	14.99	376.81	27.92
2019-2020	941.8	736.13	78.16	85.58	9.09	120.09	12.75
Somme	6729.98	5225.3	/	3118.83	/	-486.38	/
Moyenne	841.24	580.58	63.53	346.53	44.09		

Le tableau 8 présente les résultats du bilan hydrologique annuel du bassin versant du Nahr El-Bared sur la période 2011–2020, en intégrant les valeurs de la pluviométrie, de l'ETR, du débit de surface, et du stockage estimé. L'analyse met en évidence une variabilité interannuelle significative des composantes hydrologiques (Fig. 6), influencée à la fois par les conditions climatiques et par les caractéristiques physiques du bassin.

En moyenne, la pluviométrie annuelle s'élève à 841.24 mm, dont 580.58 mm (soit 63.53 %) sont restitués à l'atmosphère sous forme d'ETR, et 346.53 mm (soit 44.09 %) représentent le débit de surface. Le stockage net, estimé comme la différence résiduelle entre les précipitations et la somme de l'ETR et du débit, affiche une moyenne globale négative (-486.38 mm cumulés) sur les neuf années étudiées. Cela traduit un déséquilibre apparent du bilan hydrique, suggérant que la demande (ETR + débit) dépasse régulièrement l'apport pluviométrique annuel disponible.

Le stockage est négatif pour la majorité des années, allant de -5.16 % (en 2012-2013) à un minimum préoccupant de -80.72 % (en 2013-2014). Ce déficit chronique indique un prélèvement excessif des ressources, ou une estimation surélevée de l'ETR, ou encore un apport en eau superficielle non pris en compte dans le modèle. Toutefois, trois années seulement (2015-2016, 2018-2019, 2019-2020) montrent un stockage positif, atteignant respectivement +178.88 mm, +376.81 mm, et +120.09 mm, soit jusqu'à 27.92 % des précipitations annuelles. Ces années correspondent à des épisodes pluvieux plus intenses (jusqu'à 1349.5 mm en 2018-2019), permettant une recharge effective des nappes phréatiques. Ce constat souligne le rôle crucial des années humides dans le renouvellement des ressources en eau souterraine, en particulier dans un contexte de forte exploitation des eaux par forages.

Par ailleurs, certains écarts dans les résultats du stockage peuvent être attribués à plusieurs hypothèses :

- Le manque de données pluviométriques fiables, notamment dans les zones de haute altitude, pourrait sous-estimer les apports effectifs en eau dans les secteurs les plus contributeurs à la recharge.
- L'arrivée d'eaux souterraines exogènes, issues de bassins versants adjacents, pourrait expliquer des débits élevés observés, indépendamment des apports locaux en précipitations.

- Une surestimation de l'ETR par la formule de Turc, surtout en conditions de faible humidité ou en présence de microclimats spécifiques au bassin, pourrait fausser le bilan en réduisant artificiellement le volume d'eau disponible pour le ruissellement ou l'infiltration.

B – Formule de Thornthwaite

Cette formule empirique est fondée sur le calcul d'un « indice thermique annuel » (I) qui est en fonction de la température mensuelle moyenne. Le tableau 9 illustre les résultats de l'application de cette formule. La station de Al-Abdeh présente l'évapotranspiration potentielle (ETP) la plus élevée (1472.15 mm) alors que la plus faible valeur revient à la station de Sir Ed Danniyé (1411.99 mm). Les mois de juillet, août et septembre connaissent la plus grande ETP dans toutes les stations contrairement aux mois pluvieux qui montrent un ETP relativement plus faible.

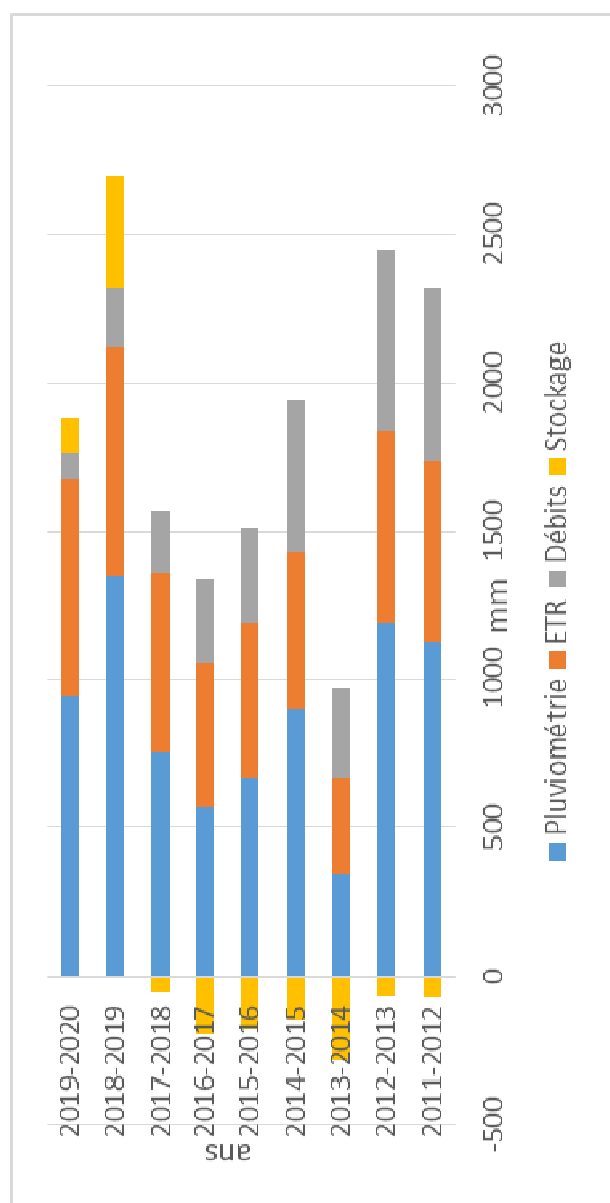


Figure 6. Composantes du bilan hydrologique durant 5 années formule de Turc (2011-2020)

Tableau 9

Évapotranspiration potentielle mensuelle dans les 4 stations selon la formule de Thornthwaite

ETP Thornthwaite	Sep	Oct	Nov	Déc	Jan	Fév	Mars	Avril	Mai	Juin	Juillet	Août
Al-Aabdé	138.84	119.88	96.31	94.59	96.83	94.50	114.86	122.56	134.64	140.49	156.00	162.65
Sir Ed Danniye	117.41	109.24	96.03	96.37	99.65	95.95	114.64	121.26	137.34	141.00	145.27	137.84
Es Sfiré	118.68	108.69	96.20	101.90	102.85	96.60	115.10	121.55	136.61	148.75	144.38	134.87
Fnaideq	114.80	108.28	98.86	107.44	107.40	105.11	117.42	121.32	136.17	139.06	144.86	135.73

À partir des valeurs mensuelles d'ETP, on estime l'évapotranspiration réelle selon la formule de Thornthwaite tout en fixant la valeur de rétention maximale du sol à 60 mm. Pour estimer la réserve utile en mm, on a utilisé les formules suivantes :

$$W330 = 257.6 - (2 * Sa) + (3.6 * Ar) + (229 * MO) ;$$

$$W1500 = 26 + (5 * Ar) + (15.8 * MO) ;$$

*Avec W330 teneur en eau à -330 hpa en mm/m, W1500 teneur en eau à -1500 hpa en mm/m et Ar : teneur en argile en %, Sa : teneur en sable en %, Mo : teneur en matière organique en %, la réserve utile en mm est calculée pour chaque horizon par la fonction suivante : $RU = (W330 - W1500) * h$; h : épaisseur de l'horizon en m) à l'échelle du bassin.*

La comparaison des valeurs de l'ETP permet de calculer l'ETR ; plusieurs cas peuvent se présenter :

- $ETP < P$ ceci implique que $ETR = ETP$;
- La quantité d'eau correspondant à $P - ETP$, est emmagasinée dans le sol jusqu'à saturation de celui-ci. La partie de l'excédent dépassant éventuellement la réserve cumulée maximale en eau du sol, constitue-le (surplus) disponible pour le ruissellement et l'infiltration. Quand $ETP = P$ ceci implique que $ETR = ETP = P$. Les réserves en eau de sol restent les mêmes que celles du mois précédent.
- $ETP > P$: $ETR = P$ + toute ou partie de la réserve en eau du sol jusqu'à épuisement de celle-ci ;
- Lorsque les réserves en eau du sol sont épuisées et que $ETP > ETR$, $ETP - ETR =$ déficience ;
- La valeur de l'ETR annuelle est la somme des 12 valeurs d'ETR mensuelles (BRGM, 1970).

L'application de la formule de Thornthwaite au bilan hydrologique du bassin versant du Nahr El-Bared pour la période 2011–2020 révèle des dynamiques contrastées entre les composantes du cycle de l'eau (Fig. 7, Tab 10). En moyenne, ETR représente 589.43 mm/an, soit 65.29 % de la

lambe d'eau précipitée. Cette valeur est légèrement supérieure à celle obtenue par la méthode de Turc, ce qui s'explique par la sensibilité de la formule de Thornthwaite aux variations de température, paramètre essentiel dans le calcul de l'ETR dans cette approche. Malgré cela, les pourcentages d'ETR restent relativement élevés, atteignant un maximum préoccupant de 94.31 % en 2013–2014, indiquant une forte perte hydrique par évapotranspiration cette année-là, au détriment du stockage et du ruissellement. La comparaison interannuelle montre que l'année 2013-2014, marquée par une pluviométrie très faible (346.1 mm), présente non seulement un taux d'ETR très élevé, mais également un stockage négatif (-56.72 mm), soulignant une situation de déficit hydrique sévère. En revanche, les années 2015-2016, 2018-2019, et 2019-2020 enregistrent des valeurs de stockage exceptionnellement positives (respectivement 1053.82 mm, 1022.24 mm et 713.56 mm), traduisant une recharge effective et abondante des aquifères grâce à des précipitations supérieures à la moyenne. Le stockage annuel moyen, estimé à 465.68 mm, équivaut à un volume de 131.08 Mm³, traduisant une capacité significative de recharge de l'aquifère du bassin. Cette situation suggère une opportunité importante pour une gestion durable des ressources en eau souterraine, notamment en contexte de pression croissante sur les forages. Il convient néanmoins de signaler une anomalie observée à la station d'Abdeh, où les valeurs d'ETR apparaissent systématiquement surestimées pour tous les mois et toutes les années, ce qui pourrait fausser localement les estimations globales. Ce biais pourrait résulter de particularités microclimatiques, d'une mauvaise calibration des données climatiques, ou d'une surévaluation de la température moyenne mensuelle utilisée dans la formule de Thornthwaite.

Tableau 10

Résultats du bilan hydrologique durant 9 années (2011-2020) selon la formule Thornthwaite

Années	Pluviométrie mm	ETR		Débits (data sources : ONL)		Déficiência (mm)	Stockage [pluviométrie – (ETR + Débits)]		
		mm	% de l'ETR	mm	% du débit		mm	% du stockage	Mm3
2011-2012	1127.75	685.94	60.82	590	52.31	-586.31	438.12	38.85	124.09
2012-2013	1194.2	714.40	59.82	610	51.08	-538.46	408.26	34.19	115.63
2013-2014	346.1	326.44	94.31	301	86.96	-224.61	-56.72	-16.39	-16.06
2014-2015	900.15	497.87	55.30	516	67.77	-368.73	116.16	15.26	32.90
2015-2016	1504.2	971.69	64.59	322	21.40	-546.31	1053.82	70.06	298.48
2016-2017	571.7	467.50	81.77	278.8	48.77	-340.82	166.28	29.09	47.26
2017-2018	759.53	568.44	74.85	213.14	33.30	-443.46	301.85	47.17	85.79
2018-2019	1349.5	551.39	40.85	202.31	14.99	-426.44	1022.24	75.75	289.53
2019-2020	941.8	521.20	55.34	85.57	9.09	-378.54	713.56	75.77	202.10
Somme	8694.93	5304.88	/	3118.83	/	-4306.67	3011.90	/	1179.72
Moyenne	966.1	589.43	65.29	346.53	55.910	-430.66	465.68	28.39	131.08

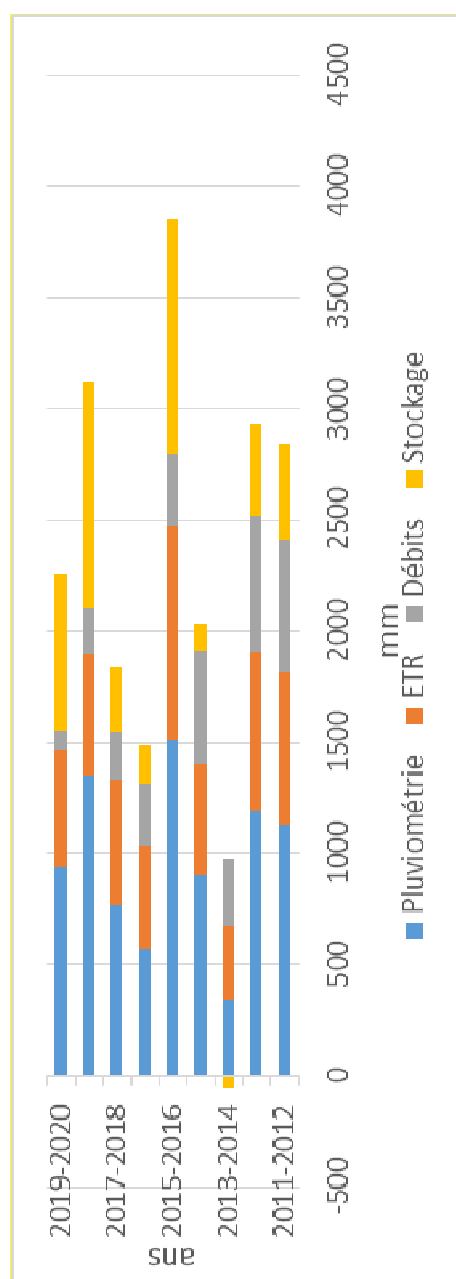


Figure 7. Illustration des éléments du bilan hydrologique durant 9 années (formule de Thornthwaite) (2011-2020)

C – Formule de Coutagne

Coutagne a proposé une autre méthode de calcul du déficit hydrique à l'échelle annuelle à travers la relation suivante :

$$D = p - \lambda \cdot p^2$$

$$\lambda = \frac{1}{0.8 + 0.14 \cdot T}$$

D : déficit d'écoulement ; P : pluie moyenne annuelle en m ; T : température moyenne annuelle.

Notons que la relation ($D = p - \lambda \cdot p^2$) s'applique uniquement si la relation λ est satisfaite : P appartient à $[1/8. \lambda, 1/2. \lambda]$.

Dans le cas où ($P < 1/8. \lambda$): le déficit d'écoulement est égal aux précipitations moyennes annuelles et le terme d'écoulement Q est nul.

A l'inverse, si ($P > 1/2. \lambda$) : il y a quasi- indépendance entre la précipitation et le déficit d'écoulement s'exprime alors comme suit:

$$D = 1/4. \lambda = 0.8 + 0.14.T / 4 = 0.20 T + 0.035 T$$

La région de 0 à 40 mètres montre, pour toutes les années, une évapotranspiration réelle (ETR) élevée en comparaison avec les autres régions pendant la même période (Tab 11). L'augmentation de ces valeurs est due au fait que la région de 0 à 40 mètres est une zone côtière, souvent caractérisée par des températures plus élevées. Ces températures élevées favorisent une évaporation plus rapide de l'eau du sol et une transpiration plus importante des plantes.

Dans les régions côtières, la disponibilité en eau du sol peut être plus faible en raison des précipitations moins fréquentes, favorisant un sol moins humide qui contribue à l'assèchement plus rapide du sol.

En revanche, dans les zones montagneuses, la topographie fait augmenter les précipitations tend vers diminuer la température, ce qui réduit le taux d'évapotranspiration par rapport aux régions côtières moins arrosées et plus chaudes (Tab 12).

Tableau 11

Résultats de la condition d'application de la formule Coutagne durant 9 années (2011-2020)

		2011- 2012	2012- 2013	2013- 2014	2014- 2015	2015- 2016	2016- 2017	2017- 2018	2018- 2019	2019- 2020
Abdeh (0-40 m)	$\lambda 1/8$	0.02	0.02	0.024	0.023	0.024	0.03	0.03	0.03	0.03
	P	1.16	0.85	0.3	0.7	0.8	0.40	0.25	0.24	0.24
	$\lambda 1/2$	0.09	0.09	0.09	0.09	0.096	0.13	0.12	0.12	0.12
Sir Ed-Dannieh (40-915 m)	$\lambda 1/8$	0.07	0.04	0.03	0.03	0.03	0.04	0.03	0.04	0.04
	P	0.4	1.27	0.31	1.21	0.92	0.68	0.63	1.21	1.76
	$\lambda 1/2$	0.29	0.18	0.15	0.15	0.14	0.15	0.14	0.14	0.14
Es-Sfieh (915-1020 m)	$\lambda 1/8$	0.03	0.03	0.04	0.06	0.03	0.04	0.04	0.04	0.04
	P	1.914	1.64	0.36	0.04	3.76	0.40	0.40	1.60	0.88
	$\lambda 1/2$	0.15	0.14	0.16	0.24	0.14	0.14	0.14	0.15	0.14
Mishmish (1020-1800m)	$\lambda 1/8$	0.04	0.03	0.05	0.04	0.04	0.04	0.04	0.04	0.04
	P	1	0.99	0.34	1.8	0.6	0.63	0.97	1.09	0.65
	$\lambda 1/2$	0.17	0.15	0.2	0.19	0.19	0.17	0.15	0.16	0.16

Tableau 12

**Évapotranspiration réelle en mm dans les quatre stations
selon la formule de Coutagne durant 9 années (2011-2020)**

Années	ETR mm				Moyenne générale
	0-40 m	40-915 m	915-1020 m	1200-1800 m	
2011-2012	1185.95	304.53	708.31	590.34	
2012-2013	1148.15	576.01	740.28	687.115	
2013-2014	1170.2	706.01	625.77	493.27	
2014-2015	1197.15	683.32	388.67	530.72	
2015-2016	1186.65	743.31	750.46	542.21	
2016-2017	879.74	731.11	760.16	617.40	
2017-2018	926.97	796.46	763.53	694.87	
2018-2019	894.60	749.97	744.78	669.32	
2019-2020	898.80	751.41	752.46	683.19	
Moyenne	1054.24	671.35	692.71	612.04	757.58

Comparaison entre les trois méthodes du calcul de l'ETR. Les estimations de l'évapotranspiration réelle (ETR) obtenues à partir des formules de Turc (580,58 mm), de Thornthwaite (589,43 mm) et de Coutagne (757,58 mm) ont été comparées à l'aide d'une analyse de variance (ANOVA) suivie d'un test de Tukey HSD, réalisée sous SPSS (fig. 8, Tab. 13). Les résultats mettent en évidence une différence statistiquement significative entre les méthodes ($p = 0,015 < 0,05$). Plus précisément, le test de Tukey HSD révèle que les méthodes de Turc et de Thornthwaite appartiennent à un même sous-ensemble homogène, indiquant l'absence de différence significative entre leurs estimations, tandis que la méthode de Coutagne forme un groupe distinct avec des valeurs significativement plus élevées.

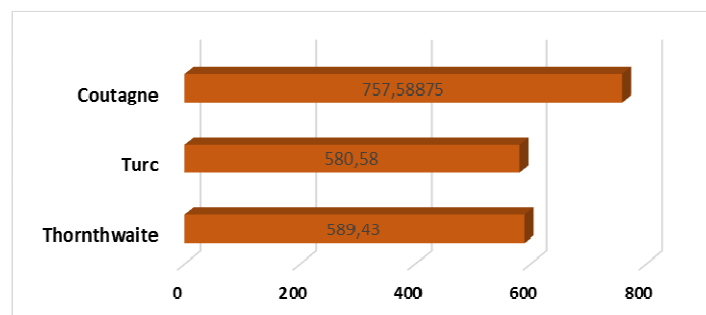


Figure 8. Comparaison des résultats de l'ETR selon les méthodes de Turc, Thornthwaite et Coutagne (2011-2020)

Dans ce contexte, le choix de la formule de Turc pour l'estimation finale de l'ETR repose sur une double justification, à la fois statistique et hydrogéologique. D'une part, sa cohérence avec les résultats de Thornthwaite renforce sa robustesse. D'autre part, les caractéristiques du bassin versant du Nahr El-Bared, dominé par des formations karstiques à forte perméabilité, favorisent une infiltration rapide des précipitations vers les aquifères. Ainsi, une méthode estimant une ETR relativement modérée, telle que celle de Turc, apparaît plus représentative du fonctionnement hydrologique du bassin, en permettant de préserver une part plus importante des précipitations pour la recharge souterraine. Cette interprétation est confortée par la permanence relative des sources, y compris en période sèche, témoignant d'une alimentation continue des nappes. Par conséquent, la méthode de Turc constitue un compromis pertinent entre cohérence statistique et réalisme hydrologique dans le contexte étudié.

Tableau 13

Comparaison entre les résultats des trois méthodes Turc, Thornthwaite et Coutagne selon le logiciel SPSS

ETR			
	Methodes	N	Subset for alpha = 0.05
			1
Tukey HSD ^a	Turc	9	580.58
	Thornthwait	9	589.43
	Coutagne	9	757.58
	Sig.		.015
Means for groups in homogeneous subsets are displayed ⁶ .			
a. Uses Harmonic Mean Sample Size ⁷ = 9.000.			

Ruissellement superficiel. Le débit offert par L'ONL (office national du Litani) (346.53 mm).

Infiltration. La méthode du bilan hydrologique est la méthode la plus utilisée pour la détermination de la lame d'eau infiltrée. L'infiltration est évaluée à partir de l'équation (Tab 14) :

$$I = P - (ETR + R) + \Delta S$$

⁶ Les moyennes pour les groupes dans les sous-ensembles homogènes sont affichées.

⁷ Utilise la taille d'échantillon moyenne harmonique

I : lame d'eau infiltrée en mm ; *P* : Pluviométrie en mm ;
ETR : évapotranspiration réelle en mm ; *R* : lame d'eau ruisselée en mm ;
 ▲ *S* : variation du stockage d'eau.

Tableau 14
 Paramètres du bilan hydrologique

P	1216.25
ETR	580.58
R (ONL)	346.53
S	10
I = 279.14	

La forte karstification des formations carbonatées du bassin versant favorise une perméabilité élevée, conditionnant ainsi une infiltration significative des eaux en période pluvieuse. Cette infiltration s'effectue selon des modalités contrastées : elle est diffuse et lente à travers le réseau de microfissures, mais peut devenir rapide et concentrée le long des discontinuités majeures telles que les fractures, failles et conduits karstiques. Les unités perméables couvrent environ 68,01 % de la superficie totale du bassin, ce qui traduit une aptitude élevée à l'infiltration, comme l'illustre la carte de perméabilité (fig. 9).

Sur le plan litho-stratigraphique, le bassin est dominé par des formations calcaires d'âge Jurassique et Crétacé, séparées par des niveaux relativement imperméables (Akkari, 2024). Cette configuration structurale contrôle fortement la circulation des eaux souterraines, notamment en termes de direction d'écoulement, de répartition spatiale et de capacité de stockage. Les aquifères karstiques associés, en particulier ceux du Jurassique moyen (J4) et du Crétacé cénomanien-turonien (C4-5), présentent une perméabilité élevée liée à leur fracturation et à leur degré de karstification, favorisant des coefficients d'infiltration importants.

L'aquifère jurassique moyen (J4), caractérisé par une épaisseur avoisinant 1000 m et un affleurement étendu, possède une capacité de recharge et de stockage notable, avec un écoulement souterrain préférentiellement orienté vers le sud-ouest et le nord-ouest (Awad et Akkari, 2023). De même, l'aquifère cénomanien-turonien (C4-5), largement développé à l'échelle du Mont-Liban et subdivisé en plusieurs sous-unités, se distingue par une forte perméabilité induite par une fracturation intense et une karstification avancée.

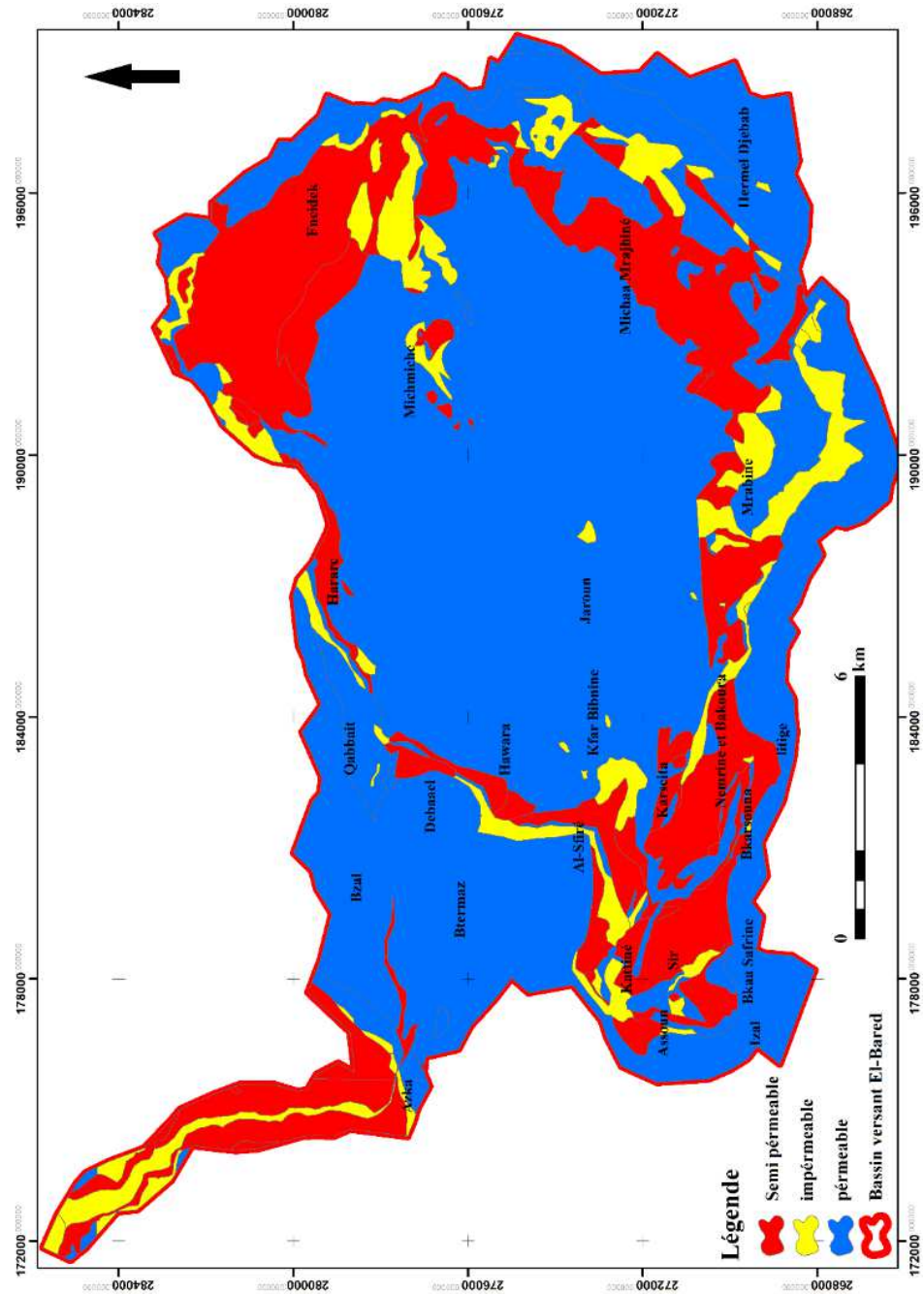


Figure 9. Carte de perméabilité du bassin versant El-Bared

Ainsi, la dominance des formations perméables et karstifiées, combinée aux caractéristiques structurales et topographiques du bassin, confère au système hydrologique une dynamique marquée par une infiltration élevée, tout en permettant localement des écoulements rapides pouvant alimenter les résurgences. Cette dualité infiltration–ruissellement joue un rôle déterminant dans le bilan hydrologique global du bassin versant.

La perméabilité poussée des massifs karstiques, favorise l'infiltration en saison pluvieuse. Cette infiltration peut être lente tout du long des petites fissures et rapide le long des gouffres, fissures ou failles. Les couches perméables atteignent 68.01% de la superficie totale, et cela se voit clairement sur la carte de perméabilité (Fig. 10).

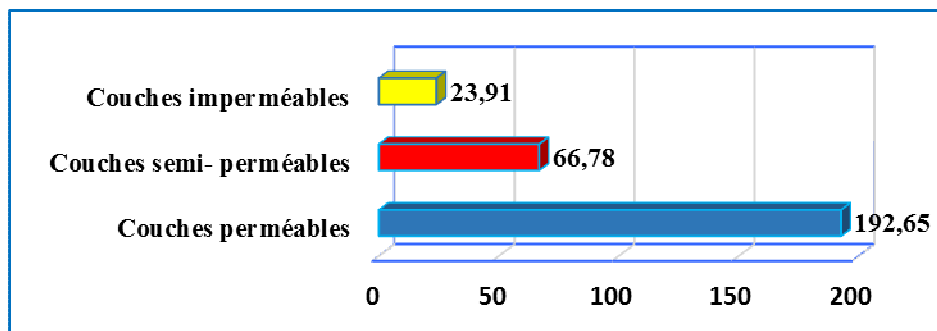


Figure 10. Perméabilité des couches géologiques dans le bassin versant du Nahr El-Bared

Utilisation humaine. Pour évaluer la quantité d'eau pour l'irrigation, on a étudié les besoins en eau des cultures en fonction des variations climatiques et des altitudes des différents types de sol (El-Hajj , 2008), (FAO, 1998) Les volumes nécessaires pour l'irrigation sont représentés dans le Tableau 15.

Nabaa Es-soukkar, El-Qseim, Sir, Fnaideq et Ez-Zahlane alimentent les villages du bassin versant Nahr El-Bared et la région voisine en eau potable (Fig. 11). Les autres sources dont le débit est faible (10 l/s) sont utilisées pour l'irrigation. La région située au Sud du bassin (13 villages) est alimentée par la source Es-Soukkar, avec un débit moyen journalier de 1515 l/s (période de crue) et El-Qseim 575 l/s.

Tableau 15

Besoins en eau des cultures

	Type de cultures				
	Sous serres	Maraîchères	Plein champ	Fruitières	Agrumes
Besoins en eau des cultures en mm	631	90	357	800	900
Besoins en eau des cultures m ³ /hectare	6310	900	3570	8000	9000
Surface agricole hectare	10.50	67.58	2110	3130.26	197.54
Besoin en eau d'irrigation Mm ³ /an	0.066	0.061	7.535	25.042	1.778
Besoin en eau totale d'irrigation Mm ³ /an	34.48 Mm ³ /an				

La partie Nord du cours d'eau comporte 19 villages ayant 9200 habitants dans la région d'Akkar. Les villages qui sont situés au centre du bassin versant sont alimentés par la source de Sir (1105 l/s) et Ez-Zahlane (432 l/s). Mais il faut noter que 37 villages dans le bassin versant ne sont pas reliés au réseau. Les données des prélèvements pour l'adduction en eau potable (2016) montrent un volume total de 6.78 Mm³/an.



Figure 11. Nabaa El-Qseim et Ez-Zahlane alimentent quelques villages du Nahr El-Bared (Jamal,2017)

Le Tableau 16 affiche l'estimation de la consommation en eau dans les secteurs agricole et eau potable.

Tableau 16

Consommation en eau dans le bassin versant du Nahr El-Bared

Agriculture	Eau potable
34.48 millions m ³	6.78 millions m ³

Bilan Hydrique final. Le Tableau 17 présente les résultats de la détermination des précipitations, de l'évapotranspiration réelle (ETR), de l'infiltration et du ruissellement, obtenus à l'aide de différentes méthodes. Certaines de ces méthodes tendent à surestimer certains paramètres, tandis que d'autres offrent des estimations plus cohérentes et fiables pour le calcul du bilan hydrologique. À la suite de cette évaluation, deux méthodes principales ont été retenues pour la suite de l'étude :

- La méthode des isohyètes pour l'estimation de la pluviométrie ;
- La formule de Turc pour le calcul de l'ETR.

Tableau 17

Paramètres calculés selon les différentes méthodes

Paramètres	Méthodes	Résultats en mm
P	Isohyètes	1216.25
	Thiessen	1054.19
ETR	Turc	580.58
	Thornthwaite	589.43
	Coutagne	757.58
I	Soustraction	279.14
R	ONL	346.53

Le choix de la méthode des isohyètes repose sur des études antérieures menées par Awad (2011) et Yousef (2015), qui ont démontré sa pertinence et sa représentativité dans des contextes similaires. Quant à la formule de Turc, elle a été privilégiée en raison de sa tendance à réduire la part de l'ETR, augmentant ainsi la part attribuée à l'infiltration, un facteur crucial dans un bassin à dominante karstique comme celui du Nahr El-Bared. L'absence apparente d'infiltration lors de certaines années, souvent signalée par d'autres approches, trouve ici une explication plus réaliste.

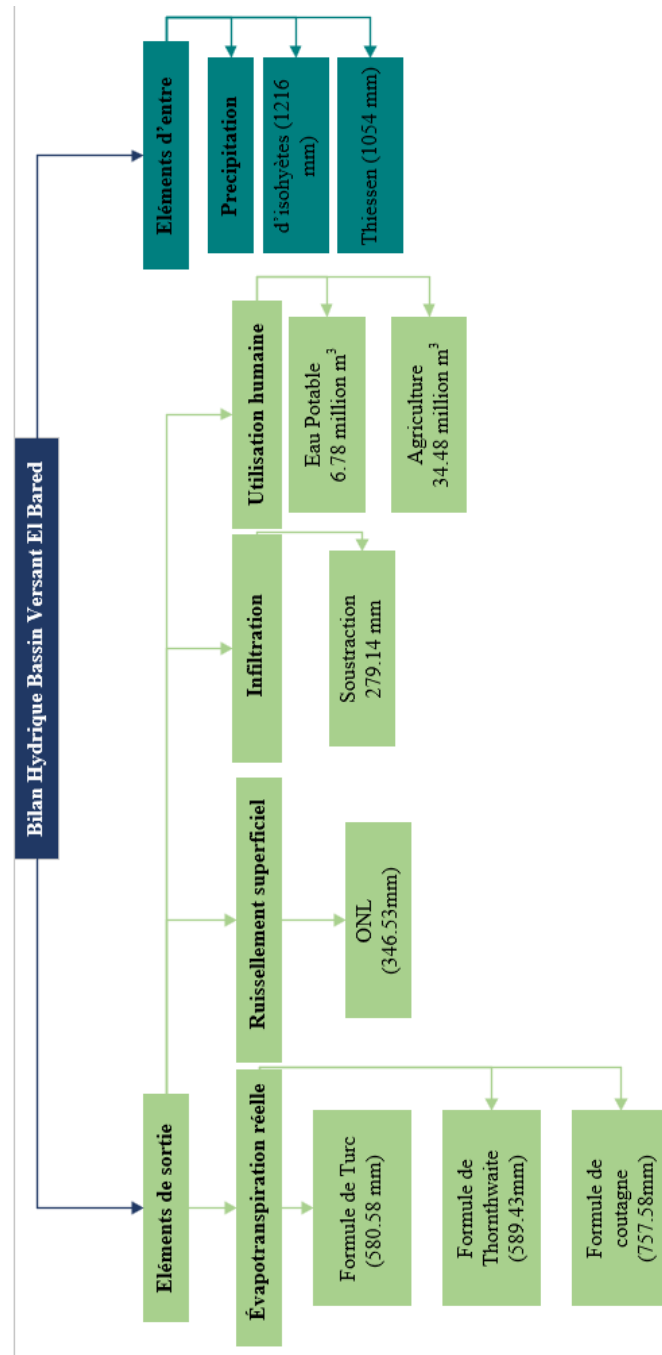


Figure 12. Bilan hydrologique annuel du Nahr El-Bared pour la période 2011-2020

L'analyse de la figure 12 montre que le bassin versant du Nahr El-Bared reçoit en moyenne 1216 mm de précipitations par an. Le ruissellement représente en moyenne 468.75 mm, soit 38 % de la lame d'eau précipitée. L'ETR, correspondant à la fraction d'eau retournant à l'atmosphère sous forme de vapeur, atteint 580.43 mm, soit 47.73 %. L'infiltration annuelle moyenne est de 279.14 mm, ce qui correspond à 22 % de la pluviométrie totale.

Cette quantité infiltrée constitue un apport significatif pour les aquifères locaux, estimé à environ 72 Mm³ par an. Ce stockage souterrain représente une ressource stratégique mobilisable, notamment via des forages ciblés dans les formations géologiques du Jurassique et du Crétacé. Ainsi, la recharge naturelle des nappes joue un rôle central dans la gestion durable des ressources hydriques dans la région.

6. Conclusion

La présente étude s'est concentrée sur l'équilibre hydrique dans le bassin versant d'Al Bared, en examinant également les paramètres morphométriques. Trois méthodes différentes (Thornthwaite, Turc, Coutagne) ont été employées pour calculer le potentiel évapotranspiratoire (ETR), tandis que deux approches distinctes (Thiessen et isohyète) ont été utilisées pour estimer les précipitations.

Les résultats obtenus ont fourni un aperçu approfondi de la distribution des ressources hydriques dans la région. Les différentes méthodes de calcul de l'ETR ont été comparées pour évaluer leur efficacité dans ce contexte particulier. De plus, les paramètres morphométriques ont été analysés pour comprendre la configuration géographique du bassin versant et son impact sur le bilan hydrique.

L'analyse de l'infiltration a révélé des variations significatives, soulignant l'importance de comprendre les processus de recharge des nappes souterraines. Les activités humaines ont également été prises en compte dans l'évaluation du bilan hydrique, mettant en évidence les pressions exercées sur les ressources en eau locales.

En conclusion, cette étude offre des informations cruciales sur la Bilan Hydrique dans le bassin versant d'Al Bared. Les résultats peuvent orienter les décideurs vers des stratégies efficaces pour assurer la disponibilité

continue de l'eau tout en prenant en compte les facteurs morphométriques et anthropiques. Ces données contribuent à une compréhension holistique de l'écosystème hydrique de la région, offrant ainsi des perspectives utiles pour la planification et la gestion des ressources en eau dans le futur.

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THE CALORIC STRESS AND TOURISM ON THE ROMANIAN PLAIN AREA

Abstract. This study aims to highlight the impact of thermal/calory stress conditions on tourism activities in southern Romania. A well-known phenomenon in human society, tourism is seen as a refined exporter of specific products (services and goods), ultimately intended to support the development of tourist destinations. The current problem of the modern world, namely climate change, has become a factor that directly influences the decision-making process specific to tourism activities. The need for adaptation actions is imposed against the backdrop of this state of change. The relative strain index is a bioclimatic index that allows the evaluation of bioclimatic conditions of thermal/calory stress, being applicable, at the latitude of our country, only during the summer. The index was calculated for the period 2000-2024, based on temperature (°C) and relative humidity air (%). The calculated values of the index highlight the main areas of bioclimatic stress or not specific to the summer season in southern Romania. The identification of these areas inevitably leads to the need for decision-makers to identify methods of adaptation to new situations in order to ensure the appropriate continuity of tourist activities.

Keywords: relative strain index, bioclimatic comfort, bioclimatic risk, tourist activity, Romanian Plain

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1. Introduction

In recent times, the adaptation of the tourism sector and recreational activities to climate change has become a necessity. This request is necessary for the specific activities of the Romanian Plain. This region imposes itself in the tourist landscape with a series of tourist activities, such as: urban tourism, fishing tourism, equestrian tourism, balneoclimatic tourism, sports tourism, gastronomic tourism, proximity tourism, etc. Tourist products offer economic benefits to all actors involved, and experiential benefits to the visitor.

The aim of this study is to evaluate the impact of thermal discomfort or comfort on the tourist and those involved in ensuring the quality of the tourism activities. For this purpose, one of the bioclimatic indices was calculated that highlights the state through which the human body tries to adapt. The adaptation of the individual is necessary to successfully complete daily activities. Thus, the bioclimatic factor must be seen as a working tool in scientific research. This factor provides information about the positive or negative potential that the climatic conditions of a region have on: the human health of the locals; the specific activities in the area; the state of comfort of those who have arrived in the area (tourists, visitors, etc.).

A human organism stressed by weather conditions can affect the daily routine of a human society. For example, in Elena Teodoreanu's scientific presentations, we find useful information about how bioclimatological and biometeorological analyses should be viewed and used: *"...two contradictory and complementary aspects... the sanogenic aspect – the elements of the climate in preserving and recovering health and the pathogenic aspect – exceeding natural limits of temperature, humidity, atmospheric pressure, which determines the body's illness or the exacerbation of some disease symptoms..."* (Teodoreanu, 2002).

The increasing appearance of studies referring to tourist comfort has brought back interest in weather forecasts and their importance for tourist activity. In general, these forecasts present weather conditions and everything that involves the assimilation of new knowledge. Scientists such as Peters (1992), Hannah (2002), Hamilton (2004) etc. have presented studies on the emergence of the relational environment developed by

the environment in which man works and the weather. For example, in 2013, Spiridonov said that all the interest in knowing has pushed the individual to identify: "*...the capacity to adapt to sudden changes in weather conditions differs from individual to individual and depends largely on genetic predisposition and specific characteristics...*". Studies have also been published on how the human body suffers under the influence of external factors (de Freitas, 1990; Fiala et. al, 2001; Chen L., 2012; Kantor Noémi, 2012; etc.). Romanian studies are not new, but neither are they very numerous. Among the best-known studies were Ciulache (2004), Ionac (2004, 2007), Bogdan (2010), Teodoreanu (2012), Grigore (2012), Scripca (2019), Ciobotaru (2018), Croitoru (2020), Ichim (2020) etc.

The climatic variability of heat stress, also influenced by global warming, may impose changes reflected both in tourism activity and in any other economic sector with some sensitivity to climate conditions.

2. Study area

Located in southeastern Europe, on the lower course of the Danube, the Romanian Plain is the largest plain located in the southern part of the country (Fig. 1). Currently, it occupies approximately 50.000 km², which represents approximately 21,0% of the total area of the country.

The plain was born and evolved through the accumulation of alluvial debris deposited by the Carpathian streams with active slope drainage, in a former large Quaternary lake. It is imposed on the Romanian geographical landscape by an almost flat appearance, with low interfluvies, which rarely exceed 300 m (Fig.2 a). These landforms are covered by thick layers of eroded loess with voids and sand dune deposits. We point out the fact that they are interrupted by several widely spaced valley bottoms, bordered by one or two levels of terraces. The low interfluvial surfaces are frequently subject to seasonal flooding due to the slope. Another floodplain area is the Danube floodplain and includes numerous side channels and fish lakes, separated by sandbanks, which support the floodplain forests.

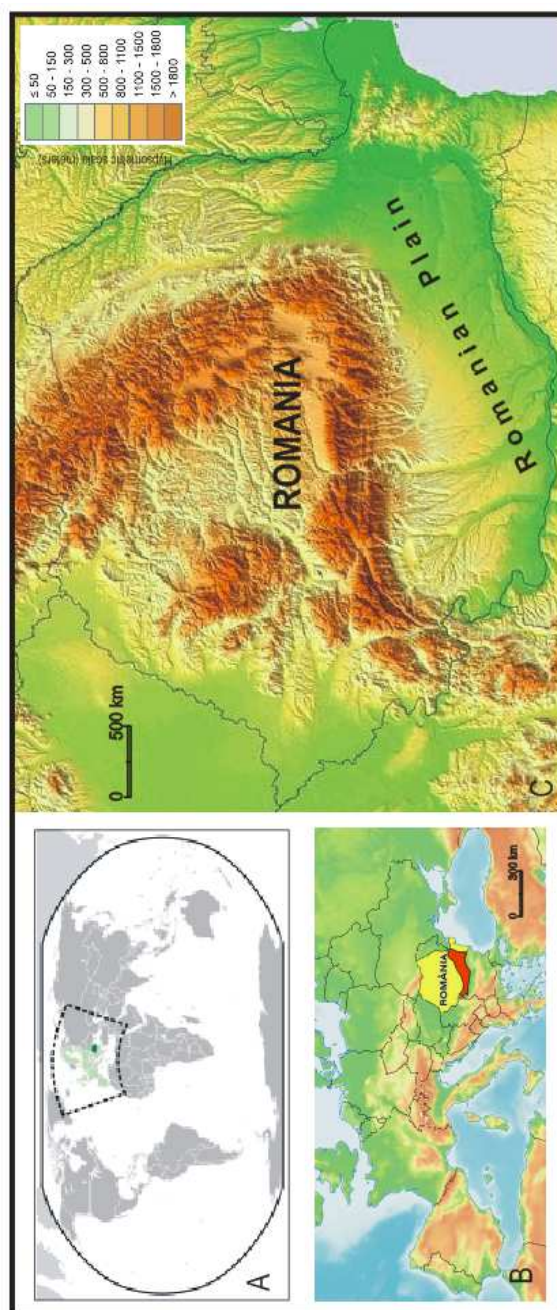


Figure 1. Romanian Plain - geographical position on the Globe (a), in Europe (b) and in Romania (c)
(Source: processing according to various maps in ArcGis Pro and Corel Draw, 2025)

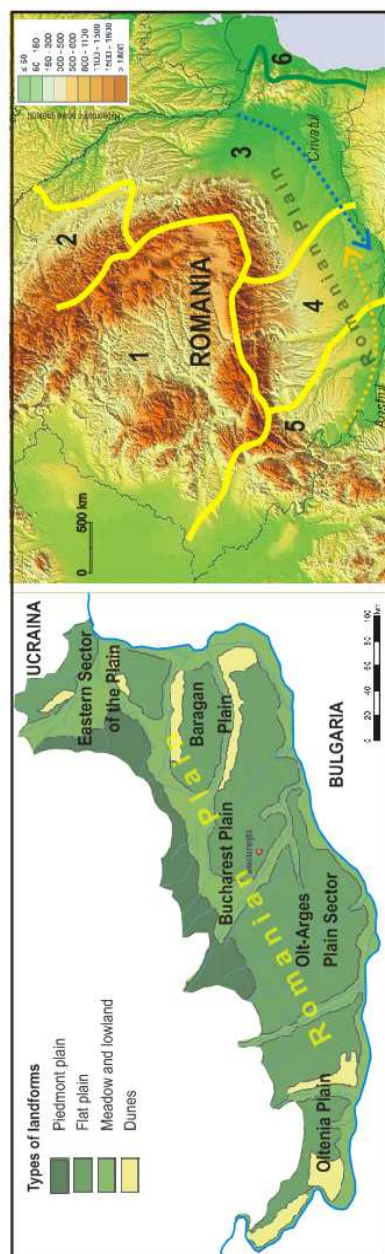


Figure 2. Romanian Plain – representation of the main landforms (a) and the climatic influences felt (b). Legend climate influences: 1 – oceanic influences; 2 – scandinavian-baltic influences; 3 – continental (aridity) influences; 4 – transitional influences; 5 – sub-mediterranean influences; 6 – pontic influences)
(Source: processing in ArcGis Pro and Corel Draw, 2025)

Regarding the climatic characteristics of the Romanian Plain, they vary from Mediterranean influences (in the west) to dry continental influences (in the east) (Fig. 2 b). The average annual atmospheric precipitation decreases steadily towards the east from 550 mm to 450 mm, while the air temperature remains relatively constant at average annual values of 10,0°C – 11,0°C. However, the influence of the relief forms gives the climate considerable variations in the plain area. Thus, extreme climatic conditions can develop, especially in summer, when the stability of tropical air masses from Africa produces high air temperatures. For this reason, the Romanian Plain not only produced the absolute maximum air temperature (44,5°C at the Ion Sion/Râmnicelu meteorological station, located near Brăila, on August 10, 1951), but also currently records the highest temperature amplitude in the country (25,0°C – 26,0°C °C).

3. Methodology

The present study aims to show the reader and outline, at the same time, through specific analyses of the relative strain index – RSI, the main areas of bioclimatic stress or not, specific to the hot season in southern Romania, respectively in the Romanian Plain. The relative strain index is a relevant bioclimatic index used to evaluate the bioclimatic stress due to overheating conditions during the summer. Its values can be quantitatively derived from the air-temperature (°C) and the real/effective vapor pressure (hPa) according to the formula: $RSI = (Ta - 21) / (58 - e)$. The mathematical calculation of this index was proposed and published in the year 1992 by Kyle W.J., in the article *“Summer and Winter patterns of human stress in Hong Kong”*.

The relative strain index was initially developed by Shapiro, in the year 1982, taking into account *“...a healthy person dressed in a business suit in a place not acclimatized to direct heat to take into account the insulation of clothing...”*. Kyle mentions that at a value of 0,30 units of the comfort index, the comfort decreases and raises problems for the elderly and those with health problems, becoming dangerous at values above 0,50 units (for example: it can affect the cardiovascular system; it can cause an increase in the mortality rate, especially for children and the elderly). Between 0,10 and 0,20 we have a comfortable state for all people, while between

0,20 and 0,30 we identify a state of moderate comfort by approaching the upper limit of the comfort state.

This study analyzes the relative strain index values, over a period of 25 years (2000-2024), using the monthly average of air-temperature (°C) and mean values of relative humidity (%), obtained from 16 reference meteorological stations located in the Romanian Plain (Fig. 3).

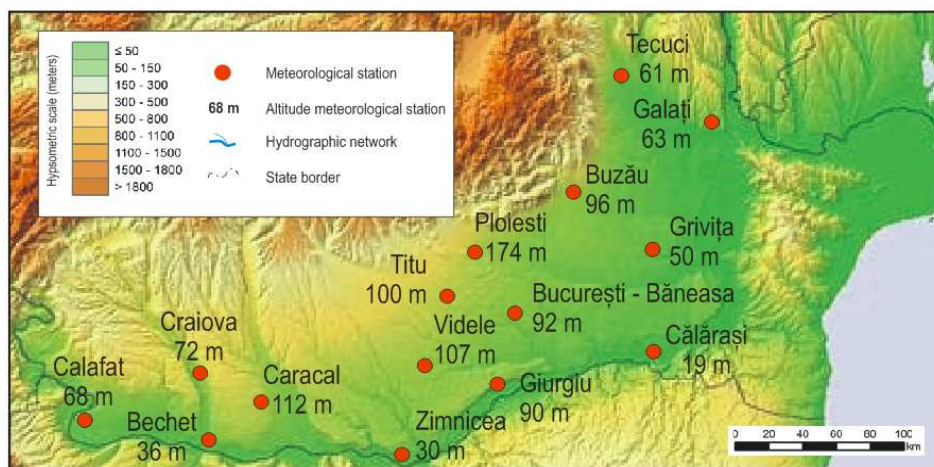


Figure 3. Romanian Plain - the geographical position and altitude of the meteorological stations used in the analysis

(Source: processing in ArcGis Pro and Corel Draw, 2025)

The calculations were based on the mathematical formula launched by Kyle W.J., but also on mathematical formulas used by Ionac Nicoleta and Ciulache Sterie, in the creation of the Bioclimatic Atlas of Romania (2008). The data used to calculate the index values, mentioned above, are for the summer season (June-August). In this way, we consider that the reader's perspective on the level of bioclimatic risk in the respective territory has been completed. In general, the detailed evaluation of bioclimatic indices is interesting and useful in studying the variation in time and space. Diagnostic analysis is useful in the efficient adoption of mitigation strategies and adaptation to variable bioclimatic conditions. We point out that currently, it has become a necessity to describe comfort conditions or bioclimatic risk related to climate along with the presentation of the weather.

4. Findings and discussion

In general, the bioclimatic factor should be seen as a tool in scientific research. This analysis offers a wide range of possible assessments of the climatic potential. This, whether positive or negative, indicates how a region imprints these characteristics on human health and the activities performed. These factors are seen as an important component in the treatment of climate on the human body.

The explanation is based, in the case of the present analysis, on the relationship established between elements such as temperature and humidity of the air. We also recall that the bioclimatic factor is not entirely "guilty" for human comfort. In the equation of human comfort, individual reactions to a banal heat exchange also intervene, that is, subjective elements that vary from individual to individual. This entire process is called the caloric exchange of the human body.

The bioclimatic risk due to warming depends both on the variation of radiative and dynamic climatogenic factors, but also on the variation of local physical-geographic factors. Thus, they become factors that play an essential role in the diversification of the climatic and, implicitly, bioclimatic conditions of the Romanian Plain area. Therefore, the detailed analysis of the different bioclimatic indices is interesting (they can also be adapted to the climate of Romania) and useful in studying their spatio-temporal variation on a single reference scale (being possible to best describe the meteorological conditions for tourists and local people, physiological comfort or the risk related to the local climate). Using the meteorological database created for this purpose, the values obtained through mathematical calculations and taking into account the applicability limits of the index (Ionac, 2008; Grigore, 2012) it was possible to create a synthetic and suggestive image of the degree of spatial and temporal extension of the heat stress specific to the Romanian Plain (Table 1).

Table 1

**Applicability limit and threshold values of RSI (units)
corresponding to different types of bioclimates**

Applicability limit: air-temperature less than or equal to + 35°C		
Relative Strain Index (RSI) - units -	Type of bioclimate	Type of bioclimatic comfort/discomfort
$RSI \leq 0.15$	Bioclimatic comfort	Bioclimatic comfort
$0.15 \leq RSI \leq 0.25$	Bioclimatic discomfort for more sensitive persons	Bioclimatic discomfort
$0.25 \leq RSI \leq 0.35$	Bioclimatic discomfort for all persons	
$0.35 \leq RSI \leq 0.45$	Overheating risk for more than 50% of the population	
$RSI \geq 0.45$	Heat-stroke risk for all population	

(Source: Grigore, 2012)

As we specified in the data and methods used, this index was calculated strictly for the summer period, namely the three months – June, July and August. Knowing the regime of this index allows the identification of specific methods of personal adjustments to deal with heat stress. For example, by reading different specialized writings we can learn how to make a realistic planning of the vacation or the recreation area (De Freitas, 2003), we can improve the conditions within the health facilities and we can opt for different daily activities (World Health Organisation, 2011), etc. These assessments are useful in adopting adaptation and mitigation strategies to bioclimatic conditions in vulnerable regions.

Relative Strain Index allows the evaluation of bioclimatic conditions of heat stress, highlighting areas of potential discomfort and even bioclimatic risk (due to hyperthermia). For this purpose, a series of graphic and cartographic representations were made (Table 2), which highlight the heat stress situation in the Romanian Plain.

Table 2
Average Relative Stress Index (units)
on the Romanian Plain, in the warm season

Stația meteorologica	luna		
	VI	VII	VIII
Eastern Sector of the Romanian Plain and the Baragan Plain			
Tecuci	0,14	0,23	0,21
Galați	0,15	0,24	0,23
Buzău	0,16	0,26	0,24
Grivița	0,27	0,30	0,28
Călărași	0,20	0,30	0,29
Bucharest Plain			
Ploiesti	0,15	0,24	0,23
Bucuresti	0,19	0,29	0,28
Târgoviște	0,14	0,26	0,23
Titu	0,17	0,27	0,25
The plain sector between Olt - Arges			
Giurgiu	0,21	0,33	0,32
Videle	0,23	0,35	0,31
Zimnicea	0,23	0,36	0,35
Oltenia Plain			
Craiova	0,22	0,36	0,31
Caracal	0,21	0,35	0,31
Calafat	0,20	0,36	0,32
Bechet	0,22	0,36	0,35

(Source: own research, 2025)

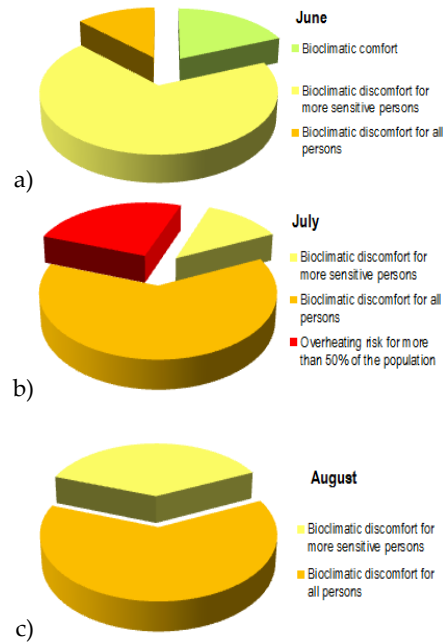


Figure 4. Monthly frequency (%)
of bioclimate changes
(Source: own research, 2025)

The corresponding RSI values that we obtained for the summer season clearly delimit several typical areas of bioclimatic risk. By visualizing and analyzing centralized data and graphic and cartographic achievements, we can identify three monthly situations.

The month of June is highlighted by two bioclimatic trends. We find the bioclimatic comfort area in the northern area of the plain, representing only 30.0% of the total area of the plain. The area of mild bioclimatic discomfort, on the other hand, dominates in most of the plain (70.0% of the total area). In this month, the vulnerable population is exposed to the danger of warming (Fig. 4a).

In July, we find that bioclimatic comfort appears insular in the north of the plain, in proportion to 5.0% of the total area of the Romanian Plain. The bioclimatic area of discomfort due to heating covers most of the plain, respectively 85.0% of the total area. This expansion of the risk area due to overheating by increasing the area also leads to an increase in the number of those affected. The calculated values indicate a physiological discomfort for all people alike, with chances of overheating risk for more than 50.0% of the population present in the identified area. In the southwest and south, representing about 10.0% of the total area of the plain, an insular area also appears with a very intense risk of overheating for the entire exposed population. These islands appear as a result of the predisposition to extremely hot and dry advections of tropical and continental air masses from North Africa (Fig.4b).

For the month of August, on the other hand, the area of bioclimatic discomfort due to heating decreases to 30.0% of the total area of the plain. Only one area with insolation can be identified, in the southern part of the Plain, representing about 4.0% of the total area. The area with moderate risk is identified in the area of the Craiova - Bechet localities. By viewing the centralization of the results and the graphical representations, we can see that the rest of the analyzed region is characterized by moderate and mild discomfort. Thus, in the case of moderate bioclimatic discomfort, over 50.0% of the population is exposed to a risk of illness or exacerbation of certain health conditions. In a proportion of 20.0% of the total area of the plain, we also find an area with mild bioclimatic discomfort. In this case, only sensitive people are exposed to a mild risk due to overheating. Regarding the area with moderate bioclimate, the discomfort decreases and is distributed evenly over the total area of the plain (Fig.4c).

Looking at the whole, it is found that only two areas in the Romanian Plain raise serious problems. These are Craiova-Bechet (in the southwest) and Zimnicea (in the south) and are individualized as two areas of real risk of heat shock. The moments of bioclimatic discomfort are due to the summer, especially, to the hot and humid days, when the human body loses heat (for example through transpiration at the skin level, upper respiratory tract, etc.), when the body fails physiologically and allows the manifestation of sensations of overheating.

The intensity and spatial extension of the bioclimatic stress due to overheating in the Romanian Plain, expressed in this case by the relative strange index, specific to the hot summer season, are related to the distribution of the main landforms and the circulation pattern of air masses. The bioclimatic stress due to overheating increases from the northwest to the southeast. In the Romanian Plain we identify a danger to human health, only in three areas. These are identified in the southwest and south of the plain. In the south of the Oltenia Plain (the area with sand dunes in the south), some local topoclimatic conditions can cause the intensification of bioclimatic stress and the islands in the area of the Băilești-Craiova-Bechet and Zimnicea localities, which are exposed to frequent advections of warm, tropical air masses from North Africa.

In general, the bioclimatic risk due to heating depends primarily, as the results obtained indicate, on the variation of radiative and dynamic climatogenic factors, but also on the variation of local physical-geographic factors. These factors play an essential role in the diversification of the climatic and, implicitly, bioclimatic conditions of the Romanian Plain. The state of bioclimatic comfort or discomfort that the human body feels directly depends on the manifestation of its caloric exchange processes. This exchange is influenced by the regime of air temperatures and relative humidity of the air. Through the combined or opposing action of the elements, it is possible to determine the amplification or diminution of the sensations of comfort or discomfort due to heating felt by the human body, at different times. The regime of sensations depends in turn on the succession of weather types and the various local influences in the Romanian Plain.

As we learn from scientific studies, presented over time, climate change is seen as a direct influence on tourism. The most affected segment of the tourist activity being the decision-making process. Weather and climate influence decisions both in the destination or receiving area, and in the region from where the tourist departs or is supplied. The need to adapt to change means increased attention to increasing resilience, reducing vulnerability, but also to appropriately handling the opportunities created by this climate change. Taking these aspects into account, decision-makers must assume a faster and more efficient adaptation. Tourism demand is affected, in addition to heat stress, by: seasonality, the tendency to

desertification, the increase in the frequency of fires (which mainly threaten infrastructure), high costs of cooling rooms in accommodation units and means of transport, the emergence of infectious diseases, the loss of natural or anthropogenic attractions, the deterioration of cultural heritage and tourism infrastructure, business interruption costs, etc.

Conclusions

Taking into account the warnings reported following the analysis, we can say that during the summer there are no prohibitions regarding tourist activity in the south of the country. The thermal condition and the adequate understanding of the concept of developing a complex relational system. The new system is as important as the one developed by the environments used by planners and decision-makers. The caloric stress on the human body becomes, in itself, a significant threat to life. Among the most well-known causes is inadequate infrastructure. In this context, the results obtained in this new segment of studying the climate and assessing the impact on tourist activities imprint a great responsibility in everyday life. Today, this responsibility consists in the generation and rapid and efficient transfer of the information obtained. Information becomes a useful tool between decision-makers and citizens. Thus, it helps to plan and assume the development of the life of the human community, in general, by respecting its requests.

The response of human society to the inevitable impact of different types of influences will be significantly different from the present one. The assessment of present and future risks already requires interdisciplinary and transdisciplinary approaches in order to couple climate modeling with socio-economic modeling. Therefore, the detailed analysis of such bioclimatic indices is not only interesting, because they have also been adapted to the Romanian climate, but also useful in studying their spatio-temporal variation on a single reference scale to best describe people's meteorological conditions or physiological comfort or climate-related risks.

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SPATIAL ACCESSIBILITY OF NON-INDIGENES TO EMPLOYMENT OPPORTUNITIES IN LAGOS METROPOLIS, NIGERIA

Abstract. In rapidly urbanising regions of the Global South, migration plays a significant role in labour markets as it increases the number of people competing for available employment opportunities. This study examines how internal migration influences employment access across the Kosofe Local Government Area of the Lagos metropolis, providing clear spatial evidence to inform better policy decisions that address unemployment issues. Data were gathered from 138 respondents using Kobo Toolbox across the study sites. Pearson correlation and spatial interpolation were used for data analysis. The study found that 47.8% of the respondents attributed unemployment to poor government policies, highlighting this as a major constraint to employment in the study area. There is a significant positive relationship ($p < 0.01$) between employment opportunity and migration, indicating that employment prospects influence the migration pattern in the study area. The study concludes that the majority of migrants do not perceive their indigene status as a barrier to access employment opportunities; they identify poor government policies as a main challenge. The study suggests that policies promoting inclusive vocational training would help migrants acquire skills in demand for employment.

Keywords: urban migration, non-indigenes, employment, spatial accessibility, government

1. Introduction

In many regions of the world, unemployment is still a major economic and social problem. The International Labour Organisation (International Labour

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Organization, 2023) states that several factors, such as migration, economic conditions, and demographic shifts, affect people's ability to find work. Rapid population growth, economic instability, and technological advancements that lower the demand for human labour make it more difficult to create sufficient employment opportunities in urban areas (Otieno & Busili, 2024; Lu, Zeng, & Hu, 2025). Because of this, many migrants are unable to find long-term work, especially in the formal sectors where entry requirements and competition are higher.

Migration has varying effects on labour markets based on the receiving area's economic structure and capacity (Roed & Schone, 2012). Migrants with skills boost economic productivity and innovation in some developed nations. But in many African countries, particularly those where migration is poorly regulated, the outcome is frequently labour market saturation and restricted access to good jobs (Akopari, 2000; Organisation for Economic Cooperation and Development, 2022). In Nigeria, migration from rural areas and neighbouring nations has contributed to rapid urbanisation in major cities like Lagos. Due to its perceived economic opportunities, improved living conditions, and industrial growth, Lagos State draws many migrants (National Bureau of Statistics, 2023). However, there is intense competition for the few available jobs as a result of the rapid migration inflow often surpassing the state labour market's capacity to absorb new workers.

However, migration imposes different challenges, which include rapid population growth and high demand for accommodations, which are capable of increasing the level of unemployment, poverty, and pressure on available social amenities. The movement of people in search of jobs has caused 'brain drain' at the source region, where educated workers leave their own area and move to metropolis in search of better jobs. This has affected economic growth and social progress at the source regions, which in most cases are rural areas or medium size urban areas (Ratha *et al.*, 2022; Onuoha & Etiebet, 2023; Isiaka, 2025; Gyanwali & Bashyal, 2025; Edino, Onalo, & Simon, 2025). Governments in destination regions face financial strain that cannot cater to the employment needs of every migrant. A high level of migration and increased unemployment lead to greater government expenses on social welfare programmes (Moridian, Radulescu, Kumar, Radu, & Mohammad, 2024; Horne, 2024; Bello & Akpan,

2025). High unemployment rates have led to increased crime, especially in urban areas where there is job scarcity (Christiana, 2012; Osho & Ojumu, 2024; Onwuka, 2025). It has been observed that long-term unemployment can lead to mental challenges such as stress, anxiety, and depression.

In Lagos State, many migrants find informal work in industries like transportation, street trading, and domestic services, which lack long-term stability, good pay, and opportunities for career advancement (Adeosun, Owolabi, Eshiet & Owolabi, 2023; NBS, 2023). Therefore, assessing the spatial accessibility of non-indigenes to employment opportunities will help in identifying and designing targeted employment programmes that are non-indigene inclusive. This study thus analyses the spatial accessibility of non-indigenes to employment opportunities in Lagos, with a focus on the factors that influence the accessibility, and strategies for improving the accessibility of everyone to employment opportunities. This study examines the non-indigenes' spatial accessibility to employment opportunities in the megacity of Lagos State.

The study is anchored on the Spatial Mismatch Theory, which was propounded by Kain in 1968 (Kain, 2004). The theory argues that employment opportunities are spatially separated from low-income migrant populations, who are restricted to residing in more distant, affordable locations. This spatial separation leads to their limited access to employment due to high transportation costs, higher commuting times, and low access to information networks. In this study, the theory explains how non-indigene migrants experience challenges in accessing jobs, not only due to a lack of opportunities but also because of spatial accessibility. Thus, employment may be influenced by the interaction between residential location and the spatial distribution of jobs, which may also be shaped by government policy.

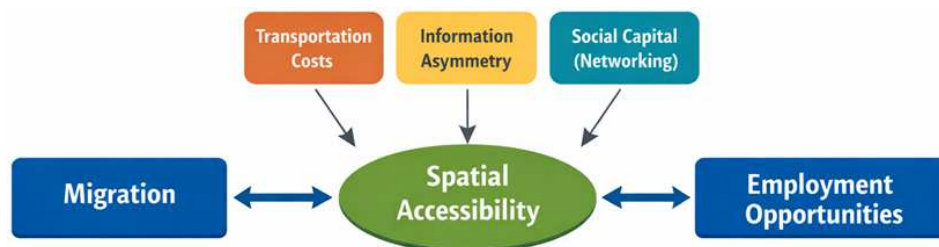


Figure 1. Conceptual Framework

Figure 1 reveals that migration and employment opportunity are connected by spatial accessibility, which is functions of transport costs, information asymmetry, and social capital. The relationship between the two major variables (migration and employment) was established. The study, however, inferred from the suggestions of the respondents on how the employment opportunity can be improved for migrants in a megacity with a highly dense population.

2. Data and Methods

Kosofe Local Government Area is one of the twenty local government areas (LGA) in Lagos State, southwestern Nigeria (Figure 2). It has an estimated population of 1,010,800. The sample size was calculated using the Taro Yamane formula, based on a marginal error of 0.05, and 95% confidence level, which resulted in a sample size of 398 for the whole population (Equation 1),

$$n = \frac{N}{1 + N(e)^2} \text{ (Equation 1)}$$

where: n = Sample size, N = Population and e = Level of error (set at 0.05 for the study).

Based on field survey estimates indicating that migrants constitute 34.5% of the study population, 138 migrants were purposively selected across the area to ensure adequate spatial representation.

The study utilised a Kobo Toolbox for data collection, which was distributed to respondents across the area. Kobo Connect Toolbox is a free and open-source platform for collecting field data with mobile devices.

A Kobo Toolbox questionnaire with pre-defined questions was purposively administered to migrants in Ketu, Isheri, Agboyi, Shangisha, Ikosi, Mile 12, and parts of Gbagada and Maryland in the Kosofe LGA of Lagos State, Nigeria. Responses were digitally captured, extracted from the Kobo Toolbox, and exported as CSV format. The data were then imported into the Statistical Package for Social Sciences (SPSS) software

for detailed data analysis. A shapefile of the study area was downloaded from the portal of Georeferenced Infrastructure and Demographic Data for Development (Grid3).

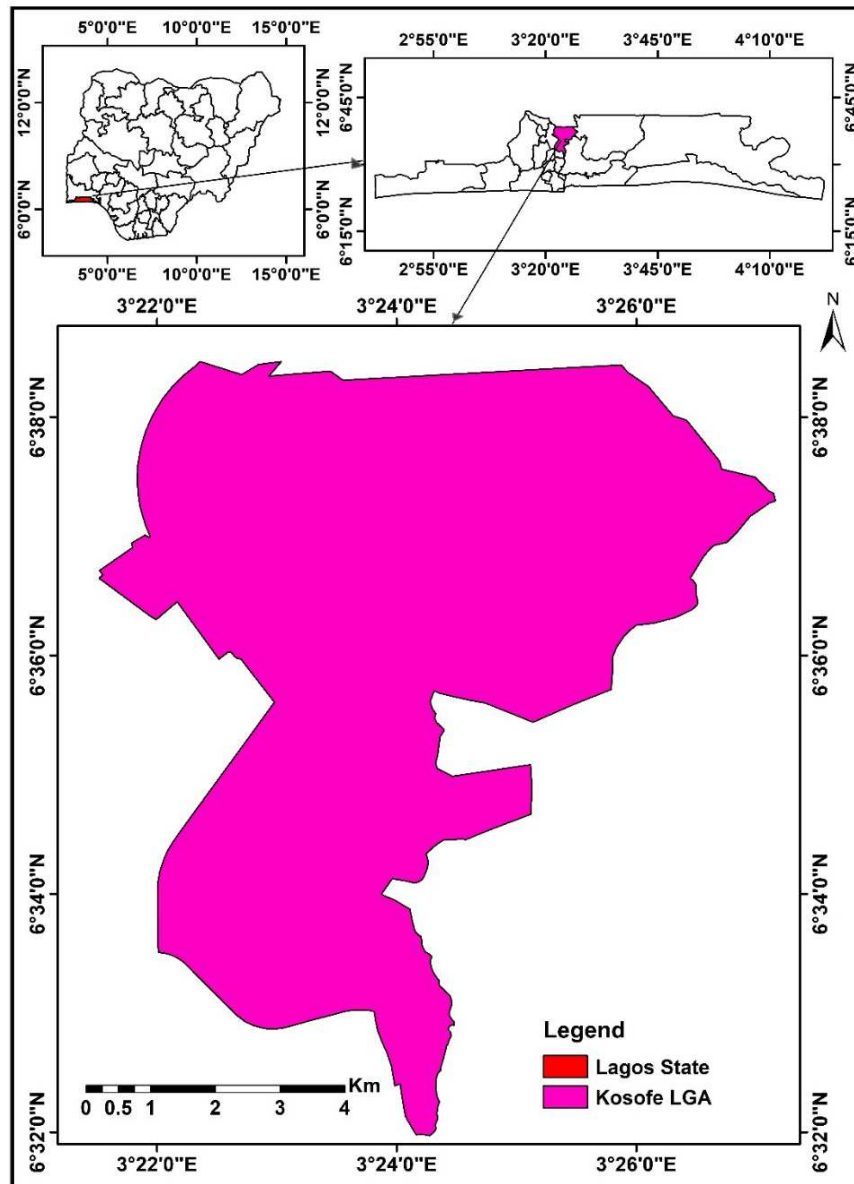


Figure 2. Kosofe Local Government Area (LGA)

Data were analyzed using descriptive statistics, correlation and spatial interpolation. Descriptive statistical tools included frequency counts, percentages, charts and graphs to summarise data. Pearson correlation was used to test the hypothesis, which stated that there is no significant relationship between migrants' influx into Lagos State and their access to employment. This test determined how strongly and in which direction the two variables were associated. The formula for the Pearson correlation coefficient is shown as Equation 2,

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}} \quad (\text{Equation 2})$$

where: n = number of respondents (migrants) surveyed, x = scores representing the level of migrants' influx, and y = scores representing access to employment. These variables were based on three Likert scale of Low coded as 1, Moderate as 2, and High as 3.

The research adopted Geographic Information System (GIS) for the spatial analysis using the spatial interpolation tool in ArcMap to reveal the non-indigenes' perceptions on their access to employment. The design of this research included the collection of point-based data (x, y) of the migrants and attribute values to interpolate migrants' access to employment.

3. Results and Discussion

This section presents the analysis and interpretation of data gathered from respondents at the Kosofe Local Government Area, Lagos State.

3.1. Spatial Patterns and Trends of Non-Indigene

Table 1 shows that the majority of non-indigenes in the area are from the southwest geopolitical zone of Nigeria, accounting for 60.8% of migrants. This suggests that a large proportion of those who relocate to Kosofe are from neighbouring states. Fewer migrants came from other geopolitical

zones of Nigeria and outside Nigeria. A major reason for migrating was searching for employment, as approximately 43% of respondents stated that they relocated to Lagos primarily to find employment. This indicates that employment opportunities in Lagos serve as pulling factors of non-indigenes from different parts of Nigeria to the area. Not all non-indigenes migrated primarily because of searching for a job, 31.2% of non-indigenes migrated in order to join their family in Lagos. To these people, searching for employment was a secondary reason (Table 1). Based on this, family and economic factors contribute more to the migration of the non-indigenes to Lagos. Economically, 71% of respondents were full-time employees, 15.9% were part-time employees, 10.1% were unemployed, and 2.9% were interns or trainees.

Table 1

Main Reason for Migrating, and Employment Opportunities

Variables	Options	Frequency	Percent (%)
Geo-Political Zone:	North Central (NC)	14	10.1
	North East (NE)	3	2.2
	North West (NW)	6	4.3
	South East (SE)	11	8
	South South (SS)	12	8.7
	South West (SW)	84	60.8
	Outside Nigeria	8	5.8
Total		138	100
Main Reason for Migrating to Lagos:	Education	14	10.1
	Find a job	59	42.8
	Others	22	15.9
	To join family	43	31.2
Total		138	100
Employment Status	Full time	98	71
	Intern/Trainee	4	2.9
	Part time	22	15.9
	Unemployed	14	10.1
Total		138	100

These employment figures suggest that the majority of migrants are economically active, potentially meeting the primary reason (seeking jobs) for their migration to Lagos. The strategic location of Kosofe with mixed socio-economic structure within the Lagos metropolis might be a factor responsible for high employment opportunities, as well as access to major industrial hubs such as Ikeja, Victoria Island and Apapa.

Considering the spatial distribution, places like Ojota and Shangisha have high concentrations of migrants who moved primarily for work. Migrants in Ogudu migrated primarily for educational purposes. In contrast, areas, such as Isheri show that migration is linked to family reunification. The spatial pattern also reveals that job-seeking is the most common migration reason, particularly in central and southwestern Kosofe. The central region of Kosofe, particularly around Shangisha, has moderate to high access. Access to employment is also low in the southwest, in Ogudu. In the northwest and north-eastern parts of the area, job opportunities are more available, as most respondents in those locations have access to employment, which is relatively high among migrants (Figure 3).

3.2. Key Factors Influencing Non-Indigenes' Employment Opportunity

The factors influencing migrants' employment are displayed in Table 2. Regarding employment status, 15.9% of respondents work part-time, while the majority (71.0%) have full-time jobs. 2.9% are interns or trainees, and 10.1% are unemployed. This reveals that although a large number of migrants are employed, some still have difficulty locating full-time or stable employment. Ease of getting job is low for 5.1%, moderate for 37.7% and high for 57.2% (Table 2). This suggests that although many migrants perceive availability of employment opportunities, many still encounter difficulties in their job search.

Table 2 also shows the causes of unemployment among migrants. The most frequently cited causes were a lack of jobs (44.2%) and poor government policies (47.8%). Few respondents cited discrimination (4.3%) or a lack of skills (3.6%) as the primary issue. Furthermore, only 19.6% of respondents claimed to have participated in a job training programme, while the majority (80.4%) had never done so.

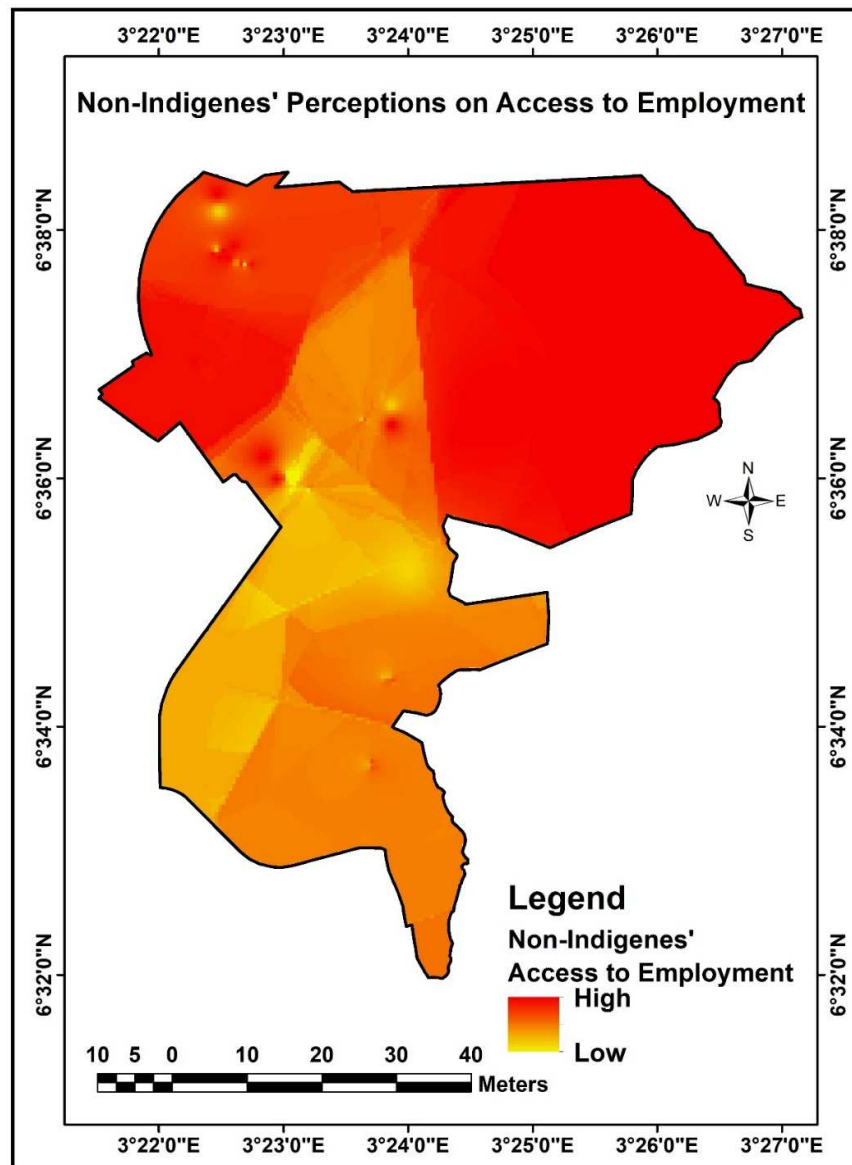


Figure 3. Non-Indigenes' access to employment

Just 8.0% of attendees reported that the training aided in their employment, compared to 74.6% who said it did not, and 17.4% who

said it was not relevant. This implies that the existing training programmes might be ineffective or poorly aligned with market demand.

Table 2

Key Factors Influencing Migrants' Employment

Variables	Options	Frequency	Percentage
Current State of Migrants' Access to Employment	High	79	57.2
	Moderate	52	37.7
	Low	7	5.1
		138	100
Major Reason for Migrant Unemployment	Lack of skills	5	3.6
	Job scarcity	61	44.2
	Discrimination	6	4.3
	Poor government policy	66	47.8
		138	100
Attendance in Job Training Programs	Yes	27	19.6
	No	111	80.4
		138	100
Training Improved Employment Chances	Yes	11	8
	No	103	74.6
	Not applicable	24	17.4
		138	100
Total		138	100

3.3. Strategies for Improving Employment Accessibility for Migrants

According to Table 3, most of the respondents agreed or strongly agreed that there are various strategies that would improve the employability of migrants in Lagos. For example, 87% agreed that providing language training schemes would help migrants secure employment, and only a small percentage disagreed. Migrant networking events and job fairs are found to be very effective, with 88.4% agreement. Job placement and mentorship programmes with the help of local businesses also received

a 90.6% level of support. Certification and vocational training programmes are also well supported, where 92.8% opined that it would help in imparting useful skills to migrants. Finally, cultural sensitivity training of employers is also advocated by nearly 90% of respondents as a way of doing away with hiring bias and promoting inclusiveness.

Table 3

Strategies for Improving Employment Accessibility for Migrants

Strategies for improving employment accessibility	Strongly disagreed (%)	Disagreed (%)	Agreed (%)	Strongly Agreed (%)
Providing language training programs	2.9	8.7	87.0	1.4
Job fairs and networking events tailored to migrant communities	0.0	11.6	88.4	0.0
Partnering with local businesses	0.0	8.0	90.6	0.7
Offering vocational training and certification programs	2.2	4.3	92.8	0.7
Cultural sensitivity training for local employers	1.4	8.0	89.1	1.4

Table 4 illustrates suggestions to increase employment accessibility among migrants in Lagos. The majority, 93.5% of the respondents, view increasing job opportunities as the best answer to increase employment access. Another minor percentage, 2.2%, showed it would help if industries and infrastructure were developed, while 4.3% gave other answers like developing other states to reduce the burden on Lagos State.

Table 4

Other suggestions to Improve Job accessibility for Migrants in Lagos state

Response Category	Frequency	Percent (%)
Creation of more job opportunities by government and private sector	129	93.50
Infrastructure and industrial development	3	2.20
Others (development of other states)	6	4.30
Total	138	100

To test the hypothesis (H_0), which claimed that there is no significant relationship between non-indigenes' influx into Lagos State and their access to employment, Pearson correlation was used. This test determined how strongly and in which direction the two variables were associated. Table 5 revealed that the Pearson correlation coefficient between the rate of migration into Lagos State and the current state of migrants' employment opportunities is $r = 0.332$, with a p-value of 0.000. This connotes a weak positive correlation, which implies that as the accessibility to employment opportunities increases, the rate at which non-indigenes migrate to Lagos also increases.

Table 5

**Relationship between Non-indigenes' Accessibility
to Employment and Rate of Migration**

Variables	Pearson correlation	N	Sig. (2-tailed)
Rate of Migration into Lagos State and migrants' Employment Access	0.332	138	0.000

The findings show that a reasonable number of migrants in Lagos are from the neighbouring states, and they mostly migrated for work and family reasons. This shows how economic opportunities and social connections drive migration in many parts of the world (Gong, Cao & Tong, 2024). Based on the study, most migrants are employed full-time, which supports their desire to work. However, a large-scale migration may increase pressure on local resources and services. Even, there is a spatial variation in migration across Nigeria as migrants from Ogun, Kwara, Osun, and Imo natives constitute a significant proportion (Adedokun & Karzanova, 2019; Oyokunyi & Adomi, 2019).

According to the results, many migrants feel that it is challenging to compete for jobs, but they also think that they have chances of getting employment. Migrants experience mixed outcomes in the labour markets. The various interventions towards improving migrants' access to work, especially those from other parts of the world, are language training, job fairs, networking, and vocational training align with global best practices.

For instance, the International Labour Organization emphasises that vocational education and training (VET) are powerful drivers of migrant integration into the economy. Also, cultural sensitivity training has, concurrently, been established to improve expatriate performance in Nigeria (Enatto, 2024). These findings provide guidance for policymakers on how to plan for more job creation and social welfare according to the International Labour Organization (2021). This can be more effective if internal migration patterns and spatial disparities in employment opportunities can be considered at the micro-scale level. The results of this study validate a significant relationship between migration and job access at the micro-levels of mega cities in Global South.

4. Conclusion

The study concludes that the level of spatial accessibility to employment opportunities for non-indigenes is high in the northern and northwestern parts of Kosofe Area of Lagos. The majority of migrants to this area are from the neighbouring states. The high employment opportunities in Lagos attracted many people to the area. Employment is not a sole motivation for migration, as some consider searching for job as secondary to family reunification in the area. It was revealed that the majority of migrants are economically active, suggesting that the primary objective of migration (employment) is largely achieved. While a small percentage identified lack of needed skills, discrimination, and poor government policies as primary barriers. These policies may not explicitly target non-indigenes, but their implementations can disproportionately disadvantage some migrants in a case where quotas systems are applied, causing perceived job scarcity among non-indigenes. This study recommends that offering inclusive vocational training coupled with favourable urban transport policies, would help migrants acquire skills that are in demand in labour markets. It also recommends that quotas systems that bring inequities and intra-urban disparities in access to employment should be abolished, especially at the micro-scale level of local government areas.

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HEAVY PRECIPITATION EVENT IN ROMANIA ON 6-9 OCTOBER 2025: ANALYSIS OF KEY SYNOPTIC CONDITIONS

Abstract. Recently, climate change has led to the intensification of heavy precipitation, often responsible for flash floods. The impact of these hydrological events has been observed at both global and regional scales. In recent years, Romania has experienced some several extreme precipitation events, such as the one recorded in the period 28–31 August 2024, when at the Mangalia weather station, a record of 325.7 mm of rainfall quantities was registered. Another event with huge amounts of precipitation occurred the following year, between 6 and 9 October 2025, when the passage of a Mediterranean cyclone led to substantial cumulative precipitation, especially in the southeastern part of Romania. The purpose of this study is to identify the synoptic context which made this hydro-meteorological event possible. The southeastern part of Romania is normally characterized by low annual precipitation quantities (generally less than 500-600 mm/year), but there are some exceptions when Mediterranean cyclones successively cross the mentioned area or when they reach the Black Sea, following a retrograde trajectory.

Keywords: heavy precipitation, specific synoptic contexts, „Barbara” Mediterranean cyclone, southeastern Romania

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Introduction

In the past century, climate change has led to an intensification of hazardous weather phenomena, which involve severe hydrological events, such as flash-floods (Constantin et al., 2024; Ilea et al., 2025). These usually occur at a local scale, but can be observed anywhere in the world, having a significant socio-economic impact (Constantin et al., 2022).

In the history of meteorological measurements in Romania, extreme precipitations have been registered both in short time intervals and by accumulation (Dragotă, 2006; Croitoru et al., 2016). A recent example in this regard can be represented by the value of 325.7 mm recorded in the period 28-31 August 2024, at Mangalia weather station (southeastern part of Romania, on the Black Sea coast) (Ilea et al., 2025). A similar situation occurred between 6 and 9 October 2025, when Mediterranean cyclone „Barbara” (named by the Italian Meteorological Service) produced very large quantities of water, yet this time these were recorded through accumulation, not in short intervals of time. The southeastern region of Romania is typically characterized by low annual precipitation, generally less than 500-600 mm/year. On the other hand, when Mediterranean cyclones successively traverse this part of the country or when they reach the Black Sea, loading with moisture and taking a retrograde trajectory, significant amounts of precipitation can be recorded in short periods of time (Tolika et al., 2024).

The purpose of this study is to identify the synoptic context that made such hydro-meteorological event possible. The respective analysis was carried out for the period 6-9 October 2025, in order to better understand the mechanism that produced the large amounts of precipitation, registered especially at Giurgiu (210.5 mm), Hârşova (125.4 mm), Constanţa-dig (120.2 mm) and Feteşti (118.6 mm) weather stations.

Materials and methods

As already mentioned, the synoptic analysis was carried out for the period 6-9 October 2025. It is mainly based on synoptic maps (ECMWF, COSMO and ICON forecast models) at the surface and different tropospheric

levels (850 hPa, 700 hPa and 500 hPa). These maps provide information on air temperature, atmospheric pressure, geopotential height and relative humidity (Deutscher Wetterdienst, 2026) across the European continent and the amount of precipitation in Romania (Romania's National Meteorological Administration – NMA, 2025). Moreover, daily precipitation data recorded at ten weather stations (WS), being representative for the study area and belonging to NMA were used. The selected WS were: Giurgiu, București-Băneasa, București-Filaret, București-Afumați, Oltenița, Slobozia, Grivița, Fetești, Hârșova and Constanța-dig (Constanța-dam) (Fig. 1). These data were also used to calculate the total precipitation over the entire analyzed period.

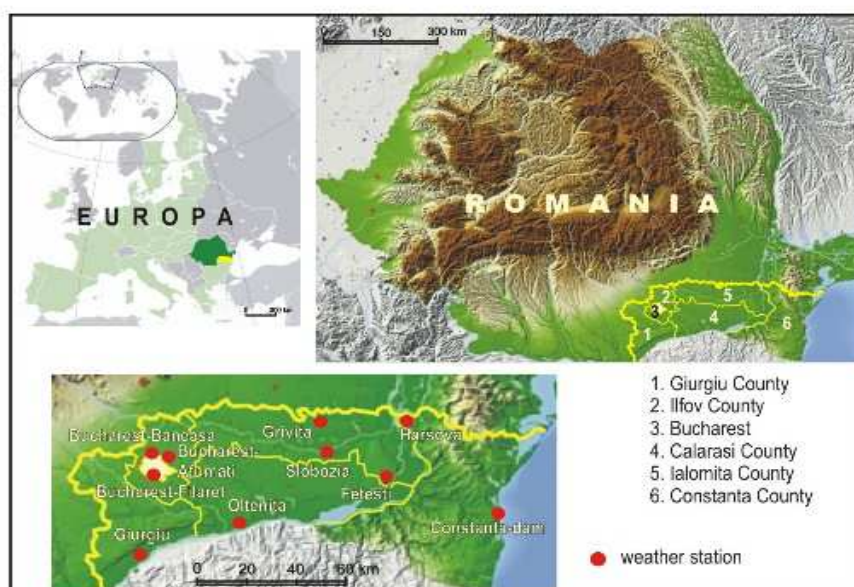


Fig. 1. The location of the study area and of the analyzed weather stations
(Source: open source processing GIS, 2026)

Moreover, on 7th October 2025, NMA issued a red code weather warning for heavy rain, especially for the southeastern regions of Romania, including the following counties: Giurgiu (GR), Ilfov (IF), Ialomița (IL), Călărași (CL), Constanța (CT) and the city of Bucharest (B). In addition, other counties in the southern and eastern part of Romania were included in an orange code weather warning (Fig. 2).

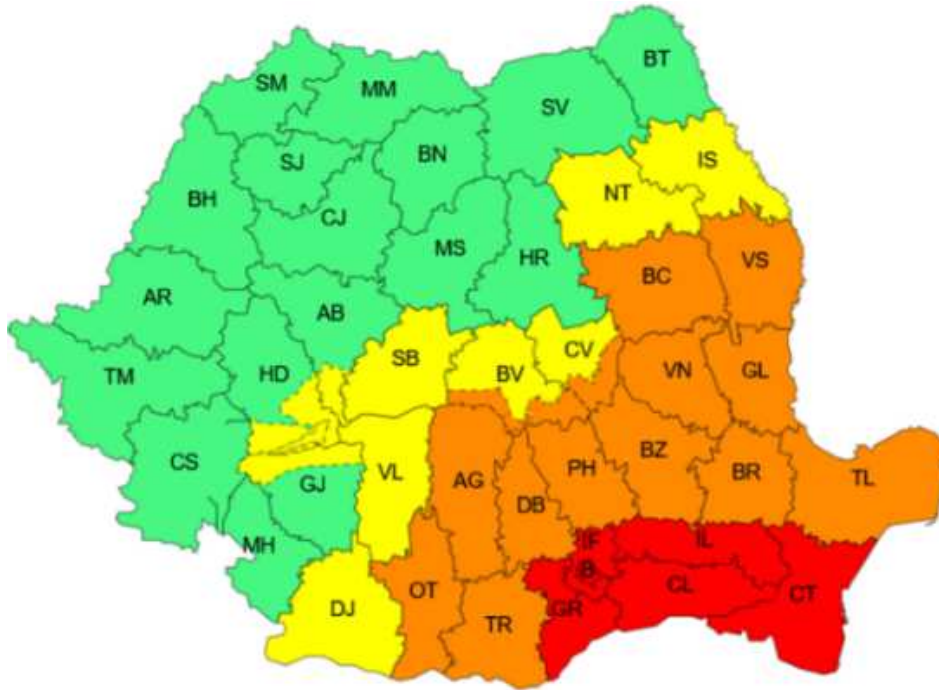
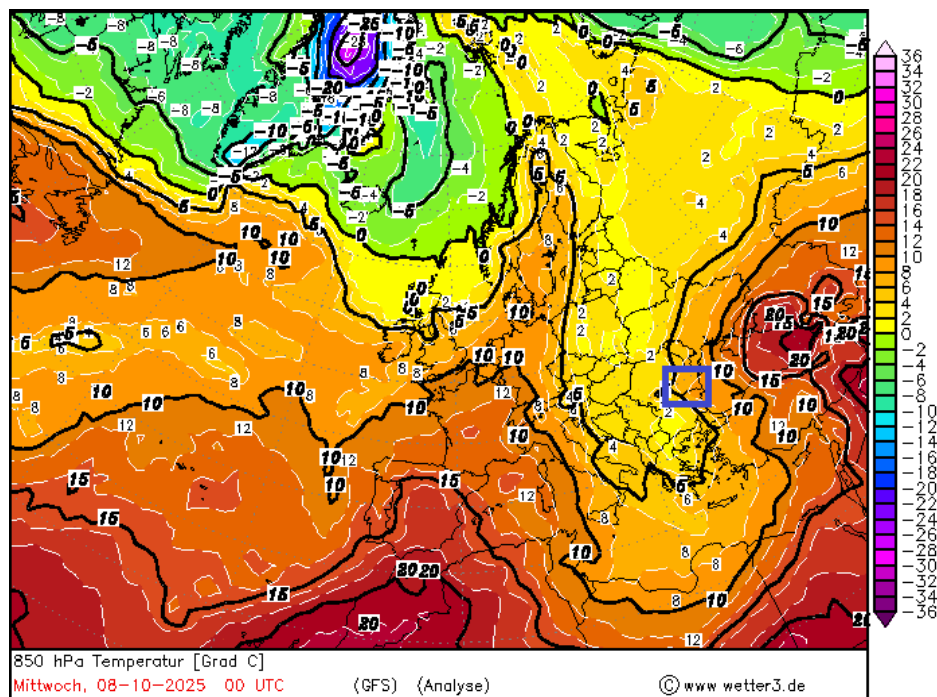
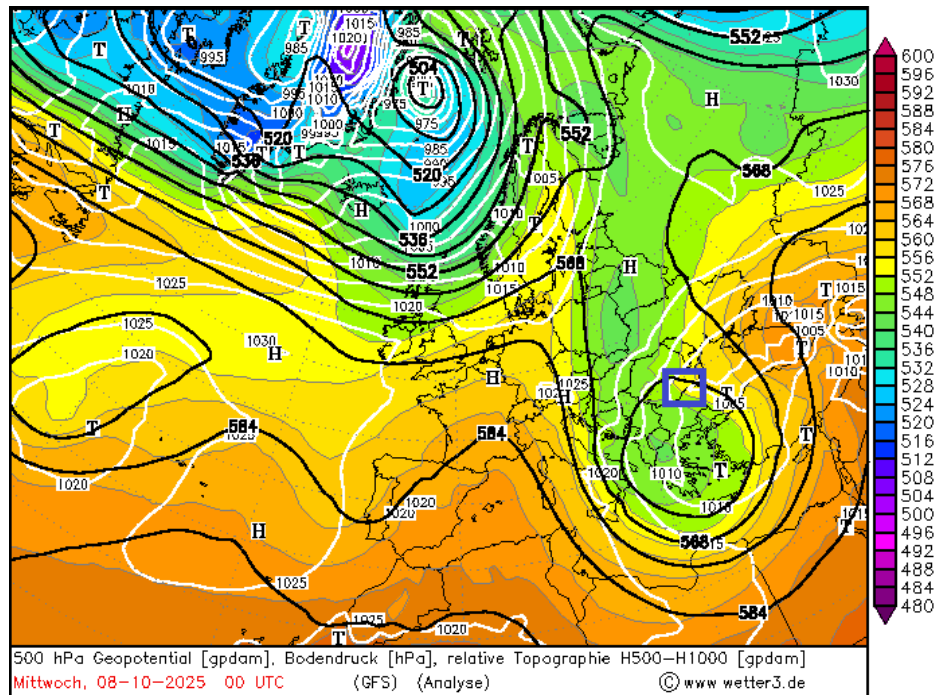


Fig. 2. The weather warning map issued by NMA on 7th October 2025. Note: green – not risk, yellow – potentially dangerous, orange – dangerous and red – very dangerous
(Source: NMA, 2025)

Results and discussion

On 7th October 2025, the occluded front associated with the Mediterranean cyclone „Barbara” became dominant, affecting the south and southeast of Romania, where significant amounts of precipitation and strong wind gusts were recorded. The synoptic circulation favored the additional supply of moisture from the Black Sea, maintaining high convective activity in Dobrogea and the southeastern Romanian Plain.

Between 8 and 9 October 2025, the depression system moved towards the northern Black Sea, simultaneously with the weakening of the baric field (1010 hPa) and the frontal activity over southeastern part of Romania (Fig. 3).



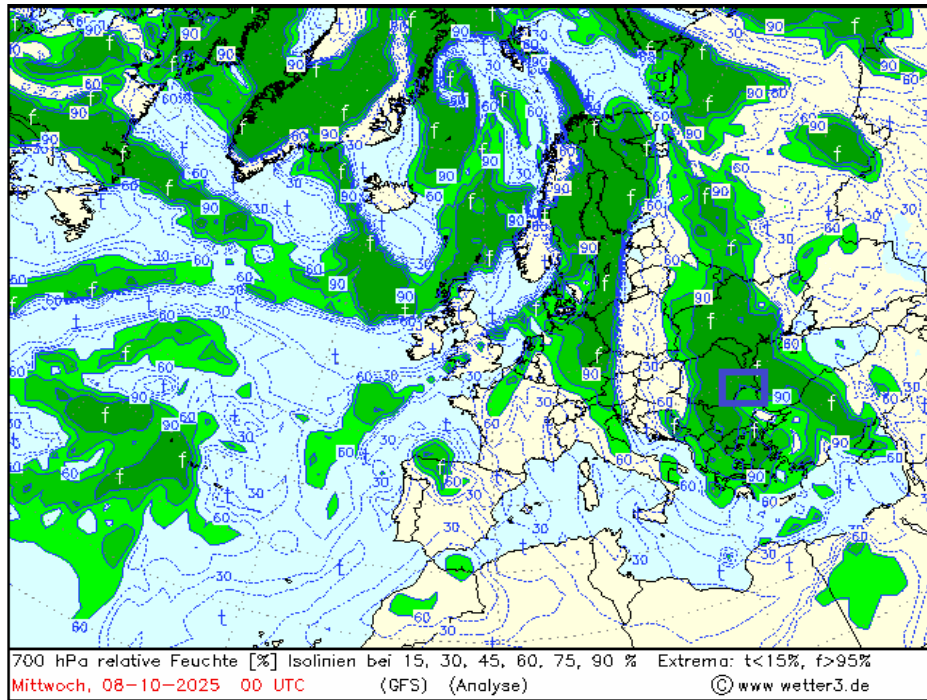


Fig. 3. The 500 hPa geopotential (black lines), the surface atmospheric pressure (white lines) and the thickness of the 500-1000 hPa layer (gpdam) (above); the 850 hPa temperature (middle); the 700 hPa relative humidity (below); GFS model, 08.10.2025, 00 UTC.

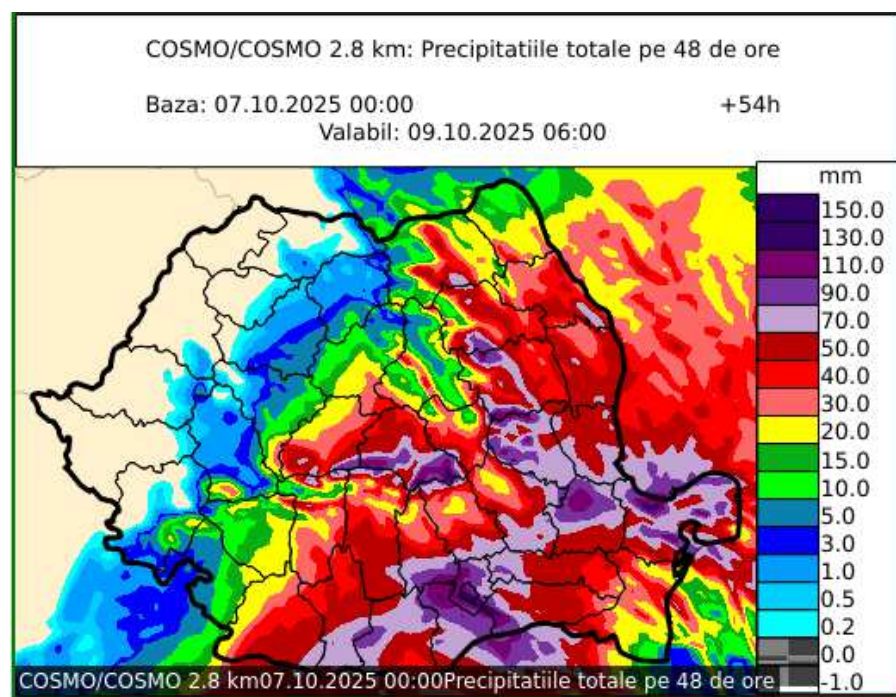
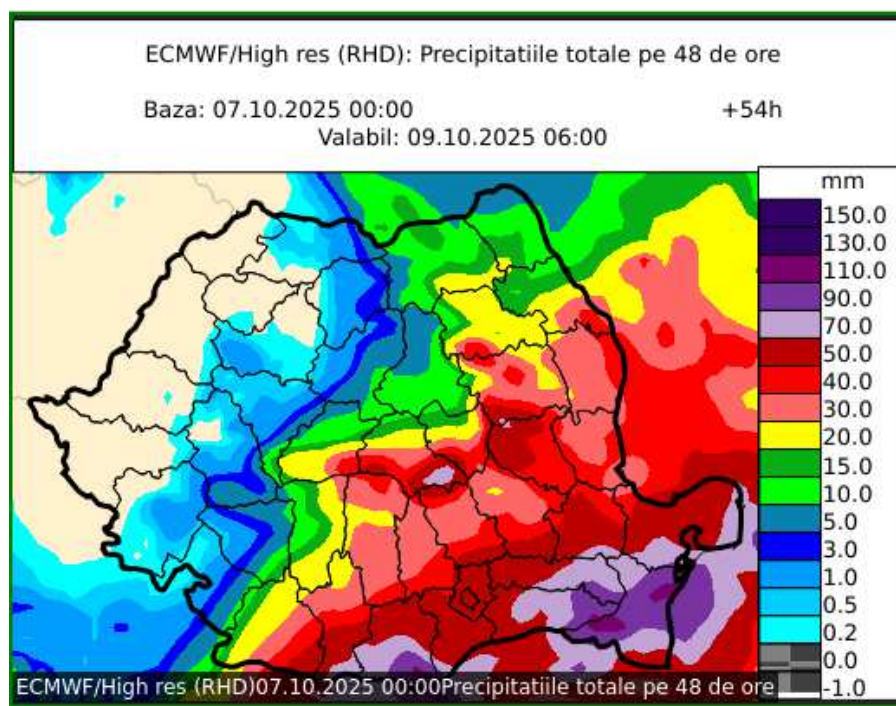
Note: study area is highlighted by a blue border

(Source: https://www.wetter3.de/archiv_gfs_dt.html, accessed on 28th January 2026)

In the middle troposphere (500 hPa) a cold core can be identified over the southern part of Romania, with a geopotential height of 560 gpdam. Moreover, the temperature at 850 hPa was around only 3°C and the relative humidity at 700 hPa exceeded 90%.

The synoptic evolution of the cyclone indicated a classic pattern of Mediterranean cyclogenesis with trans-Balkan trajectory, characterized by well-structured atmospheric fronts, consistent moisture supply and a significant pluviometric impact on the countries of southeastern Europe.

All forecast models predicted high amounts of precipitation (over 90 mm within 48 hours) but the area with the highest quantities was different in the case of the ECMWF model, which indicated these amounts in Constanța, eastern Călărași and Ialomița counties. On the other hand, COSMO and ICON models indicated substantial cumulative precipitation in Giurgiu, Ilfov and western Călărași counties, but also in the city of Bucharest (Fig. 4).



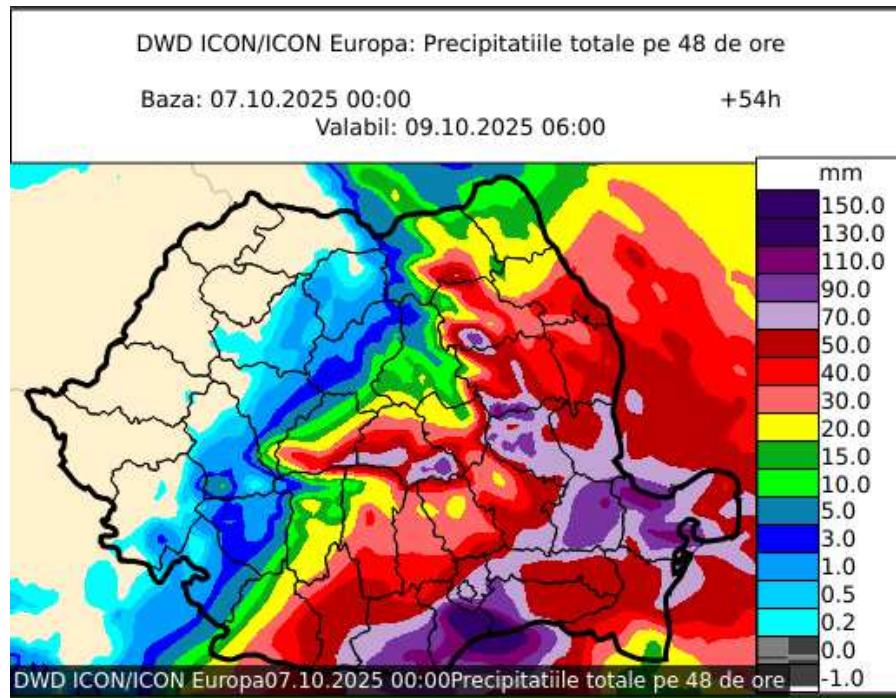


Fig. 4. The amount of precipitation forecasted in Romania between 7-9 October 2025, by the models ECMWF (above) COSMO (middle) and ICON (below) on 07.10.2025, 00 UTC
(Source: NMA, 2025)

The recorded precipitation amounts ranged between 77.7 mm at București-Băneasa and 210.5 mm at Giurgiu weather stations (WS). Due to the slow movement of cyclone „Barbara”, the southeastern part of Romania received the largest rainfall totals during the analyzed period. Other notable precipitation quantities were recorded at Hârșova (125.4 mm), Constanța-dig (120.2 mm), Fetești (118.6 mm), Oltenița (115.5 mm) and Slobozia (100.2 mm) (Table 1), justifying the previously issued red code weather warning. In Bucharest city there were registered 84 mm at București-Filaret WS, 77.8 mm at București-Afumați WS, and 77.7 mm at București-Băneasa WS.

It should be noted that the multi-year average precipitation (1961-2024) in October for the study region is only 31-50 mm.

Table 1

Daily and total precipitation amounts (mm) recorded between 6-9 October 2025 at the weather stations analyzed in the study area

WS / Day	06-07.10	07-08.10	08-09.10	06-09.10
Giurgiu	14.3	117.3	78.9	210.5
București-Băneasa	3.2	49.8	24.7	77.7
București-Filaret	4.7	52.5	26.8	84.0
București-Afumați	6.3	49.1	22.4	77.8
Oltenița	12.4	70.9	32.2	115.5
Slobozia	6.1	58.6	35.6	100.2
Grivița	7.6	57.6	31.9	97.1
Fetești	10.3	75.1	33.1	118.6
Hârșova	9.6	78	37.8	125.4
Constanța-dig	4.4	100.2	15.6	120.2

Source: National Meteorological Administration (NMA), 2025.

Conclusions

One of the most severe hydro-meteorological events recorded in southern and southeastern Romania occurred between 6-9 October 2025. Thus, large amounts of precipitation that should have normally been recorded in more than six months were registered in a relatively short period of time. However, the hydrological effects were not significant, as the recorded values were distributed over several days instead of a single episode.

The Mediterranean cyclone, named by the Italian Meteorological Service "Barbara" formed on 5th October 2025, over the Ionian Sea, as a result of the interaction between warm and humid air above the Mediterranean Sea and an extensive area of cold air in the middle troposphere (500 hPa), located over central and eastern Europe.

The run of the ECMWF, COSMO and ICON models (from 7th October 2025, 00 UTC) showed significant differences regarding the location of the highest possible amounts of precipitation, but all of them highlighted that the most susceptible area would be the southeastern part of Romania, lying exactly within the counties included in the red code weather warning issued by Romania's National Meteorological Administration (NMA) on the morning of the respective day.

The largest quantities were registered in Giurgiu, Constanța, Ialomița and Călărași counties, being the most affected by the heavy precipitation event in the period between 6-9 October 2025.

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Zion Sonia Estelle ADJO¹

LES TRANSPORTEURS SAHÉLIENS AU PORT D'ABIDJAN

Résumé. Le port d'Abidjan est directement relié aux pays sahéliens grâce à un réseau routier bitumé et une liaison ferroviaire de 1250 Km, depuis les abords des quais jusqu'au Burkina-Faso. Pour le transport de leurs marchandises dans le contexte du commerce extérieur, les pays sahéliens (Mali, Burkina-Faso et Niger) se sont toujours intéressés au port d'Abidjan. Le choix du corridor ivoirien par les chargeurs de ces pays, de préférence aux autres voies de la sous-région, soulève des interrogations quant aux réalités du port d'Abidjan comme point de transit. Plusieurs interrogations surgissent du choix du corridor ivoirien par les chargeurs des pays sahéliens par rapport aux autres corridors de la sous-région. Par ailleurs, les chargeurs de ces pays sont confrontés à diverses réalités en faisant du port d'Abidjan le point de transit de leurs marchandises. Cette étude explore les réalités des transporteurs (camionneurs, usagers du train) sahéliens au port d'Abidjan. Son élaboration a été possible grâce à la recherche documentaire, à l'observation directe et à l'enquête de terrain. Les résultats révèlent que l'état satisfaisant des réseaux routier et ferroviaire ivoiriens, couplé aux relations sociales de longue date établies en Côte d'Ivoire et bien d'autres raisons, retiennent l'intérêt particulier des transporteurs sahéliens pour l'acheminement de leurs marchandises via le port d'Abidjan. En dépit de ces atouts, les transporteurs sahéliens sont confrontés à des situations désagréables sur le corridor ivoirien et même au sein du port.

Mots-clés : port d'Abidjan, corridor, pays sahéliens, transports, chargeurs.

Introduction

Le Port d'Abidjan dispose d'une excellente connexion aux voies maritimes internationales ainsi qu'aux routes terrestres et à la voie ferroviaire vers

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l'intérieur du pays avec les États de l'hinterland en l'occurrence les pays sahéliens (le Mali, le Burkina-Faso et le Niger). Par conséquent, cette synergie favorise des flux commerciaux faisant du port d'Abidjan un pôle important pour le commerce régional en Afrique de l'ouest. Entre plusieurs ports de la sous-région, le port d'Abidjan dispose d'atouts liés aux infrastructures de transport et aux contextes socio-culturel et historique de longue date. La présence des transporteurs sahéliens au port d'Abidjan est un marqueur de fidélisation des clients du port qui en dépit des difficultés inhérentes à leur fréquentation, ne rechignent pas à le fréquenter, quand même des situations de crise adviennent parfois. Dans cette perspective, (Ake Aké 2019 : 83) définit le port comme une véritable porte océane pour les pays sans façade maritime. Ce qui fait de cette infrastructure le lieu d'interconnexion des transports maritimes, offrant un avantage économique dans les échanges commerciaux des pays de l'hinterland avec le reste du monde. Toutefois, l'efficacité de ce système repose sur un acteur central à savoir le transporteur. Selon le (Dictionnaire Larousse 2022), celui-ci se définit comme la personne s'engageant à assurer le déplacement d'une marchandise en vertu d'un contrat de transport. À cet égard (Togola Lassina 2021 : 291) souligne que l'économie des pays enclavés est tributaire en grande partie du transport, singulièrement du transport routier qui assure la liaison physique entre les pays côtiers et ceux sans littoral. Dès lors, les corridors deviennent les vecteurs essentiels des processus d'intégration sous-régionale. Le trafic du Mali, du Burkina Faso et dans une moindre mesure celui du Niger atteste le statut du port d'Abidjan en tant que plateforme logistique incontournable, dont le rayonnement impacte favorablement l'économie internationale. En dépit du rôle primordial dévolu au port d'Abidjan, les conditions opérationnelles des acteurs de terrain méritent une analyse approfondie. C'est dans cette optique que s'inscrit la présente étude qui a pour objectif de mettre en lumière les réalités vécues par les transporteurs sahéliens lors de l'acheminement de leurs marchandises via le port d'Abidjan.

Méthodologie

1. Cadre théorique de l'étude

La réalisation de cette étude a été possible par la recherche documentaire et les enquêtes de terrain. En ce qui concerne la recherche documentaire,

plusieurs ouvrages tels que des articles scientifiques, des brochures en lien avec le port d'Abidjan, le transport des marchandises des pays de l'hinterland a été exploité. Ces ouvrages ont été consultés à la bibliothèque de l'Académie Régionale des Sciences et Technique de la Mer (ARSTM) et au centre de documentation et d'outillage du Port d'Abidjan. L'enquête de terrain s'est effectuée auprès de personnes ressources du milieu maritime et portuaire, par le biais d'un questionnaire adapté. Nous avons réalisé des entretiens avec les représentants des transporteurs et des chargeurs de l'hinterland en Côte d'Ivoire, notamment l'OTRAF (organisation des transporteurs du Faso) le CBC (conseil Burkinabé des chargeurs), le CNUT (conseil nigérien des utilisateurs de transporteurs) et le CMC (conseil malien des chargeurs). Les questions portaient sur le choix du port d'Abidjan pour le transit de leurs marchandises, sur les difficultés rencontrées lors du transit de leurs marchandises. Ces enquêtes ont eu lieu du 14 octobre au 29 novembre 2025. Le tableau 1 ci-dessous fait le bilan des personnes ressources enquêtées.

Tableau 1

**Effectif des personnes ressources interrogées
lors des entretiens**

Structures	Effectifs
OTRAF	2
CBC	2
CNUT	2
EMACI	2
Total	8

Source : nos enquêtes, 2025

2. Présentation de l'espace d'étude

Le cadre spatial de notre recherche est le port d'Abidjan (Figure 1). Ce port qui dispose d'un domaine de 800 ha, se situe au sud de la lagune Ebrié. Il est à cheval sur les communes du Plateau, de Treichville et de Port-Bouët. Les travaux de redimensionnement du canal de Vridi achevés en 2018 permettent désormais d'accueillir des navires de (plus de 350 m de long), avec un tirant d'eau pouvant atteindre 16 mètres. Ce qui augmente la compétitivité du port d'Abidjan (N'Guessan A.A.B. et Adjo S., 2024, p. 331).

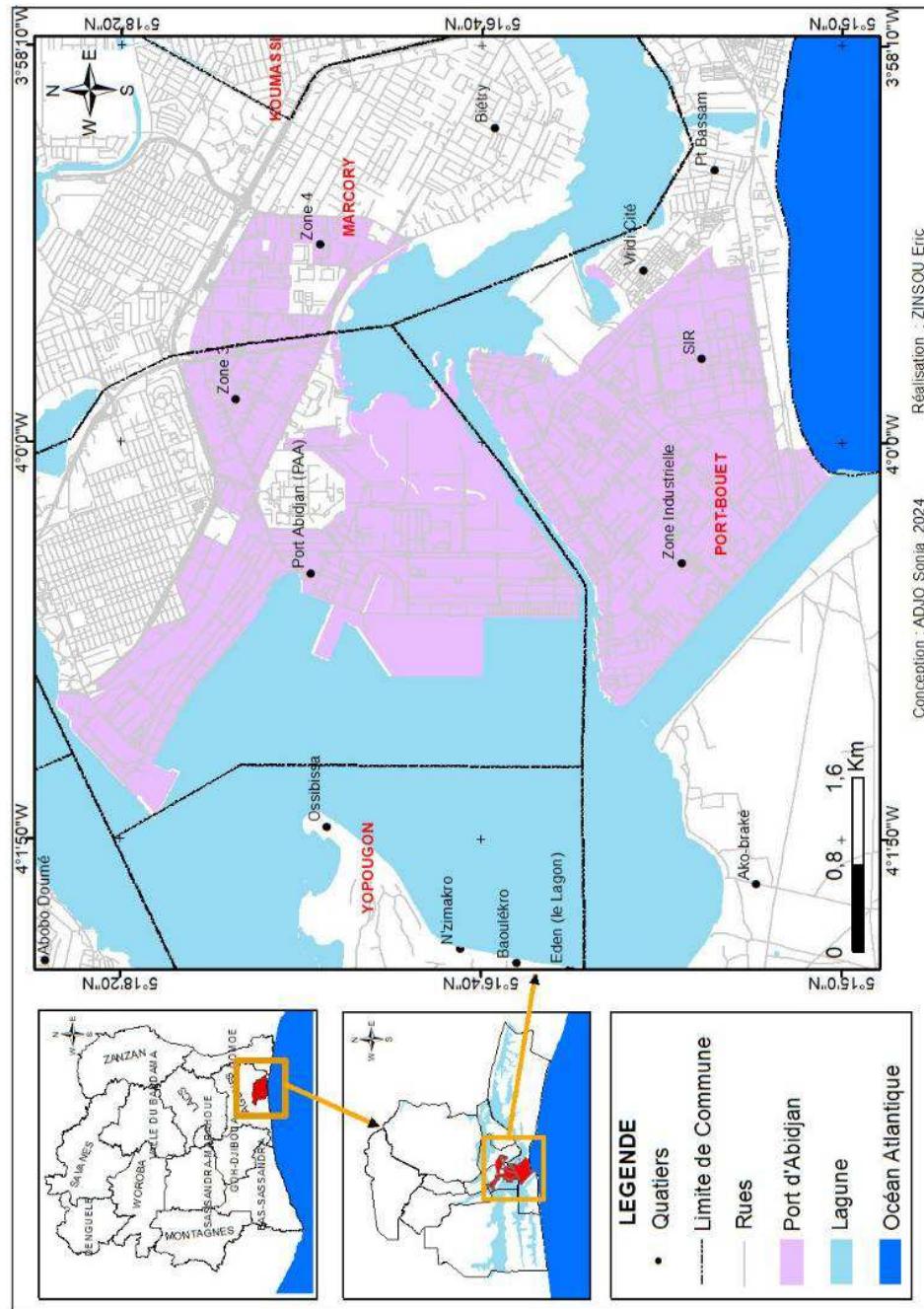


Figure 1. Le Port Autonome d'Abidjan

Résultats

1. Le port d'Abidjan, un choix stratégique de longue date pour les transporteurs sahéliens

Les transporteurs des pays de l'hinterland optent pour le port d'Abidjan par rapport à sa position de hub régional, pour les infrastructures et équipements modernes. Le bon réseau routier et le chemin de fer performant ne peuvent être que bénéfique en termes de coût et de rapidité d'acheminement pour les transporteurs sahéliens.

1.1. Un port aux infrastructures modernes

Pour améliorer ses performances afin d'être plus compétitif, le port d'Abidjan, a réalisé plusieurs projets. Le môle du port de pêche, opérationnel depuis 2015, permet de recevoir des navires de pêche de 9,5 à 11 mètres de tirant d'eau. Le canal de Vridi élargi et approfondi, a été inauguré en 2019. Il permet désormais de recevoir des navires sans limitation de longueur avec 16 mètres de tirant d'eau. L'Autorité portuaire a procédé également à la création de terrains par remblaiement de la baie lagunaire de Vridi-Biétry sur une superficie de 40 hectares pour recevoir des unités industrialo-portuaires. Un terminal roulier a été construit et mis en service depuis 2018. Un autre projet qui constitue le fleuron de la vision stratégique de l'Autorité portuaire est celui du deuxième terminal à conteneurs mis en service en novembre 2022. Cette deuxième plateforme logistique porte la capacité d'accueil des conteneurs au port d'Abidjan à 2 500 000 EVP. À côté de ces réalisations, un autre projet de grande envergure est pratiquement achevé. Il s'agit des travaux de construction des infrastructures du nouveau terminal céréalier, qui facilite l'accueil de navires Overpanamax pouvant transporter entre 40 000 et 50 000 tonnes de vracs alimentaires (contre 30 000 tonnes en 2023). Ce terminal est également conçu pour jouer un rôle capital en matière de sécurité alimentaire, tant pour la Côte d'Ivoire que pour les pays sans littoral de l'hinterland ouest africain dont les besoins en produits céréaliers vont sans cesse croissant. La mise en service du second terminal à conteneurs (TC2) et l'extension des quais ont contribué à la

performance du port d'Abidjan, la photo 1 ci-dessous montre le TC2, doté d'équipements de dernière génération. Ce nouveau terminal moderne, bâti sur 37,5 ha de terre-plein avec 16 m de tirant d'eau, dispose de 06 portiques de quai de grandes portées, de 18 portiques de parc électriques et de 36 tracteurs électriques. Il renforce la capacité de traitement des conteneurs au port d'Abidjan, qui passe ainsi de 1 à 2,5 millions de TEU ce qui permet d'accroître considérablement la capacité de traitement des conteneurs. Le port d'Abidjan, avec la réalisation de ces infrastructures modernes, a pu rattraper son retard en termes d'investissements en l'espace d'une décennie, et améliorer sa productivité et sa compétitivité (PAA 2023).



*Photo 1. Le deuxième terminal à conteneurs (TC2)
(Cliché : PAA, 2024)*

1.2. Le développement continue des infrastructures de transport terrestre

1.2.1. La voie routière

La voie routière est la voie de communication la plus utilisée par les camionneurs sahéliens pour l'acheminement de leurs marchandises. Ces transporteurs optent pour le mode de transport routier du fait de la

rapidité des livraisons qui se font de porte à porte, et la flexibilité qui s'aperçoit dans la modification des itinéraires en cas d'urgence, ainsi que la capacité à s'adapter efficacement aux imprévus.

Ces dernières années, le réseau s'est amélioré par les actions des structures habilitées agissant sur ordre du gouvernement ivoirien. L'amélioration du réseau routier ivoirien a renforcé les choix du port d'Abidjan comme port de transit par les opérateurs des pays sans littoral. Ils apprécient la qualité du réseau routier comme « *bonne* ». La fluidité du trafic routier leur permet de gagner en temps. La figure 2 met en relief le corridor ivoirien. La côte d'Ivoire possède un réseau routier dense, soit l'un des meilleurs de la sous-région. Plus de 82 000 km dont environ 900 km revêtu, y compris 400 km d'autoroutes. Le linéaire du réseau routier revêtu a connu un accroissement ces dernières années, en passant de 6500 km en 2015 à 9200 km à fin juillet. Les transporteurs sahéliens adoptent l'itinéraire le plus fiable et direct pour l'acheminement des marchandises. Selon les résultats des enquêtes ont peu identifier les principaux trajets utilisés par les camionneurs. Il s'agit de :

- **Axe 1** – pour les camionneurs Maliens l'itinéraire se présente comme suit : Abidjan - Yamoussoukro - Bouaké - Ferkéssédougou - Mali.
- **Axe 2** – pour les camionneurs Burkinabés l'itinéraire est le suivant : Abidjan - Yamoussoukro - Bouaké - Ferkéssédougou - Burkina-Faso.

Les transporteurs Nigériens transitent leurs marchandises depuis le port d'Abidjan, vers le Burkina -Faso et ensuite les acheminent de la capitale Burkinabé vers le Niger (Niamey).

Cependant, on note quelques itinéraires de contournements en fonction des besoins des camionneurs ou des difficultés rencontrées par ceux-ci. Ainsi pour se rendre au Mali le camionneur utilise la ligne routière suivante : Abidjan - Yamoussoukro - Bouaké - Katiola - Boundiali. Quant 'au Burkina-Faso la ligne de contournement qui n'est pas aussi très aisée est la voie qui longe la frontière Est : Abidjan - Abengourou - Bondoukou - Bouna.

À travers nos enquêtes auprès des camionneurs, il ressort le réseau routier ivoirien est l'un des meilleurs de la sous-région.

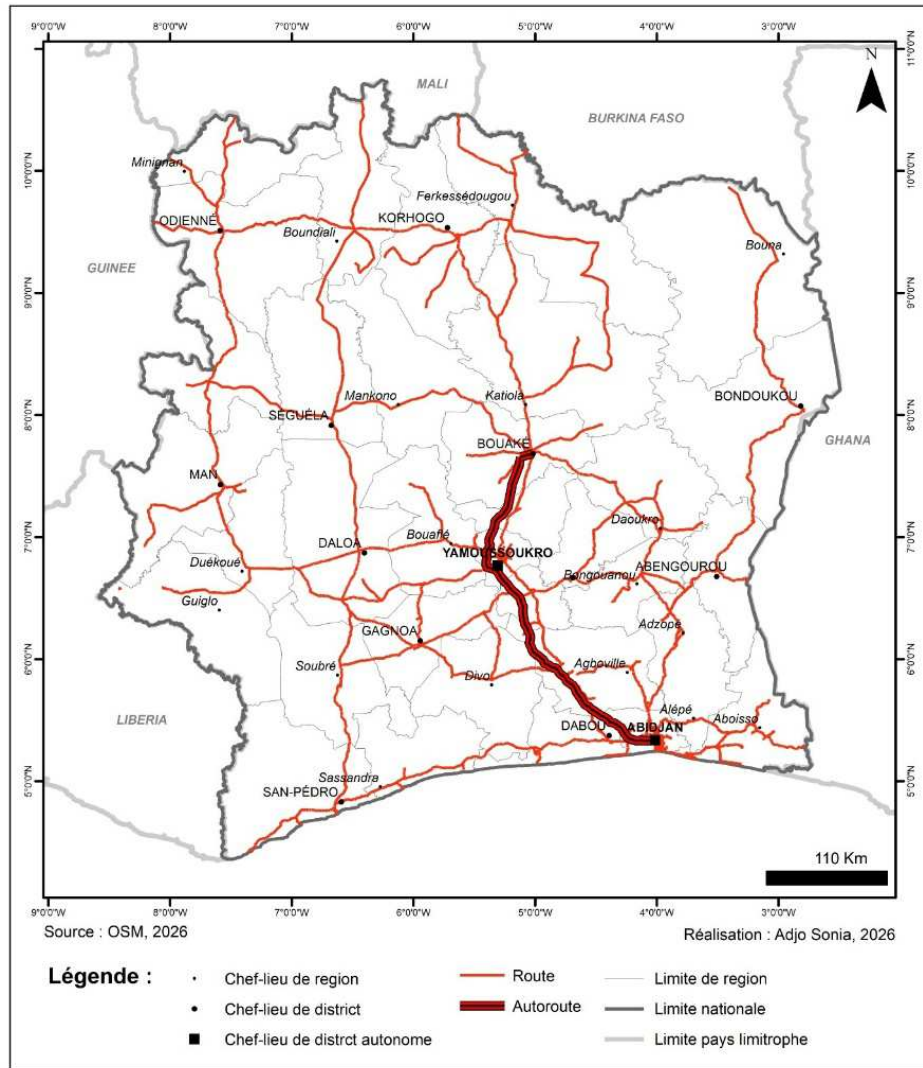


Figure 2. Le corridor Ivoirien

1.2.2. La voie ferroviaire

La voie ferroviaire, reliant le port Abidjan à Ouagadougou est longue de 1260 Km. Elle est exploitée par la SITARAIL depuis 1995. C'est une infrastructure permettant le développement économique et visant la réduction de la

congestion routière dans le transit des marchandises. Le chemin de fer est la voie de communication la plus efficace et la plus efficiente en matière d'acheminement des marchandises. À ce sujet, un transporteur burkinabé qui a voulu garder l'anonymat, dit ceci : « *Au niveau de la voie ferroviaire, il n'y a pas trop de tracasseries* ». Pour l'acheminement des marchandises en vrac, les transporteurs Burkinabé et Nigériens choisissent le mode ferroviaire pour la fluidité du trafic, l'absence d'embouteillage, la rapidité des embarquements et des débarquements des marchandises et le coût réduit du service par rapport à la route. Plusieurs aménagements en vue d'accroître le trafic ferroviaire sont mis en œuvre. La photo 2 ci-dessous, présente une section de la voie ferrée dans la commune de Treichville, à 200 m du terminal minéralier au port d'Abidjan. Cette voie a connu un aménagement récent dans le but de faciliter le transport de marchandises par le rail et d'accroître les mouvements d'importations et d'exportations en provenance et à destination des pays de l'hinterland.

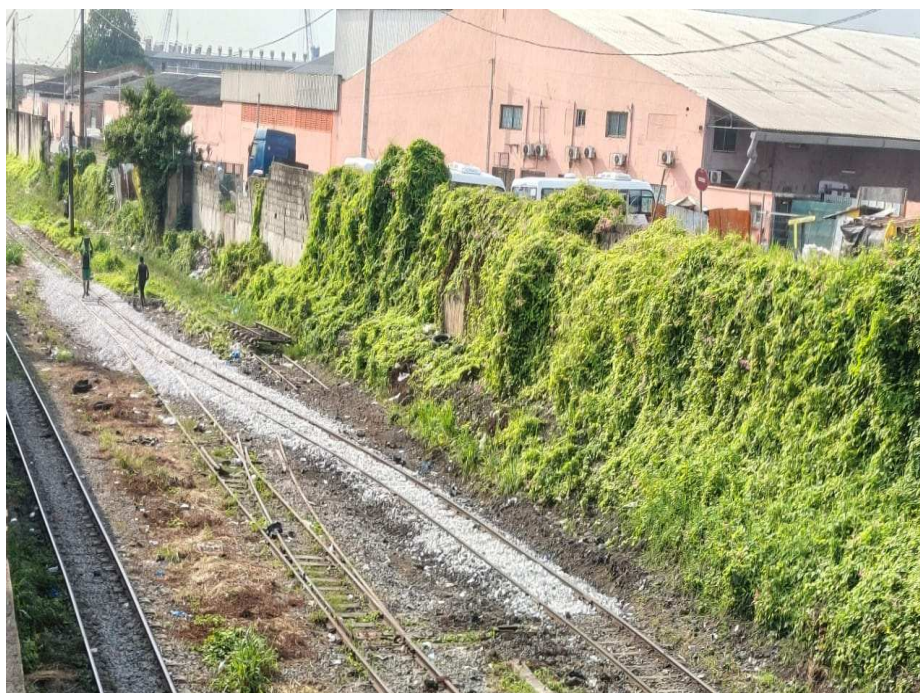


Photo 2. La voie ferroviaire partiellement réhabilitée en zone portuaire à Abidjan
(Cliché : Adjo S., 2025)

1.3. La sécurité et la sûreté au port d'Abidjan

Étant des fonctions régaliennes importantes, la sécurité et la sûreté portuaire consistent à assurer la protection des biens, des personnes, des installations logistiques contre tous les actes malveillants, tels que les vols de marchandises, le piratage, les incendies, le terrorisme, le brigandage etc. Les transporteurs sahéliens désireux de faire transiter leurs marchandises en sécurité et dans de bonnes conditions, estiment que le port d'Abidjan est l'idéal, En raison de sa certification à la norme ISPS depuis 2004. Des mesures de sécurité et de sûreté ont été prises en conséquence et s'améliorent progressivement. Au port d'Abidjan, un parc de sécurité est dédié au stockage et à la manutention des marchandises dangereuses. Pour être plus efficace en matière de sécurité et de sûreté, le port d'Abidjan collabore étroitement avec la Direction Générale des Affaires Maritimes et Portuaires (DGAMP) et la Marine nationale (N'Guessan A.A.B. / Adjo S., 2024 : 335).

1.4. Les facteurs socioculturels

Selon les transporteurs sahéliens, l'intérêt de faire passer leurs marchandises par le port d'Abidjan se situe aussi au niveau socioculturel. Les relations entre les pays sahéliens et la Côte d'Ivoire sont anciennes et profondes, favorisant l'intégration régionale. L'inexistence des barrières linguistiques permet une communication fluide, efficace, créant aussi un sentiment de sécurité pour les transporteurs. Ces facteurs socioculturels facilitent les importations et les exportations des transporteurs sahéliens par le port d'Abidjan. La monnaie utilisée entre la Côte d'Ivoire et les pays du sahel, notamment le Mali, le Burkina-Faso et le Niger est le FCFA. Cette monnaie commune stimule les échanges commerciaux, créant un climat de transparence dans les coûts des transactions effectuées.

2. Impacts du transport de marchandises des pays sahéliens dans le port d'Abidjan

2.1. Contribution du trafic des pays sahéliens dans le développement économique du port d'Abidjan

Les pays sahéliens contribuent pour une part non négligeable dans le développement économique du port d'Abidjan à travers leurs importations et exportations. Les marchandises en transit, ont connu en 2024 une légère hausse de +0,8% pour 2 919 355 tonnes de marchandises traitées. Par pays, il est question respectivement pour le Burkina Faso de 2 058 803 tonnes (en baisse de -7%), cette baisse est en rapport avec les tensions socio-politiques passées, Ces tensions ont agi sur les flux de marchandises, malgré que les relations commerciales demeurent, un climat de méfiance se serait installé entre les deux États. Les tracasseries routières et ferroviaires que subissent les transporteurs Burkinabé sont aussi facteurs de la baisse du trafic. Pour le Mali, le volume est de 835 216 tonnes, en forte hausse (+24,3%), confirmant la consolidation de ce corridor. Cette dynamique témoigne de la confiance durable des opérateurs maliens et du rôle central du port d'Abidjan dans l'approvisionnement de l'économie Malienne. Pour le Niger, on note une progression spectaculaire (de 6 à 1 123 tonnes, soit +18 620%), traduisant une très forte reprise d'activités. Les pays côtiers ont vu leur trafic doublé (+131%), bien que représentant encore des volumes modestes (24 214 tonnes). Le trafic de transit reste globalement stable à 2 919 355 tonnes (+0,8%), mais présente une évolution contrastée selon les destinations (PAA 2024 : 11).

2.2. Les obstacles rencontrés par les transporteurs sahéliens

Pour l'acheminement de leurs marchandises, les transporteurs sahéliens sont confrontés à des tracasseries qui affectent leurs activités et mettent en mal la compétitivité du port d'Abidjan par rapport aux ports concurrents de la sous-région.

2.2.1. La lenteur des procédures administratives et douanières

Les transporteurs sahéliens estiment que le nombre pléthorique et le traitement manuel des documents administratifs et douaniers, la file d'attente pour l'achat du laissez-passer, la lenteur du scanner de la douane et l'affluences des acteurs intermédiaires informels, mettent à mal leur passage au port d'Abidjan. Les marchandises restent immobilisées pendant plusieurs jours pour apporter certaines corrections aux éventuelles erreurs. Cela retarde la livraison de leurs marchandises à l'importation comme à l'exportation. Lors de nos enquêtes de terrain, nous avons interrogé un transporteur malien qui a voulu l'anonymat., Ce dernier affirme : « lorsque les documents sont en règle nous acheminons nos produits vers le Mali en 3 ou 4 jours. Lors des difficultés rencontrées l'acheminement des marchandises fait une à deux semaines environ ».

2.2.2. Les tracasseries routières et les difficultés liées à la voie ferrée unique

Au niveau de la voie routière, les transporteurs des pays de l'hinterland sont exposés au racket lors des contrôles intempestifs institués par les forces de l'ordre, à des prélèvements illicites sur leurs marchandises, favorisant ainsi des faux frais de route.

Bien que le réseau routier ivoirien ait connu une amélioration significative ces dernières années, les camionneurs sahéliens soulignent que de manière périodique, ils perçoivent à certains endroits le mauvais état des routes. En ce qui concerne la voie ferroviaire, le délai des livraisons est retardé du fait de la seule ligne de rail depuis la gare ferroviaire de Treichville jusqu'à Kaya au Burkina-Faso. L'unicité de cette ligne ferroviaire ne permet pas de positionner plusieurs trains. Il faut attendre des jours pour pouvoir mettre en circulation d'autres trains. La figure 3 met en évidence la ligne ferroviaire d'Abidjan à Kaya.

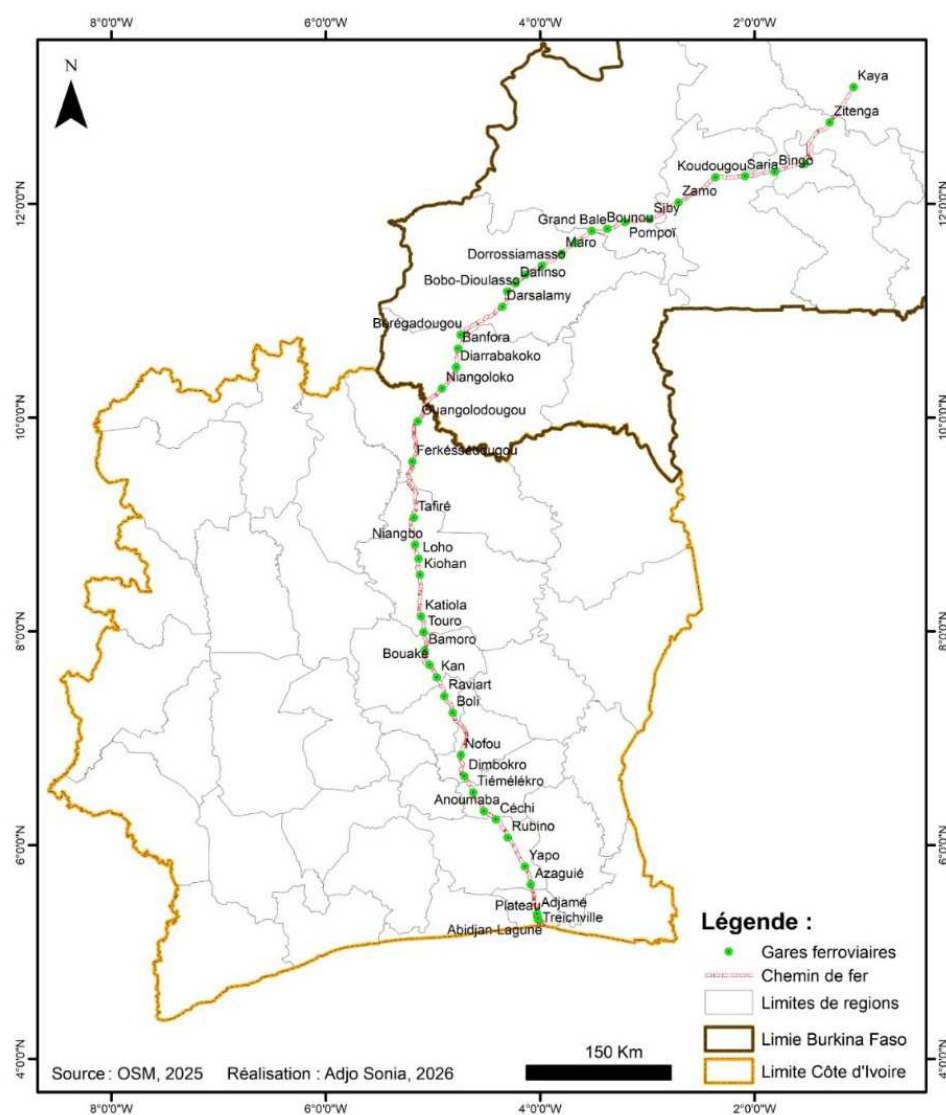


Figure 3. La ligne ferroviaire Abidjan-Kaya

La vétusté de la voie ferrée à des endroits et le mauvais état de certains wagons mettent en péril le délai de livraison des marchandises. La ligne ferroviaire est sensible aux aléas climatiques qui freinent le trafic. En 2020 et 2023, lors de la saison pluvieuse, certaines sections de l'axe ferroviaire qui relie Abidjan à Kaya ont été affectées par des inondations,

emportant des portions de remblais. À Abidjan, dans les communes de Vridi et de Treichville, la voie ferrée est encombrée par des déchets de tout genre, représentant des risques potentiels de déraillement et d'endommagement du matériel roulant. Ces faits compromettent la stabilité des rails, et mettent à mal l'image du transport ferroviaire. La photo 3 montre l'état d'insalubrité au niveau des rails à Vridi dans la commune de Port-Bouët (Vridi).



Photo 3. La voie ferroviaire envahie par les ordures dans le quartier de Vridi à Port-Bouët

(Cliché : Adjo S., 2025)

3. Perspectives de solutions pour l'amélioration du trafic des transporteurs sahéliens

3.1. Précautions adoptées par les transporteurs sahéliens pour l'amélioration du trafic de marchandises

Les transporteurs sahéliens devant des difficultés liées au transit de leurs marchandises, prennent des précautions pour acheminer celles-ci en bon état. Ils respectent les charges légales, roulent à vitesse moyenne réduisant ainsi les risques d'accidents. La Douane ivoirienne escorte les marchandises telles que le sucre, l'huile, les voitures d'occasion et le carburant. L'escorte

de la Douane vise à renforcer la sécurité du transport des biens sensibles, afin qu'ils atteignent leur destination finale sans détournement. Les transporteurs souscrivent aux assurances pour être à l'abri d'éventuels dommages au cours de l'acheminement des cargaisons.

3.2. Recommandations face aux difficultés du transport terrestre des marchandises

Afin de répondre aux attentes des transporteurs de l'hinterland, et de permettre au port d'Abidjan d'être plus compétitif, plusieurs actions doivent être menées au niveau des voies de desserte terrestre (voie routière et ferroviaire).

3.2.1. Au niveau routier

Concernant la voie routière, il serait judicieux de veiller à l'entretien de la voirie de sorte à prévenir les nids de poule à certains endroits. Il est question de réduire de la sorte les dommages aux camions en provenance ou à destination de l'hinterland. Les barrages et corridors illicites doivent être supprimer pour mettre fin à tous types de racket Il faut également dénoncer et sanctionner par des mesures strictes les faits de racket de certains agents des forces de l'ordre. La digitalisation de certains documents permettra de limiter ou de mettre fin aux interactions entre les transporteurs et les forces de l'ordre. Il faudrait aussi, mettre les transporteurs sahéliens dans des dispositions confortables en créant des aires de repos avec les commodités tels que : la connexion internet, la restauration, des toilettes, un lieu de prière etc. afin de lutter contre la fatigue, de réduire les risques d'accidents et de fluidifier le trafic.

3.2.2. Au niveau de la voie ferroviaire

Par rapport à la voie ferrée, il serait judicieux de créer d'autres lignes de desserte pour l'acheminement des marchandises des pays sans façade

maritime, pour plus d'efficacité dans les délais de livraison. L'extension de la voie ferroviaire vers le Niger permettrait au port d'Abidjan d'être la destination de choix des chargeurs et des transporteurs nigériens. Il conviendrait de renforcer les rails par des matériaux solides et résilients en cas d'intempéries. Le nombre de wagons pour le transport des marchandises doit être revu à la hausse pour plus de flexibilité dans les opérations. Il serait aussi opportun de réhabiliter entièrement si possible la ligne ferroviaire afin d'éviter des déraillements. La figure 3 met en évidence les processus de restructuration pour les activités qui peuvent être facilement externalisées à des fournisseurs concurrentiels, où les activités qui incorporent des compétences centrales ou rares pouvant être conservées et améliorées au sein du chemin de fer.

Discussion

Cette étude avait pour objectif, d'explorer les réalités des transporteurs (camionneurs, usagers du train) sahéliens au port d'Abidjan. Les résultats obtenus montrent les raisons du choix du port d'Abidjan par les transporteurs des pays de l'hinterland. Ces choix se traduisent par les infrastructures et équipements modernes, par le développement des voies terrestres et aussi les facteurs socioculturels existant. Pendant le transit de leurs marchandises, les transporteurs sahéliens sont confrontés à de multiples obstacles tels que : la lenteur des procédures administratives et douanières, les tracasseries routières et ferroviaires. Les résultats de cette recherche sont similaires avec les travaux d'Antoine Frémont (2018 : 9), il souligne que La reconquête de l'hinterland passe aussi par le développement des zones logistiques dans l'hinterland de proximité. Le Havre comme Marseille axent leurs efforts sur la recherche de foncier disponible et la possibilité de réduire les procédures environnementales, notamment en les anticipant, pour installer rapidement les entrepôts à partir du moment où le client est trouvé. L'axe Seine comme Marseille-Fos enregistrent depuis plusieurs années des succès importants en matière d'implantations logistiques. La Région Hauts de France cherche à tirer parti de sa localisation sur un des grands itinéraires de transit Nord-Sud de l'Europe pour attirer des implantations logistiques sur Dunkerque mais aussi Lille et Dourges.

Au-delà de la logistique, toute nouvelle implantation industrielle est une clé du développement portuaire tant les activités maritimes et économiques sont intimement liées dans des économies ouvertes. Dans la même veine, (Léandre Edgard NDJAMBOU et *al.* 2019 : 103) montrent que La stratégie de conquête d'un hinterland international pour les ports gabonais repose sur trois principaux axes. Premièrement, la confirmation de Port Gentil comme le cœur du dispositif portuaire national. Plusieurs raisons expliquent ce choix : les caractéristiques nautiques favorables ; l'ouverture imminente de la route devant désormais connecter la presqu'île Mandji au reste du territoire national ; les perspectives de réalisation de la zone franche et des projets connexes. Deuxièmement, la création d'une plateforme logistique à Booué, au centre du pays, destinée à mieux préparer les cargaisons à l'exportation ; l'objectif étant d'éviter l'engorgement des plateformes portuaires de Port Gentil et de Libreville-Owendo. Troisièmement, l'aménagement d'un port sec à Mekambo (nord-est) pour y accomplir les formalités nécessaires pour les marchandises en transit (dédouanement, groupage, dégroupage, contrôles divers.)

Pour LOWANI A., 2005, cité par Ousseiny SIGUE (2017 : 62), les pays sans littoral ont besoin des pays côtiers pour l'exportation des produits comme le coton, le karité, les fruits et légumes et pour l'importation des produits manufacturés. Par conséquent, le trafic de ces pays enclavés apparaît important et vital tant pour l'hinterland que pour les pays ayant une façade maritime. Selon (World Bank Group 2017 : 4) les chemins de fer sont idéaux pour transporter de grands volumes de marchandises en vrac ou de passagers. Les coûts du transport ferroviaire pour les matériaux en vrac sont généralement assez bas, typiquement moins de 0.03 USD par tonne-kilomètre ; le transport de passagers est également peu coûteux, typiquement moins de 0.10 USD par passager-kilomètre. Sur les réseaux relativement denses orientés vers le fret, le transport ferroviaire peut en moyenne coûter moins de 0.02 USD par TKM, et le transport ferroviaire de passagers peut coûter beaucoup moins de 0.10 USD par passager-kilomètre, suivant la manière dont les transports sont subventionnés et la densité de passagers.

Il ressort que le passage portuaire est une des difficultés rencontrées par les transporteurs routiers, (NIERAT Patrick 2021 : 5-6) présente les obstacles des transporteurs routiers opérant sur les conteneurs maritimes.

Le port affecte un ou deux reach stackers pour le (dé)chargement des camions. Ceci a des conséquences sur la durée des opérations dans le port. De plus, des temps d'attente peuvent se former lorsque les camions sont nombreux. Ceci impacte alors le travail du conducteur en dehors du terminal, son aptitude de travail et la possibilité d'effectuer sa mission dans la journée. Pour Olivier CASLIN (2017 : 10-11), depuis les indépendances en Afrique, nous assistons à une dégradation progressive du système ferroviaire, auquel est venu se substituer la route. Le transport routier s'est ainsi développé parce que le rail n'était pas performant et que son schéma d'exploitation n'était plus adapté aux attentes de la clientèle. La capacité des ports à desservir correctement les grands centres de consommation, mais également les zones intérieures enclavées est un élément important. Dans ce domaine, le rôle du secteur ferroviaire et routier sont essentiels.

Nos résultats ont montré que les transporteurs sahéliens opèrent leurs choix en fonctions de certains critères tels que : les infrastructures et équipements modernes, un excellent réseau routier et ferroviaire et aussi la sécurité et la sûreté au port d'Abidjan. Cependant ils y rencontrent certaines difficultés. Outre les points évoqués dans cette recherche, il serait important d'orienter la réflexion vers les facteurs socio-politiques qui pourraient être un critère de méfiance entre les États, qui pourraient créer une baisse du trafic des marchandises.

Conclusion

À terme, nous retenons que le Port d'Abidjan est indispensable pour les opérations d'importation et exportation des marchandises pour les pays de l'hinterland, permettant ainsi une augmentation non négligeable du trafic dudit port.

Cependant, force est de constater que les transporteurs sahéliens sont souvent confrontés à des difficultés au niveau de la voie routière et ferroviaire, qui impactent la compétitivité du port d'Abidjan. Les rackets, les barrages illicites, les acteurs intermédiaires informels et la lenteur dans l'émission des documents administratifs, génèrent des faux frais pour les transporteurs sahéliens et retardent la livraison de leurs

marchandises. Pour rester compétitif, le port d'Abidjan doit continuer d'investir dans le développement des infrastructures et superstructures, aussi des mesures de sécurité et de sûreté doivent être améliorées afin de fluidifier le trafic jusqu'à la destination finale.

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„DE-A ARHITECTURA” PROGRAM: AN INTERDISCIPLINARY EDUCATIONAL MODEL LINKING ARCHITECTURE, URBAN PLANNING, GEOGRAPHY AND ECOLOGY

Abstract. Introducing architecture into the school environment through dedicated educational projects plays a significant formative role, extending beyond strictly aesthetic and technical dimensions. The aim of this paper is to highlight how „De-a Arhitectura” project, as a model of good practice for developing critical thinking and responsibility toward the built environment, contributes to enriching the school curriculum, particularly in relation to disciplines such as geography, ecological education, and arts, through an interdisciplinary and applied approach. This educational project has been implemented in Romania since the 2011-2012 school year. This initiative involves the implementation of interactive educational projects carried out in schools throughout an entire school year, based on methods that have been tested and officially recognized as pedagogically valid. „De-a Arhitectura” project promotes education for the built environment through activities adapted to primary, lower, and upper secondary education. This project facilitates the progressive understanding of concepts related to space, form, function, scale and ecology, maintaining students' motivation for learning. In Romania, the introduction of this educational project in schools represents a strategic initiative, given that awareness in and education regarding the built environment and urban and rural spaces remain insufficiently developed within the general curriculum.

Keywords: interactive pedagogy, built environment education, project-based learning, creativity, interdisciplinarity, civic responsibility, recycling

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1. Introduction

The relationship between school space and educational process is supported by intrinsic motivation, an essential element that connects students, teachers, teaching methods, the curriculum, the school environment, and the community (Mihăilescu 2020: 2). In context of the future school, the accelerated integration of technology across all fields of knowledge generates profound transformations in learning content, the types of competencies required, and the diversification of information sources (Mihăilescu 2020). The increasing complexity of contemporary societies requires the redefinition of educational models in order to equip new generations with solid scientific and technological competencies (Glass et al. 2024; Martínez et al. 2024; Taha et al., 2021). This challenge involves adopting innovative methodologies, modern educational tools, and multidisciplinary teaching activities (Martínez et al. 2024), that encourage students' active engagement in the learning process and in the community (Glass et al. 2024).

In this context, active methodologies have emerged as an alternative to the traditional teaching model, in which the teacher is the main transmitter of knowledge, and the student has a passive role, merely as a receiver of information (Martínez et al. 2024). A relevant example is the STEAM educational model, which includes the arts as an integrating element and promotes interdisciplinary, creative, and innovative learning situations, contributing to the development of an integrated understanding of scientific, technical, and artistic disciplines (Yim et al. 2025), and enhancing knowledge acquisition and meaningful learning (Martínez et al. 2024).

The relationship between society, buildings, and cities highlights the role of architecture as an essential element that strengthens this connection. The city, the neighborhood, or the dwelling represents the physical framework of everyday activities – educational, recreational, or professional – and is composed of buildings with various styles and functions (Martínez et al. 2024). The living environment, to which some residents may feel attached, can be understood as a set of buildings with different architectural styles, depending on their utility (Martínez et al. 2024). Most often, architectural details become visible only in the context of transformations such as renovations, restorations, demolitions, or

the construction of new buildings). Typically, responsibility for such interventions is attributed to architects, while public reactions often manifest intuitive, expressed through simple appreciations or criticisms sometimes formulated subjectively (Martínez et al. 2024), without a deeper understanding of the principles underlying these changes.

Society should not only use the city, but also understand it, enjoy it, and participate responsibly in its development (Martínez et al. 2024). However, this responsibility is not learned intuitively and requires appropriate training. The transformation of the city is not exclusively the responsibility of specialists, but also of the residents (Arin 2014), who, however, are not always sufficiently informed or trained to evaluate, adapt, or propose solutions aimed at improving the quality of life (Martínez et al. 2024). Therefore, the lack of knowledge regarding the built and geographic environment justifies the need to educate young people about the basic concepts of architecture, urban planning, geography, and ecology. These fields provide essential knowledge for understanding the limits and potential of the sustainable development of the built environment.

Numerous studies highlight the importance of introducing architectural concepts as early as primary school (Acer 2016; Arin 2014; Martínez et al. 2024; Sulima 2020; Zamfir, Mihăilă 2018) through dedicated educational projects, emphasizing their formative role beyond purely aesthetic and technical dimensions. Architecture can be easily integrated into the school curriculum by linking it with disciplines such as the arts, mathematics, or technology (Acer 2016), as well as geography, history, civic education, and music (Havaşi 2020). Such an interdisciplinary approach enables children to perceive the world as an integrated whole (Acer 2016) and to understand the connections between different fields of knowledge.

The importance of including architecture projects in pre-university education, adapted to different levels of difficulty, derives from the need to align educational content with students' stage of cognitive development. Such a gradual approach facilitates the progressive understanding of concepts related to space, form, function, scale, and ecology, avoiding conceptual overload while maintaining students' motivation for learning. At the same time, this approach is necessary for society, given the relatively low level of social awareness regarding historic buildings (Martínez et al. 2024). In this regard, early education represents one of the most effective

ways to protect cultural heritage and cultural landscapes, while also promoting the principles of sustainable development (Sulima 2020; Achille and Fiorillo 2022).

Furthermore, through practical activities, education in architecture provides children with experiences that highlight the dynamics of space and the built environment (Acer 2016), while fostering innovation, creativity, design skills, and teamwork (Arin 2014; Martínez et al. 2024). As future adults, they will be involved in decision-making process that influence the configuration and evolution of the communities they belong (Acer 2016; Glass et al. 2024). At the same time, architecture projects, integrated within active pedagogical methodologies, contribute to preparing children to respond effectively to current and future challenges (Martínez et al. 2024).

In most countries in America and Europe, architects' associations or various independent organizations organize programs and workshops dedicated to architecture education for children and young people (Acer 2016).

The program "De-a Arhitectura. Education for Architecture and the Built Environment," initiated in the Romanian school system in 2011 by the De-a Arhitectura Association (Order of Architects of Romania 2021), celebrated 14 years of activity in the 2025-2026 school year. This period has been characterized by the implementation of interactive educational projects carried out in schools throughout an entire school year, based on methods that have been tested and officially recognized as pedagogically valid (Igloo 2024).

In Romania, the introduction of architectural educational projects in schools represents a strategic initiative, given that awareness of the built environment and education regarding urban and rural environment remain insufficiently developed within the general curriculum. Such initiatives contribute to the formation of a critical awareness of the quality of the built environment, of cultural heritage, and processes of territorial transformation.

The aim of the paper is to argue how the "De-a Arhitectura" program, as a model of good practice for developing critical thinking and responsibility toward the built environment, contributes to enriching the school curriculum, especially in relation to disciplines such as geography, environmental education, and the arts, through an interdisciplinary and applied approach.

2. Methodology

The present study is based on qualitative research, focused on a descriptive-analytical approach. Several research methods were used in developing the study: documentary analysis, a case study represented by 'De-a Arhitectura' project as a whole and several selected mini-projects/workshops, the method of analysis and synthesis applied to the relationship between the interactive educational project and the school curriculum, content analysis of some educational mini-projects, as well as participatory observation.

The documentary analysis involved the selection and processing of information from the specialized literature on architecture education applied in pre-university education, as well as the consultation of guides and teaching materials from „De-a Arhitectura” educational program and the national curriculum. Correlated with the method of analysis and synthesis, this stage aimed to identify the pedagogical foundations of the educational program selected as a case study, to examine its objectives and methodologies used, its usefulness in developing the targeted types of competencies, and its alignment with the competencies provided in the school curriculum.

„De-a Arhitectura” program was treated as an educational case study, analyzing its structure, the typology of activities, levels of difficulty, and the degree of disciplinary integration. The authors also conducted a content analysis of selected workshops, focusing on active learning strategies, targeted competencies, interdisciplinary connections (architecture-geography-ecology-arts), as well as the integration of real-world learning contexts.

Participatory observation also constituted a relevant method, being applied by the teacher and the volunteer architect involved in the implementation of the project.

3. Results

3.1. Presentation „De-a Arhitectura” program

"De-a Arhitectura" program is dedicated to students in primary, lower, and upper secondary education and consists of a series of courses and

activities complementary to the current school curriculum. The objective of the program is to provide students with a basic understanding of the built environment and fundamental concepts of architecture and urban planning, alongside the knowledge accumulated in school in other subjects (geography, history) (Order of Architects of Romania 2021). The program was initially funded as a cultural project in 2015 by the Order of Architects of Romania (OAR), and later it gained the status of a priority cultural project.

Over time, this initiative has produced visible results in the development of pupils' competencies and has achieved numerous successes in promoting architecture education.

Participation in the project activities supports students' understanding of the built environment which they live and carry out their daily activities through experiential and interdisciplinary learning. The approach integrates elements of technological education, mathematics, digital literacy, practical skills, local history and geography, and civic education. Students explore architecture and the built environment both from a citizen's perspective and from that of professionals such as architects, urban planners, or landscape designers, fostering critical awareness of citizens' responsibility toward the spaces in which they live (Order of Architects of Romania 2021).

The implementation of this educational program is carried out through a collaborative model that involves resource persons (volunteer architects) who work with teachers, forming mentoring teams (Igloo 2024). This interdisciplinary formula creates a complex educational framework, in which the professional expertise of architects is integrated into the pedagogical process, ensuring both conceptual rigor and practical relevance. The continuity of this initiative is due to the dedication and involvement of teachers who, step by step, guide pupils through a unique educational experience. By integrating architectural concepts into interdisciplinary teaching, professors provide children with new perspectives on the world (Igloo 2024).

The structure of the projects is adapted to the stages of cognitive development and to the competencies specific to each age group. The typology and level of difficulty of the projects are correlated with the level of understanding associated with each educational stage. In primary education, activities are correlated with elements of the school curriculum regarding environmental exploration and the development of observation

and spatial representation skills. Thus, for grades I and II (ages 6-9), the program “De-a Arhitectura mini” is carried out; for grades III and IV (ages 9-12), the program “De-a Arhitectura in My City” introduces children to issues related to the city and public space; while the educational program for lower and upper secondary education (ages 12-18), “My school Can Be Cool (De-a Arhitectura in My School)” stimulates critical reflection on the built space (De-a Arhitectura Association 2024; Sava et al. 2016).

3.2. Presentation of several workshop / projects' examples

The team, composed of a teacher and an architect, guides the students in observing and analyzing the built urban environment. The general competence targeted by the program for grades I and II focuses on identifying the interdependent relationship between the characteristics of inhabitants and the specifics features of the natural and built environments in which they live. Intuitively, children discover concepts related to architecture and urban planning while traveling alongside Little Griffy and Little Seed, two imaginary dragons through different countries: Land of Water People, Land of Little Animals, Land of Hardworking People and Land of Lazyfolk (fig. 1 a, b, c, d).

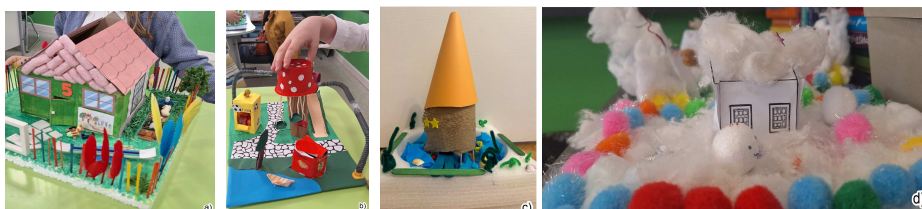


Figure 1. Fairy tale houses made by first grade students
(Source: Barbu A. E.)

As students progressively develop their crafting skills and acquire new knowledge about the geographical environment in the second grade, such as flat landforms (plains and deltas) or mountainous relief, they engage in the creating scale models representing types of dwellings adapted to different natural environments. In the case of the coastal

environment (Fig. 2a), students analyze particular characteristics such as the proximity to the sea, wind action, and high humidity, and reflect on how these factors influence the form, orientation, and materials used in construction. Architectural solutions adapted to climatic conditions are discussed, including appropriate roof designs, strategically oriented windows, the use of moisture-resistant materials, the presence of terraces, and houses raised on stilts.

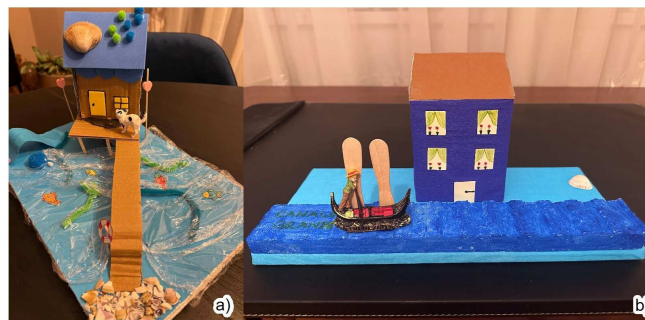


Figure 2. Typical houses from coastal (a) and lagoon (b) environments created by second-grade students
(Source: Barbu A. E., Merciu F. C.)

In the case of the lagoon environment (Fig. 2 b), students observe the relationship between buildings and the presence of water, their integration into the natural landscape (such as the canals within the city), and the types of transport adapted to the characteristics of the geographical setting. Through the creation of scale models, children do not merely reproduce architectural forms, but also understand how buildings adapt to the specific features of the geographical environment, becoming aware of the interdependence between natural factors and human intervention. This activity contributes to the development of spatial thinking, with housing perceived as the result of the interaction between nature and society.

In the third and fourth grades, students also take part in urban exploration activities (Fig. 3a), which allow them to discover the surrounding environment and experience it through multiple senses. Students receive a set of guiding questions designed to support their investigation of the built environment.



Figure 3. Urban environment exploration (a) and the creation of a scale model representing housing types within a historic urban fabric (b)
(Source: Barbu A. E.)

For example, during the first exploration activity, third-grade students were informed that they would explore the surroundings of the school in order to observe the relationship between the scale of the built environment and their own body scale. Working in teams, they searched the tallest and the smallest buildings in the area and measured the width of the street or the façade of a building using their own bodies. The list of guiding questions also included: How does my perception of the built environment change with distance? What materials did you observe? How do you think the natural environment looked in the past?

Students are then asked to apply the concepts learned in class by developing various individual creative projects in the form of scale models during workshop activities, analysing the data, photographs, and materials collected during the exploration. At the end of the school year, a collective project is carried out in teams (Fig. 4 a, b, c). The workshops are among the students' favorite activities, as they provide opportunities to practice crafting skills and develop new ideas in an environment where experimentation is encouraged and mistakes are not emphasized.

A simple exercise thus becomes a meaningful learning experience. A wide variety of materials are used, including paper, modeling clay, sticks, and packaging materials, demonstrating how, with little imagination, everyday objects can be creatively transformed into important elements of a project. Finally, students present their work to their classmates or as part of an exhibition (Fig. 4), particularly in the case of the collective project. In doing so, they overcome their fear of speaking and explain the reasoning behind their choices.



Figure 4. Scale models representing neighborhoods (a, b) and playgrounds (c) presented at „De-a Arhitectura” Exhibition organized at the „Ion Mincu” University of Architecture and Urbanism (Bucharest, June 2025)
(Source: Barbu A. E., Merciu C.)

3.3. Results of „De-a arhitectura” educational program

The learning outcomes are aligned with the key competencies outlined in the national education framework, but they also include knowledge, skills, and values that are not commonly addressed in other educational programs in Romania. These include understanding the relationship between the socio-cultural context and the built environment – bridging social sciences and natural sciences – as well as an integrated approach specific to education for sustainable development, which simultaneously considers environmental protection, heritage conservation, and social and economic development (Igloo 2024).

Throughout the implementation of the „De-a Arhitectura” program, 37,334 students from public schools, ranging from primary to high school level, have participated, with the support of 1,430 teachers and 1,300 volunteer architects (De-a Arhitectura Association, Activity Report, 2024). Initially implemented in major urban centers in Romania (Bucharest, Timișoara, Cluj-Napoca, Sibiu, Arad), the program was later extended to rural areas and, in recent years, has been implemented in 36 counties (Fig. 5).

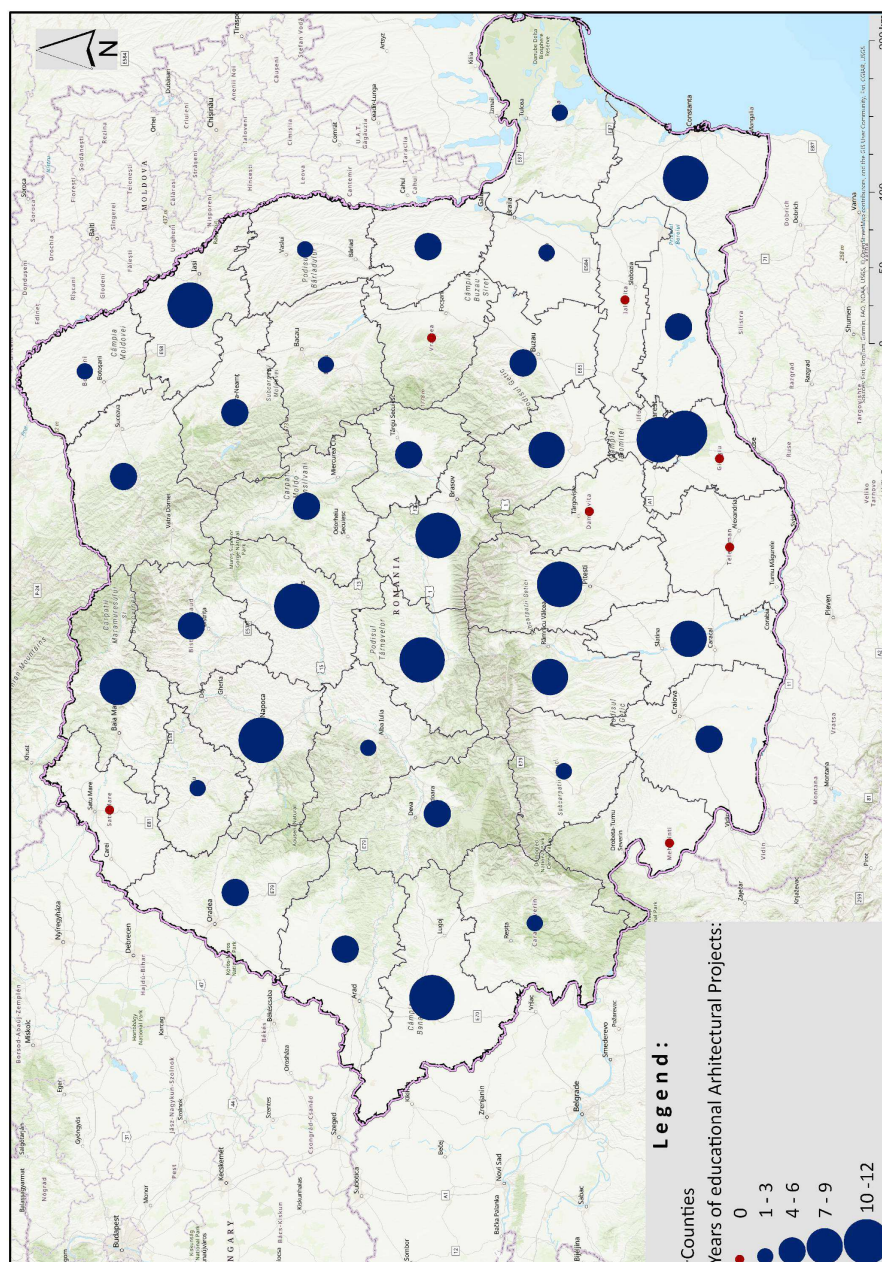


Figure 5. The territorial distribution of „De-a Arhitectura” project at the county level (2012–2024)

(Source: results obtained by the authors based on the processing of data presented by the „De-a arhitectura” Association, Activity Reports 2012-2024)

Education in architecture develops students' ability to analyze the built environment while fostering responsibility toward public space and cultural heritage. It enhances spatial perception and visual literacy and encourages students to understand communities as complex systems in which decisions about buildings, green spaces, and infrastructure affect quality of life. Such initiatives also strengthen civic awareness by promoting responsible planning, sustainability, and heritage protection. By extending learning beyond the classroom, these programs help younger generations develop a sense of belonging and a better understanding of the importance of integrating historic buildings and heritage areas into contemporary urban development. Moreover, the transition to geography concepts introduced in the fourth grade becomes significantly easier.

A defining feature of the program is its interdisciplinary character. The proposed activities integrate concepts related to architecture, urban planning, geography, and ecology, facilitating the understanding of the relationship between space, community, and the natural environment. Students are introduced, in an age-appropriate manner, to concepts such as spatial orientation, urban structure and functions, and the interaction between built and natural environments, while developing basic geographical competencies and early ecological awareness. The connection between visual arts and recycling in primary school activities increases children's environmental awareness (Mendizabal 2022) and encourages responsible attitudes toward resource consumption. The ecological dimension is further addressed through the use of recyclable materials, particularly reused paper and cardboard, in the creation of scale models. Through the proposed activities, students do not merely accumulate information but also assume active roles – as observers of space, novice designers, and analysts of their own city. This active engagement fosters the development of an early identity related to the field, which the literature describes as the initial stage in the formation of vocational identity (Niță et al. 2018). Although the direct impact on university choices was not measured in this study, participation in such programs may increase awareness of these fields and positively influence future educational and professional decisions.

5. Conclusions

This study highlights the relevance and coherence of „De-a Arhitectura” educational project within primary education, emphasizing its contribution to the development of observation skills, spatial representation, critical thinking, and responsibility toward the built environment.

Furthermore, this educational initiative may play a significant role in stimulating students’ vocational orientation by providing early exposure to professional fields related to the built environment, such as architecture, urban planning, and geography. By fostering spatial thinking, creativity, and the ability to analyze the relationship between the natural and built environments, students may discover interests and abilities relevant to these professional paths. In this sense, the program goes beyond a strictly disciplinary dimension and can be placed within the broader framework of career education, contributing to the early shaping of students’ educational interests and aspirations.

However, the findings of the study should be interpreted in light of certain methodological limitations. First, the research considered only a selection of projects implemented at the primary school level, without extending the analysis to programs designed for lower and upper secondary education. Second, the study did not include questionnaires or interviews with teachers and volunteer architects involved in the implementation of the educational project.

Future research will focus on extending the investigation to all educational levels included in the program and on integrating both quantitative and qualitative research methods (such as questionnaires and interviews). Such an approach would allow for a more comprehensive assessment of the program’s educational impact and its interdisciplinary character, including its influence on students’ educational orientation.

In conclusion, even within the limits of the present analysis, the „De-a Arhitectura” programs for primary education emerge as a relevant instrument for fostering a culture of the built environment. The educational program contributes to the development of essential transversal competencies necessary for shaping future active and responsible citizens, while promoting interdisciplinarity, ecological responsibility, and openness toward fields such as geography, architecture, and urban planning.

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**GOUVERNANCE URBAINE ET RECOMPOSITION SPATIALE
AU MAROC : ENJEUX DE COORDINATION
ET DE COHESION TERRITORIALE**

Résumé. Les transformations urbaines au Maroc, marquées par une urbanisation soutenue, une polarisation spatiale et une différenciation fonctionnelle, posent des enjeux croissants de gouvernance. Cet article analyse les relations entre gouvernance urbaine et organisation de l'espace, en mettant l'accent sur la coordination des acteurs et l'articulation des instruments de planification. La recherche adopte une approche qualitative fondée sur une grille multidimensionnelle (institutionnelle, multi-niveaux, intégrée, opérationnelle, participative, adaptative), inspirée de Healey (2007), Edelenbos et Boonstra (2023, 2025) et Kramer et al. (2024). Elle mobilise une analyse croisée des cadres juridiques, des documents de planification, des rapports institutionnels et des données statistiques, complétée par une illustration à partir de l'agglomération de Rabat. Les résultats montrent que, malgré la consolidation des dispositifs institutionnels, des écarts persistent entre planification stratégique et mise en œuvre, en raison de la fragmentation des instruments, de l'hétérogénéité des capacités territoriales et de logiques centralisées.

Mots-clés : gouvernance urbaine, planification urbaine, organisation spatiale, dynamiques territoriales, Maroc, coordination multi-niveaux, transformation urbaine

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Introduction

Les transformations urbaines contemporaines, portées par des dynamiques économiques, technologiques et environnementales, redéfinissent le rôle des villes et renforcent les enjeux de gouvernance. À l'échelle internationale, les grands pôles urbains concentrent populations, investissements et fonctions stratégiques, entraînant une recomposition des formes urbaines. La densification, l'extension périurbaine, la diversification des territoires traduisent une mutation structurelle des systèmes urbains, posant des enjeux renouvelés d'aménagement et de gouvernance.

Au niveau national, l'urbanisation traduit une transformation structurelle du système territorial marocain, passé d'un profil majoritairement rural (29 % d'urbains dans les années 1960) à une société largement urbanisée (62,8 % en 2024) (Haut-Commissariat au Plan, 1994–2024). Cette dynamique, combinée aux politiques d'aménagement et de développement économique, a engendré une recomposition spatiale marquée par la concentration des fonctions économiques et institutionnelles dans les principaux pôles urbains, renforçant les enjeux de gouvernance liés à la coordination des acteurs, à l'articulation des échelles et à la cohérence des politiques publiques.

Dans ce contexte, les transformations du système urbain marocain mettent en évidence le rôle central de la gouvernance urbaine dans l'orientation et la régulation des dynamiques territoriales. Celle-ci renvoie à la capacité des acteurs publics et privés à coordonner leurs actions, à articuler les différentes échelles d'intervention et à assurer la cohérence entre vision stratégique et mise en œuvre opérationnelle.

Toutefois, la gouvernance urbaine ne peut être appréhendée comme un processus linéaire. Dans la littérature, elle est analysée comme un système d'action caractérisé par la pluralité des référentiels, la coexistence de visions différenciées et la diversité des échelles d'intervention (Edelenbos & Boonstra, 2023 : 171–172). Ces éléments traduisent des relations complexes entre structures institutionnelles et capacités d'action des acteurs. Dans ce cadre, l'action urbaine se déploie dans un environnement marqué par l'imbrication de logiques et de temporalités multiples, complexifiant les processus de décision et de coordination.

Cette complexité prend une dimension particulière, dans le cas marocain. Malgré la consolidation du cadre institutionnel et le renforcement des

instruments de planification territoriale, la question demeure de savoir dans quelle mesure ces dispositifs assurent l'articulation des échelles de l'action publique et accompagnent la transformation spatiale urbaine ?

Dans cette perspective, le présent article analyse les mécanismes de gouvernance urbaine au Maroc, Afin d'en apprécier les mécanismes, les interactions et les limites, ainsi que la capacité du système territorial à assurer la cohérence entre vision stratégique, coordination multi-niveaux et mise en œuvre opérationnelle.

Ainsi on suppose que la cohérence des aménagements économiques, du développement territorial, ainsi que la convergence des outils de planification et la synergie entre les acteurs à multiniveau, constituent la quintessence de toute gouvernance urbaine susceptible d'accompagner les mutations que connaissent les espaces urbains marocains.

Sur le plan méthodologique, l'analyse repose sur une approche qualitative fondée sur une grille multidimensionnelle de la gouvernance urbaine (institutionnelle, multi-niveaux, intégrée, opérationnelle, participative et adaptative). Cette grille s'appuie sur les travaux de Patsy Healey (2007), Jurian Edelenbos et Beitske Boonstra (2023, 2025), ainsi que Johannes Kramer et al. (2024), mettant en évidence la dimension relationnelle et évolutive des processus de gouvernance. Elle permet d'appréhender la gouvernance urbaine comme un système d'interactions entre acteurs, instruments et échelles territoriales, et d'analyser son rôle dans la structuration de l'espace urbain.

L'analyse repose sur des sources documentaires et institutionnelles, incluant les cadres juridiques et réglementaires de la gouvernance territoriale au Maroc (Constitution de 2011, lois organiques, textes d'urbanisme) ainsi que les principaux documents de planification afin d'analyser l'articulation entre orientations stratégiques et dispositifs opérationnels. Elle est complétée par l'analyse de rapports d'organismes nationaux et internationaux et par une lecture croisée de données statistiques ainsi que par une illustration à travers l'agglomération de Rabat pour éclairer les mécanismes de coordination à l'échelle métropolitaine. L'article s'organise en deux parties : la première présente le cadre théorique, la seconde analyse le cas marocain à travers les dynamiques urbaines, les dispositifs institutionnels et les mécanismes de coordination territorial.

1. Cadre theorique : les piliers structurants de la gouvernance urbaine

Dans la littérature scientifique, la gouvernance urbaine est généralement définie comme l'ensemble des processus et mécanismes par lesquels les acteurs publics, privés et la société civile orientent et coordonnent le développement urbain, (Edelenbos et Boonstra 2025: 2). Elle renvoie à des formes d'action collective fondées sur l'interaction entre acteurs, caractérisées par des relations d'interdépendance et des processus collaboratifs (Healey 2007 : 13-14). Les travaux récents mettent en évidence plusieurs caractéristiques de cette gouvernance : une dimension démocratique et inclusive favorisant la participation ; une approche intégrée et orientée vers le long terme assurant la cohérence des politiques publiques ; une gouvernance multi-niveaux impliquant la coordination entre niveaux de gouvernement ; une dimension territoriale considérant les villes comme des systèmes complexes d'interactions ; ainsi qu'une capacité institutionnelle fondée sur la coopération et l'apprentissage collectif.(ONU-Habitat 2016: 28). La gouvernance urbaine peut ainsi être appréhendée comme un système d'interactions entre acteurs et institutions structuré autour de plusieurs dimensions analytiques, présentées dans le schéma ci-après :



Figure 1. Schéma conceptuel des piliers structurants de la gouvernance urbaine
(Source : Élaboration des auteurs à partir de ONU-Habitat (2016) et Kramer et al. (2024))

1.1. Le pilier institutionnel et organisationnel

Le pilier institutionnel et organisationnel constitue l'ossature de la gouvernance urbaine, en définissant le cadre de l'action publique territoriale et la

répartition des responsabilités entre les acteurs impliqués dans la gestion des villes. Des travaux récents (Kramer et al. 2024 : 5) mettent en évidence que l'efficacité des politiques urbaines dépend largement des configurations institutionnelles et des interactions entre les acteurs, notamment à travers les « constellations d'acteurs », qui renvoient aux relations, responsabilités et dynamiques d'interaction entre les parties prenantes dans les processus de gouvernance.

1.2. Le pilier opérationnel et technique

Le pilier opérationnel et technique constitue le socle pragmatique de la gouvernance urbaine, assurant la traduction des orientations stratégiques en instruments fondés sur l'information territoriale. Il mobilise notamment des outils tels que les systèmes d'information géographique, les bases de données, les plateformes numériques, les observatoires urbains et les dispositifs de suivi-évaluation.

À cet égard, les travaux d'ONU-Habitat soulignent que les observatoires urbains constituent des dispositifs de production et de mobilisation des connaissances à différentes échelles, contribuant à l'analyse des dynamiques urbaines et à l'élaboration de politiques publiques adaptées (ONU-Habitat 2021 : 22).

1.3. Le pilier participatif et inclusif

Le pilier participatif et inclusif constitue le fondement démocratique de la gouvernance urbaine, en reposant sur l'implication des citoyens et des parties prenantes dans l'élaboration, la mise en œuvre et l'évaluation des politiques urbaines. Il vise à dépasser les consultations ponctuelles pour instaurer des processus durables de concertation et de co-construction entre autorités publiques, société civile et communautés locales. Les travaux d'ONU-Habitat soulignent que la participation citoyenne ne produit des effets réels que lorsqu'elle influence effectivement les processus de décision, et non lorsqu'elle se limite à des formes symboliques ou consultatives. Dans cette perspective, la gouvernance urbaine est appelée à devenir plus

transparente et participative afin de renforcer la confiance entre autorités publiques et citoyens et de consolider le contrat social dans les villes (ONU-Habitat 2022 : 259).

1.4. Le pilier adaptatif et innovant

Le pilier adaptatif et innovant traduit la capacité de la gouvernance urbaine à s'ajuster aux transformations économiques, sociales et environnementales, ainsi qu'aux incertitudes. Il repose sur l'intégration du numérique, de l'innovation sociale et des mécanismes de résilience, afin de renforcer la réactivité de l'action publique et de promouvoir des modes de gouvernance flexibles. Il met aussi l'accent sur l'anticipation des crises, la mobilisation de réponses adaptées et l'expérimentation de nouvelles approches.

Les travaux d'ONU-Habitat soulignent que des villes durables et résilientes reposent sur des systèmes de gouvernance intégrant planification, coordination multi-niveaux et participation citoyenne (ONU-Habitat 2020 : 169).

1.5. Le pilier de la coordination multi-niveaux des échelles territoriales

Le pilier de la coordination multi-niveaux constitue un élément structurant de la gouvernance urbaine. Il renvoie à un système d'interactions visant à assurer la cohérence des politiques publiques, la continuité de l'action territoriale et l'effectivité des instruments à différentes échelles. Il repose sur des mécanismes verticaux, assurant l'adaptation des orientations nationales aux niveaux régional et local, et horizontaux, favorisant la coopération entre acteurs d'un même niveau.

Cette double articulation vise à renforcer l'intégration des politiques urbaines et la cohérence des projets territoriaux. À cet égard, la littérature récente souligne que l'efficacité de l'action publique dépend largement de la capacité des systèmes de gouvernance à établir des passerelles entre les différents groupes d'acteurs reliant connaissances, intérêts et ressources dans la conduite des transformations urbaines (Kramer et al. 2024 : 9).

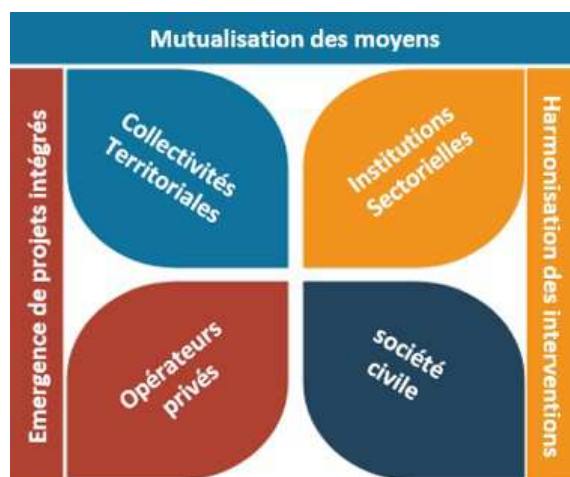


Figure 2. Articulation des acteurs dans la coordination multi-niveaux de la gouvernance urbaine
(Source : Élaboration des auteurs)

1.6. Le pilier de la planification intégrée

La planification intégrée constitue un levier central de la gouvernance urbaine, en visant à dépasser les approches sectorielles fragmentées au profit de stratégies territoriales globales articulant développement économique, aménagement de l'espace, mobilité, logement, environnement et inclusion sociale. Elle repose sur une approche systémique de l'action publique visant à assurer la cohérence entre orientations stratégiques nationales et leur déclinaison opérationnelle à l'échelle des territoires, tout en permettant l'adaptation des politiques publiques aux spécificités locales. Elle implique une interaction étroite entre l'État, les collectivités territoriales et les acteurs institutionnels et socio-économiques participant à la production de la ville, afin de favoriser la convergence des politiques sectorielles et l'articulation des instruments de planification.

Dès lors, la littérature souligne que la planification territoriale a évolué d'un outil d'aménagement vers un instrument stratégique de gouvernance, notamment depuis les années 1980 en Europe dans un contexte de métropolisation et de renforcement des coopérations institutionnelles entre acteurs territoriaux (OCDE 2015 : 195-196).

2. La gouvernance urbaine au Maroc : dynamiques institutionnelles et coordination territoriale

La gouvernance urbaine au Maroc s'inscrit dans un processus de transformations progressives, marquées par une recomposition des cadres institutionnels, des modes de planification et des rapports entre niveaux de décision. Les dynamiques urbaines et les réformes territoriales engagées au cours des dernières décennies ont conduit à une redéfinition du rôle de l'État, des collectivités territoriales et des acteurs publics dans la conduite de l'action urbaine. Ce contexte se caractérise par la recherche d'un équilibre entre centralisation stratégique et territorialisation des politiques publiques, dans un cadre institutionnel en consolidation.

2.2. Dynamiques urbaines au Maroc : grandes tendances, recompositions et interactions urbaines

Les dynamiques urbaines contemporaines au Maroc s'inscrivent dans un processus de recomposition spatiale marqué par des logiques différenciées de concentration, de diffusion et d'organisation du réseau urbain. L'urbanisation ne se déploie pas de manière homogène à l'échelle du territoire national, mais s'organise selon des gradients spatiaux qui traduisent des niveaux différenciés d'attractivité, d'accessibilité et d'intégration territoriale entre les villes.

La carte met en évidence une forte corrélation entre la taille des agglomérations et leur proximité au littoral, où se concentrent les principales villes et fonctions économiques. À l'inverse, l'intérieur du pays se caractérise par un réseau urbain plus dispersé et dominé par des villes de taille intermédiaire ou petite. Cette organisation traduit une structuration hiérarchisée du système urbain marocain, dont l'évolution récente est analysée à travers la répartition de la population urbaine entre 2014 et 2024.

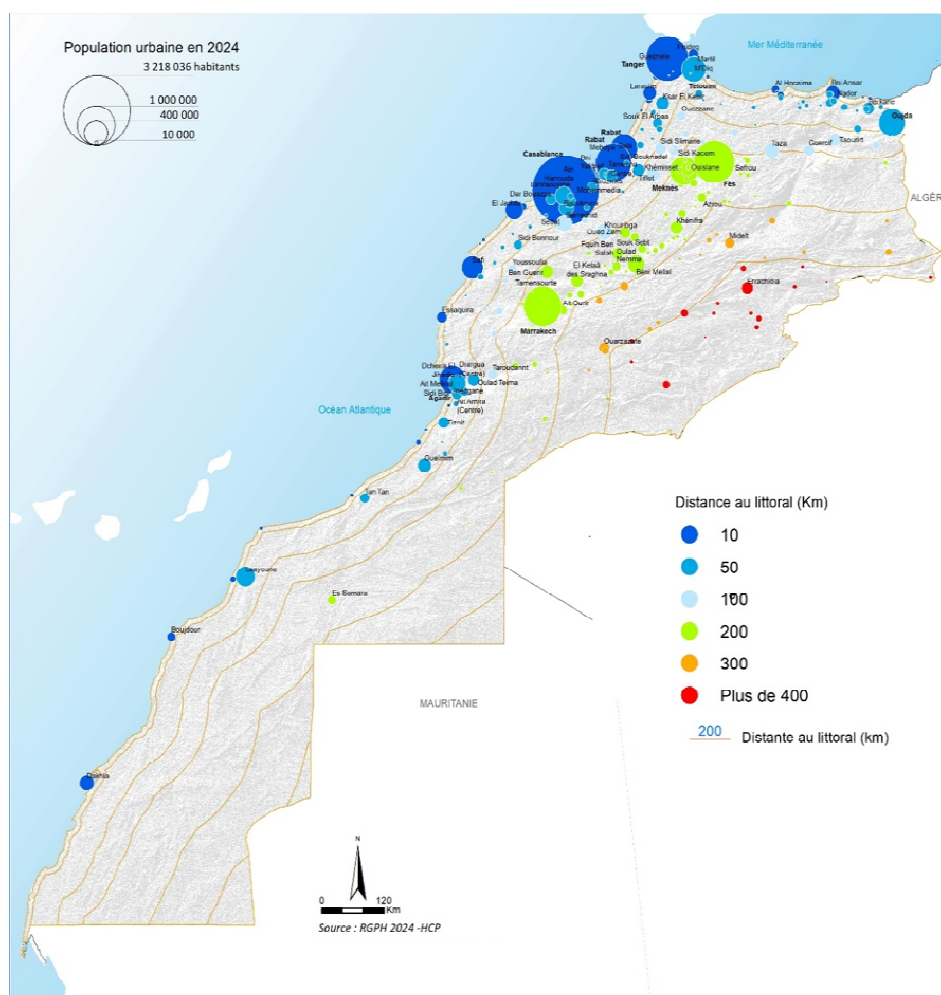


Figure 3. Distribution spatiale des villes marocaines selon leur taille démographique et leur distance au littoral (2024)

(Source : Direction de l'Aménagement du Territoire (DAT),
à partir des données du Haut-Commissariat au Plan (RGPH 2024))

Le graphique met en évidence une évolution différenciée de la population urbaine selon les catégories de villes entre 2014 et 2024, confirmant les logiques de concentration hiérarchique observées dans l'organisation du système urbain. La croissance urbaine bénéficie principalement aux grandes villes et métropoles, dont la population est passée de 8 337 350 en 2014 à 10 187 150 habitants en 2024. Les villes intermédiaires enregistrent

également une progression notable, tandis que les petites villes connaissent une évolution limitée, avec une population globalement stable autour de 4 millions d’habitants ce qui traduit un renforcement du poids démographique des principaux pôles urbains dans l’armature nationale, en lien avec leur rôle structurant dans l’organisation des activités économiques, la concentration des emplois qualifiés et la présence d’équipements majeurs.

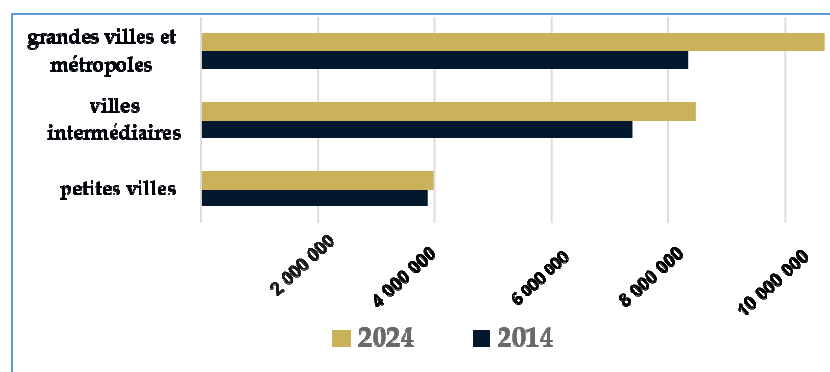


Figure 4. Évolution de la population urbaine par catégorie de villes au Maroc (2014–2024)
(Source : Élaboration des auteurs à partir des données du Haut-Commissariat au Plan (RGPH 2014 et 2024))

2.2. Gouvernance urbaine au Maroc : acteurs, instruments et coordination multi-niveaux de l'action territoriale

L'analyse de la gouvernance urbaine au Maroc peut être appréhendée à travers plusieurs piliers structurants, permettant de mettre en évidence les modalités d'organisation, de coordination et d'opérationnalisation de l'action urbaine dans le contexte national. Elle s'inscrit dans un système caractérisé par l'intervention d'un ensemble diversifié d'acteurs publics, associant à la fois les structures étatiques centrales et les collectivités territoriales, ainsi que des opérateurs parapublics et privés. Cette pluralité d'acteurs interroge le pilotage effectif de la planification urbaine et met en lumière des dynamiques ambivalentes, marquées par une volonté de renforcement de la décentralisation et des prérogatives locales, tout en demeurant, dans la pratique, largement influencées par le rôle structurant de l'État central.

*2.2.1. Pilier institutionnel et organisationnel :
recomposition de la gouvernance territoriale*

L'évolution du cadre institutionnel marocain traduit une transformation progressive de l'organisation de l'action publique territoriale. Les réformes ont redéfini les relations entre l'État, les régions et les collectivités territoriales, tout en renforçant les instruments de planification. Cette dynamique s'inscrit dans une gouvernance de plus en plus structurée autour de la coordination multi-niveaux, où la territorialisation des politiques publiques devient un levier central.

Cette structuration repose sur un ensemble hiérarchisé de textes juridiques encadrant les mécanismes institutionnels de la gouvernance territoriale. Si la notion de « gouvernance urbaine » n'y est pas toujours explicitement formulée, ses principes fondamentaux, notamment la convergence de l'action publique, la coordination entre acteurs, ainsi que la participation citoyenne, y sont progressivement intégrés. La Constitution de 2011 consacre la planification territoriale et confère aux SRAT un fondement constitutionnel. Ce cadre est complété par les lois organiques relatives aux collectivités territoriales qui précisent la répartition des compétences et les mécanismes de gouvernance, ainsi que par la loi n°12-90 sur l'urbanisme instituant les instruments de planification (SDAU et PA). La régionalisation avancée consacrée par la Constitution de 2011 (art. 136) constitue un levier central, renforçant le rôle des collectivités territoriales et favorisant une gouvernance urbaine davantage articulée entre les échelles de décision.

2.2.2. Pilier de coordination multiniveau : organisation et articulation des acteurs

La gouvernance urbaine au Maroc repose sur l'interaction d'une pluralité d'acteurs institutionnels impliqués dans la planification, la production et la gestion de l'espace urbain. Elle associe l'État central, les collectivités territoriales, les établissements publics et agences nationales, ainsi que les acteurs privés et la société civile, traduisant une organisation multiniveau de l'action urbaine. Toutefois, la superposition des instruments de planification, la coexistence de cadres sectoriels distincts et la multiplicité des échelles d'intervention peuvent générer des zones d'intersection institutionnelle.

Dans ce contexte, l'enjeu central réside dans la capacité des dispositifs de gouvernance à assurer une coordination effective garantissant la cohérence des politiques urbaines ce qui conduit à appréhender cette organisation à travers les trois catégories d'acteurs : publics, parapublics et privés/associatifs.

- **Les acteurs publics : articulation entre pilotage étatique et territorialisation des politiques urbaines**

Les acteurs publics constituent le socle de la gouvernance urbaine au Maroc. L'État central conserve un rôle déterminant dans la définition des orientations stratégiques, tandis que les collectivités territoriales voient leurs compétences renforcées depuis la Constitution de 2011, qui consacre la régionalisation avancée (Titre IX, articles 135 à 146) et la libre administration, tout en organisant la répartition des compétences entre niveaux de gouvernance. Dans cette configuration, l'État agit comme stratège et régulateur, assurant la cohérence des politiques publiques, tandis que les collectivités contribuent à leur territorialisation. Cette organisation traduit une co-gestion de l'espace urbain entre niveau central et niveaux territoriaux.

- **Les acteurs parapublics : instruments opérationnels de l'action publique urbaine**

Les établissements publics et agences nationales constituent un maillon essentiel de la mise en œuvre des politiques urbaines. Dotés d'une autonomie administrative et financière, ils assurent la conception et la réalisation d'infrastructures structurantes. L'Office National des Chemins de Fer (ONCF) pilote le développement du réseau ferroviaire et de la ligne à grande vitesse Tanger-Kénitra, inaugurée en 2018, tandis que la société Autoroutes du Maroc (ADM) gère plus de 1 800 km d'autoroutes, renforçant la connectivité nationale.

Dans le domaine de l'habitat, le groupe Al Omrane joue un rôle central dans la production de logements et la mise en œuvre des programmes urbains. À fin décembre 2024, ses programmes totalisent 54 956 logements

mis en chantier et 46 922 achevés, dont 34 130 et 27 718 en maîtrise d'ouvrage propre, le reste étant réalisé en partenariat avec le secteur privé (Groupe Al Omrane 2024 : 12). Par ailleurs, l'Agence Marocaine de Développement de la Logistique (AMDL) contribue à la structuration des plateformes logistiques via un réseau national intégré couvrant environ 3 300 hectares à long terme, dans le cadre de la stratégie nationale de compétitivité logistique (AMDL 2023 : 6).

- **Les acteurs privés et la société civile :**
diversification des acteurs et recomposition de l'action urbaine

Les acteurs privés occupent une place croissante dans la production de l'espace urbain et les dynamiques économiques locales. Les promoteurs immobiliers contribuent à l'élargissement de l'offre résidentielle, comme l'illustre le groupe Addoha, dont la production a atteint 10 376 unités en 2024, contre 7281 en 2023 et 2303 en 2022 (Groupe Addoha, 2024, p. 7), confirmant le rôle croissant du secteur privé.

Les opérateurs de transport, tels qu'ALSA Maroc, exploitent des réseaux urbains dans plusieurs agglomérations et assurent la mobilité quotidienne. Par ailleurs, l'implantation d'industries structurantes, notamment les complexes automobiles de Renault à Tanger et Casablanca, contribue à la création d'emplois et génère des dynamiques urbaines induites, en matière d'urbanisation, de logement et de services.

Cette montée en puissance du secteur privé s'inscrit dans une évolution plus large des modes d'intervention publique, marquée par des logiques de néolibéralisation engagées depuis les années 1980, notamment à travers les effets du Programme d'Ajustement Structurel (PAS). Celui-ci a contribué à redéfinir le rôle de l'État, favorisant un repositionnement progressif vers des fonctions de régulation et ouvrant davantage le champ de la production urbaine aux acteurs privés. Cette recomposition traduit ainsi un glissement vers des formes d'action publique plus partenariales, où le secteur privé devient un acteur central du développement urbain, tout en soulevant des enjeux en matière de régulation, d'équité territoriale et d'accès aux services urbains.

Illustration territoriale :**L'architecture institutionnelle de l'agglomération de Rabat**

À Rabat, l'architecture institutionnelle de la gouvernance urbaine s'appuie sur un ensemble d'acteurs exerçant des compétences complémentaires, en l'absence d'une instance métropolitaine unifiée. Dans ce cadre, l'Établissement de Coopération Intercommunale (ECI Al Assima) assure la gestion de fonctions intercommunales telles que le transport urbain ou la gestion de la décharge, conformément à l'article 134 de la loi organique n°113-14. Son cadre institutionnel est précisé à l'article 133, qui dispose que «il peut être constitué entre des communes liées territorialement, à leur initiative, des établissements de coopération intercommunale dotés de la personnalité morale et de l'autonomie financière », et que « la création de ces établissements de coopération ou l'adhésion d'une commune audit établissement est déclarée par arrêté de l'autorité gouvernementale chargée de l'intérieur ».

La mise en œuvre opérationnelle des politiques urbaines repose par ailleurs sur une constellation de Sociétés de Développement Local (SDL) créées en application de la loi organique n°113-14, notamment son article 130 relatif à la création des sociétés de développement. Sous la coordination de la Wilaya, ces entités jouent un rôle structurant : Rabat Région Aménagement, dédiée à la conduite des projets urbains et à la maîtrise d'ouvrage déléguée ; Rabat Région Mobilité, chargée de la planification et de la gestion de la mobilité ; et Rabat Culture, responsable des programmes culturels et patrimoniaux. Ce dispositif contribue à structurer l'action publique locale, à assurer la mise en œuvre des projets et à accompagner les transformations urbaines et métropolitaines engagées dans la région de Rabat-Salé-Kénitra.

*2.2.3. Pilier de la planification intégrée :
articulation des instruments de planification*

Le pilier de la planification intégrée repose sur l'articulation des instruments de planification territoriale encadrant le développement urbain. Au Maroc, cette articulation s'inscrit dans une logique de gouvernance multi-niveaux, où les orientations stratégiques nationales se déclinent aux niveaux régional, provincial et communal afin d'assurer la cohérence de l'action publique territoriale.

Toutefois, cette coordination se heurte souvent à des difficultés de synchronisation entre les cycles de planification et les conditions de mise en œuvre des projets urbains. Les documents stratégiques s'inscrivent dans des temporalités longues, tandis que les dynamiques foncières, financières et institutionnelles évoluent à des rythmes plus rapides, générant des écarts entre programmation et réalisation.

Dans ce contexte, le renforcement de la planification intégrée suppose une meilleure articulation entre conception stratégique, programmation financière et capacités opérationnelles des acteurs publics.

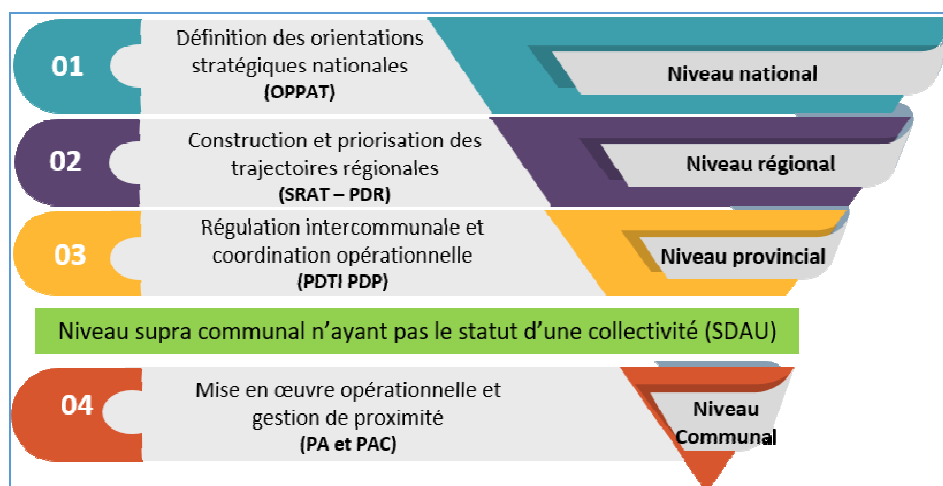


Figure 5. Articulation multi-niveaux des instruments de planification territoriale au Maroc
(Source : Élaboration des auteurs)

À l'échelle nationale, les Orientations de la Politique Publique d'Aménagement du Territoire (OPPAT) constituent le cadre stratégique de l'action territoriale de l'État. Elles définissent les orientations du développement territorial, assurent la cohérence des politiques publiques et orientent les documents régionaux de planification. À ce titre, l'article 88 de la loi organique n°111-14 prévoit que le Schéma Régional d'Aménagement du Territoire (SRAT) soit élaboré conformément aux orientations nationales.

À l'échelle régionale, le SRAT constitue l'outil stratégique majeur de planification territoriale. Institué par la loi organique n°111-14, il traduit la mission de planification confiée aux conseils régionaux dans le cadre de la régionalisation avancée. Conformément à l'article 89, il assure l'articulation entre orientations nationales et instruments infra-régionaux, favorisant la convergence des politiques sectorielles et la cohérence des projets territoriaux.

2.2.4. Pilier opérationnel et technique : instruments de mise en œuvre et capacités opérationnelles

Si les SRAT définissent les orientations du développement territorial, leur effectivité dépend de leur traduction en dispositifs opérationnels. Le pilier opérationnel et technique regroupe les outils de mise en œuvre, notamment la planification des investissements, la coordination des projets et la régulation de l'urbanisation, du niveau régional au communal. Toutefois, leur efficacité dépend autant des capacités territoriales que de leur architecture institutionnelle. Dans ce contexte, la gouvernance territoriale marocaine se caractérise par une hétérogénéité des capacités techniques, organisationnelles et financières entre collectivités territoriales, influençant leurs modalités d'intervention en matière de planification et de programmation. Les analyses de l'OCDE indiquent, à cet égard, que les collectivités territoriales marocaines disposent encore de marges budgétaires limitées : en 2020, leurs dépenses représentaient environ 12 % des dépenses publiques totales et 3,6 % du PIB, contre près de 17 % du PIB en moyenne dans les pays de l'OCDE (OCDE, 2025 : 13).

- **Le Plan de Développement Régional (PDR)** constitue l'instrument de programmation opérationnelle du développement territorial adopté par le conseil régional. Institué par la loi organique n°111-14 (art. 83 à 87), il est élaboré au début du mandat selon une démarche participative, en coordination avec le wali, pour une durée de six ans, et définit les actions prioritaires en cohérence avec le Schéma Régional d'Aménagement du Territoire (SRAT). Par son caractère contractuel, il favorise la convergence des financements publics et renforce le rôle des régions dans le développement territorial intégré.
- **Le Projet de Développement Territorial Intégré (PDTI)** constitue un nouveau levier de coordination intercommunale et de développement intégré. Il s'inscrit dans l'évolution vers des modes d'intervention plus territorialisés, conformément aux Hautes Orientations Royales appelant à « amorcer un véritable sursaut dans la mise à niveau globale des espaces territoriaux et dans le rattrapage des disparités sociales et spatiales » et à dépasser « les canevas classiques du développement social » (Discours de Sa Majesté le Roi Mohammed VI, Fête du Trône, Tétouan,

29 juillet 2025). Le PDTI vise ainsi à coordonner l'action publique à l'échelle de territoires fonctionnels à partir d'une vision commune de développement et d'une priorisation concertée des projets structurants.

- **Le Programme de Développement de la Préfecture ou de la Province (PDP)**, prévu par la loi organique n°112-14 (art. 80), est élaboré pour six ans sur la base d'un diagnostic territorial. Il vise à coordonner les interventions publiques et à assurer la complémentarité entre actions provinciales et communales, contribuant à la cohérence territoriale et à la territorialisation des politiques publiques.
- **Le Schéma Directeur d'Aménagement Urbain (SDAU)** est un instrument de planification urbaine prévu par la loi n°12-90 (art. 3). Document-cadre de long terme, il organise la coordination des acteurs, oriente l'urbanisation et assure la cohérence entre interventions publiques et initiatives privées. Les plans d'aménagement et de zonage doivent s'y conformer, ce qui en fait un levier central de régulation territoriale.
- Le **Plan d'Aménagement (PA)**, prévu par la loi n°12-90 (art. 19), est l'instrument réglementaire de planification urbaine à l'échelle communale. Il assure la traduction spatiale des orientations du SDAU et fixe les règles d'utilisation du sol opposables aux acteurs publics et privés. Il détermine notamment l'affectation des zones, la localisation des équipements, les emprises viaires et les conditions de constructibilité. Par son caractère réglementaire, il encadre l'urbanisation et sert de référence pour la délivrance des autorisations. Il contribue ainsi à la régulation et à la gouvernance urbaine à l'échelle communale.
- Le **Plan d'Action Communal (PAC)**, institué par la loi organique n°113-14 (art. 78), est l'instrument de planification stratégique et de programmation à l'échelle communale. Élaboré pour six ans sur la base d'un diagnostic participatif, il définit les priorités de développement et assure la cohérence avec les orientations des instruments supérieurs. Il permet de prioriser les investissements, de mobiliser les ressources et de coordonner les acteurs. Complémentaire du Plan d'Aménagement, il constitue le cadre opérationnel des politiques locales de développement.

*2.2.5. Le pilier adaptatif et innovant : observation territoriale
et gouvernance fondée sur les données*

Dans le contexte marocain, l'amorce récente du développement de dispositifs d'observation territoriale fondés sur la production d'indicateurs multidimensionnels contribue au renforcement des capacités d'analyse et d'anticipation des dynamiques urbaines. Dans cette dynamique, les travaux menés par l'OCDE ont abouti à l'élaboration d'un système composé de 28 indicateurs territoriaux structurés autour de cinq thématiques et mobilisés dans six régions pilotes, visant à améliorer la compréhension des transformations économiques, sociales et environnementales des territoires et à appuyer la prise de décision publique (OCDE, 2025 : 17-18).

Ces travaux mettent également en évidence plusieurs leviers d'évolution dans les pratiques de gouvernance territoriale et urbaine, **qui éclairent les enjeux de structuration des dispositifs d'observation territoriale dans le contexte marocain**. Ils soulignent notamment la nécessité de développer de nouveaux indicateurs afin de combler certaines lacunes de données dans des domaines tels que l'accès aux espaces verts, aux transports publics ou aux ressources en eau. Ils mettent également l'accent sur la modernisation des systèmes statistiques, l'intégration des registres administratifs et de sources de données innovantes, ainsi que sur le renforcement de la coordination entre ministères et niveaux de gouvernement dans la production et l'utilisation des données territoriales (OCDE, 2025 : 54)

*2.2.6. Le pilier participatif et inclusif : institutionnalisation et limites
de la participation citoyenne*

Le pilier participatif et inclusif renvoie à la capacité des systèmes de gouvernance urbaine à intégrer les citoyens, les associations et les acteurs sociaux dans les processus d'élaboration, de mise en œuvre et d'évaluation des politiques publiques territoriales. Au Maroc, cette orientation a été consacrée par la Constitution de 2011, qui érige la démocratie citoyenne et participative parmi les fondements du régime politique et institue plusieurs mécanismes de participation tels que les pétitions, les motions législatives et les dispositifs de consultation et de

concertation publiques (Article 1er de la Constitution). Au niveau territorial, les lois organiques relatives aux collectivités territoriales adoptées en 2015 ont également introduit l'obligation de recourir à des démarches participatives dans l'élaboration des programmes de développement régionaux, préfectoraux et communaux. Toutefois, malgré ces avancées institutionnelles, l'effectivité de ces mécanismes demeure limitée. Le Conseil économique, social et environnemental souligne ainsi que la mise en œuvre de la participation citoyenne reste entravée par l'absence à l'échelle nationale d'un cadre juridique spécifique régissant les modalités de consultation et de concertation publiques (CESE, 2024, p. 13). De plus, l'absence d'un cadre juridique précis et contraignant définissant les suites à donner aux pétitions et motions acceptées limite l'impact réel des consultations publiques, ce qui peut affaiblir la confiance des citoyens et freiner l'émergence d'une culture de participation active dans la gouvernance territoriale (CESE, 2024, p.14).

Conclusion

L'analyse de la gouvernance urbaine au Maroc met en évidence une évolution progressive vers un modèle territorial fondé sur l'intégration des échelles d'intervention, la diversification des acteurs et la structuration d'instruments de planification complémentaires. L'architecture institutionnelle issue de la régionalisation avancée, combinée à la consolidation progressive des dispositifs de planification stratégique et opérationnelle, traduit une volonté d'inscrire le développement urbain dans une logique plus cohérente, territorialisée et durable.

Toutefois, cette transformation ne relève pas uniquement d'un renouvellement des cadres juridiques ou des outils de planification. Elle renvoie avant tout à la capacité du système territorial à assurer une articulation effective entre vision stratégique, programmation financière et mise en œuvre opérationnelle. Les écarts observés entre planification et exécution prennent des formes variées, notamment des décalages temporels entre programmation et réalisation, une articulation limitée entre instruments stratégiques et opérationnels, ainsi qu'une mise en œuvre différenciée selon les territoires. Ces écarts s'expliquent par la fragmentation des instruments de planification, l'hétérogénéité des

capacités institutionnelles, techniques et financières des collectivités territoriales, ainsi que la persistance de logiques centralisées dans la prise de décision. Ils traduisent ainsi moins des dysfonctionnements isolés qu'une phase de transition vers une gouvernance multi-niveaux encore en consolidation.

Dans ce contexte, l'enjeu central de la gouvernance urbaine marocaine réside désormais dans le passage d'une logique de juxtaposition des interventions à une véritable synchronisation des politiques publiques territoriales. La consolidation d'une gouvernance multi-niveaux effective suppose, au-delà des réformes engagées, le renforcement des mécanismes de coordination verticale et horizontale, la clarification des responsabilités entre acteurs et le développement des capacités territoriales. La cohérence de l'action urbaine dépend ainsi de la capacité à articuler les instruments existants autour de projets territoriaux partagés, capables d'intégrer les dynamiques métropolitaines, les exigences d'équité spatiale et les impératifs de compétitivité territoriale.

À l'heure où les villes concentrent l'essentiel des dynamiques démographiques, économiques et environnementales, la gouvernance urbaine apparaît comme un levier déterminant de transformation territoriale. Son renforcement suppose moins la multiplication des instruments que leur mise en convergence effective, afin de faire du territoire non seulement un espace d'aménagement, mais un véritable cadre de production du développement intégré et inclusif.

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EVOLVING ASPECTS OF TOURISM DEVELOPMENT STRATEGIES: A PLANNING VISION FOR ORADEA MUNICIPALITY (ROMANIA)

Abstract. Tourism represents a strategic sector for the economic development of major urban centres in Romania, which compete to attract both domestic and international visitors while strengthening their regional image as successful tourist destinations. This paper represents a second part of a more comprehensive study and analyses the evolution of tourism development strategies in the context of contemporary strategic planning goals, using a comparative perspective on the strategic documents regarding tourism development for Oradea municipality. The theoretical framework addresses key concepts related to tourism destination management, sustainable development, and the role of stakeholder cooperation in tourism development. The analysis focuses on the development strategies of Oradea for the periods 2017–2023 and 2021–2027, emphasizing the main strategic directions and priority objectives established at the local level for the development of this economic sector. The results underline the importance of capitalizing on cultural and architectural heritage, modernizing tourism infrastructure, and promoting the destination on international markets. This research highlights the importance of strategic planning for strengthening the competitiveness of urban destinations.

Keywords: tourism strategies, planning, urban tourism, destination management, sustainable development

1. Introduction

Strategic planning is one of the central concepts in tourism management (Murphy & Murphy, 2004), being considered an essential tool for guiding

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the development of tourist destinations and for the management of profile organization (Phillips & Moutinho, 2014), increasing their competitiveness on the international market.

In the context of globalisation and increased competition among tourism destinations, the development of coherent strategies adapted to the local context is becoming a fundamental condition for the efficient use of tourism resources and for ensuring a sustainable development of the tourism sector.

Located in the north-western part of Romania, on the border with Hungary, Oradea is the capital of Bihor County and exploited since historical times its economic and cultural geographical advantages for tourism development.

The present study is part of broader research focusing on the evolving aspects of tourism development in this important urban area, which has significantly expanded its leisure activities in recent years (Crețu & Lequeux Dincă, 2025). This paper specifically adopts a comparative perspective on the main strategic documents related to tourism development in Oradea Municipality, aiming to demonstrate that progress in tourism planning has been both a key contributing factor to and a driving force behind the significant development of this sector.

2. Study background and scientific literature

2.1. Strategic planning and its role in tourism development

Strategic planning in tourism involves a complex process, which includes the analysis of the internal and external environment, the establishment of long-term goals and the identification of the necessary actions to achieve them. Recent research on strategic planning in tourism and hospitality has developed significantly in recent decades, reflecting the growing importance of strategic management within tourism organizations which set their goals and adapt their strategies to changes in the economic and social environment (Phillips & Moutinho, 2014). Aladag et al. (2020) also highlight that the process of implementing strategies is an essential stage for the success of strategic management in tourism and the efficiency of strategic planning depends largely on the ability of organizations to turn strategic plans into concrete actions and monitor the obtained results.

At the level of tourist destinations, strategic planning is closely linked to the concept of destination competitiveness. In this context, Ritchie and Crouch (2003) stress that the success of a tourist destination depends on its ability to strategically manage tourist resources and coordinate the activities of actors involved in tourism development. Strategic planning is therefore an essential tool for integrating these elements into a coherent vision and also a sustainable pattern for tourism development (Dincă, 2013). Analysing the role of the actors involved in the strategic planning process, Nunkoo (2018) highlights the importance of social capital in developing and implementing tourism development strategies, and the significant influence of cooperation and trust relations between stakeholders on the success of the planning process.

Strategic planning also plays an important role in harnessing the tourism potential at regional level (Fletcher, 1996) while considering both the natural and cultural resources of the area and the economic and social context in which hospitality industry grows. At this level the collaboration between local authorities, the private sector and the local community, as well as their ability to capitalize on the competitive advantages of the region is essential (Fletcher, 1996).

Within the management of tourist destinations, an important role is played by the destination management organizations (Destination Management Organizations – DMO), which coordinate the activities of tourism promotion and development and were recently implemented by governance endeavours for Romanian regional and local tourism destinations (Lequeux-Dincă & Teodorescu, 2024). The collaborative approach to destination marketing and management and involving mainly partnership and networking actions than centralized administrative policies was emphasized in the scientific literature (Fyall & Garrod, 2008; Morgan et al., 2012) that emphasize management methods inspired by Lean principles as tools that can help optimize decision-making processes and increase the performance of organizations involved in tourism destination management (Foris et al., 2020).

The increased importance of the relationship between strategic tourism planning and spatial or urban planning emphasized the need of urban tourism integration into spatial planning strategies to ensure effective management of tourist flows and to prevent adverse effects on the environment and local communities (Klepej & Marot, 2024).

In the Romanian context, also influenced by EU planning policies, stakeholder governance was developed through significant efforts supported by European programs, ultimately leading to regional and local success stories that were highlighted and promoted by the national media (Lequeux-Dincă & Teodorescu, 2024). Oradea is an illustrative example of urban success story highlighted in the Romanian economic context as an important investment hub (mediafax.ro) with significant results of urban regeneration and tourist and visitor attractiveness also confirmed by the post-Covid important tourism flows recovery rates (Crețu & Lequeux Dincă, 2025).

2.2. Priority objectives in the strategic development of tourism in Oradea municipality from a contemporary perspective

In recent decades, tourism has become one of the most dynamic sectors of the global economy, having a significant impact on the economic, social and cultural development of destinations. Tourism development strategies have the role of establishing the priority directions of action, coordinating the activities of the actors involved and ensuring a sustainable use of tourism resources and in this context contemporary tourism must be analysed in close connection with the principles of sustainable development (Dincă, 2013).

The concept of sustainable development has become a central element in public policies globally, especially after the adoption of the 2030 Agenda for Sustainable Development by the United Nations (2025) which includes a set of 17 Sustainable Development Goals (Sustainable Development Goals – SDGs) (United Nations, 2025), aiming to promote balanced economic development, protect the environment and improve the quality of life of the population. Recent studies (Rabadán-Martín et al., 2025) show an important increase in research on tourism and SDGs since 2017, predominantly centred on SDG 8 (Decent Work and Economic Growth) and SDG 12 (Responsible Consumption and Production), with ecotourism, behavioral models, and the role of tourism in social inclusion constituting some of the predominant themes.

The integration of SDGs into tourism development strategies contributes to the creation of more resilient and efficient tourism systems, in which economic development should be correlated with social responsibility

and environmental protection while involving local communities in the tourism development process (Dahri et al., 2025). The cooperation between public authorities, the private sector and local communities and an integrated approach in the development of sustainable tourism is essential especially for vulnerable tourism attractive regions for promoting responsible use of resources and ensuring a fair distribution of the benefits generated by tourism activity (Erdeli & Dincă, 2011; Rahmatin and Nawangsari, 2025). These aspects are more and more emphasized also for urban environments where cultural assets and heritage objectives require also complex management in view of appropriate rehabilitation and reuse strategies also for tourism purposes (Merciu et al., 2021).

These aspects can be also underscored for the case of Oradea, a city that has experienced in recent years a significant development of the tourism sector and which supported the capitalization of the architectural and cultural heritage of the city and by active tourism promotion policies. A relevant example in this respect is the participation of Oradea Municipality in the World Travel Market in London (Oradea.ro, 2024; Agerpres, 2024) or at international tourism fairs in Helsinki and Vienna (Stiripesurse.ro, 2025; Travel and Tour World, 2025).

In this context, the comparative analysis of tourism development strategies of Oradea becomes relevant for understanding how strategic priorities of tourism development are formulated while identifying the main action and investment priorities by administrative authorities.

3. Methodology

The present study is based on a qualitative research approach focused on the analysis of strategic planning documents related to the development of tourism in the municipality of Oradea. The research methodology combines document analysis, comparative analysis, and content analysis techniques, supported by visual data representation tools (Lequeux-Dincă & Teodorescu, 2024) in order to highlight the evolution of tourism development priorities within the local strategic framework.

The first stage of the research consisted in the identification and selection of the main strategic planning documents relevant for tourism

development at the municipal level. In this context, two key documents were analysed: the Integrated Urban Development Strategy of Oradea Municipality for the period 2017–2023 and the Integrated Urban Development Strategy for Oradea Municipality and the Oradea Metropolitan Area for the period 2021–2027 (Primăria Municipiului Oradea, 2017; 2021). These documents represent the main policy instruments through which local authorities define development priorities, strategic objectives, and intervention axes for the medium and long term.

The methodological approach is based on the analysis of secondary sources, the selected strategies being examined in order to identify the main strategic objectives, priorities, and areas of intervention related to tourism development. The analysis focused particularly on the sections of the strategies referring to tourism, urban attractiveness, cultural heritage valorisation, tourism infrastructure, and destination promotion.

In order to identify the dominant themes and priorities reflected in the analysed documents, a qualitative content analysis was carried out. This process involved extracting the most frequently used concepts and key terms related to tourism development from the strategic texts. The selected keywords were then processed using visual analysis techniques in order to highlight their frequency and importance within the strategic discourse.

To support this analysis, three-word clouds were generated based on the textual content of the analysed strategies. The purpose of these visual representations was to illustrate the prominence of specific concepts and strategic directions within the planning documents. Word clouds provide an intuitive representation of the most frequently used terms, allowing the identification of the thematic priorities emphasized by the local authorities in the process of tourism planning (Lequeux-Dincă et al., 2018).

In addition to the visual analysis, a comparative analysis of the two strategic documents was conducted in order to highlight the evolution of tourism development priorities between the two programming periods. The comparison focused on the structure of the strategic objectives, the complexity of the intervention axes, and the importance assigned to tourism within the broader framework of urban development. The results of this comparison were synthesized in a colour-coded table that facilitates the identification of similarities, differences, and the progressive maturation of the strategic planning process.

4. Results and discussion

4.1. Tourism development strategic goals for Oradea municipality

The Integrated Urban Development Strategy of Oradea Municipality for the period 2017–2023 included a limited number of strategic objectives, focused mainly on solving specific problems and outlining general development directions. In contrast, the new strategy for 2021–2027 is distinguished by a much more rigorous structure and a much more comprehensive framework of objectives and areas of intervention, which respond to both current European priorities and identified local challenges. This evolution reflects the maturation of the strategic planning process at the municipal and metropolitan level, ensuring an integrated approach tailored to the complex needs of the community.

For the new strategic horizon, 2021–2027, the Integrated Urban Development Strategy for the Municipality of Oradea and the Metropolitan Area propose a more complex approach, structured around development objectives and specific areas of intervention. These integrate both European priorities regarding the green and digital transition and the needs identified at the local and metropolitan levels. The list of strategic objectives and specific areas of intervention outlines a medium-term vision that focuses on sustainable urban mobility, digitization, tourism development, and strengthening administrative capacity, ensuring the continuity and expansion of the directions initiated in the previous period (Figure 1).

Mainly from tourism point of view the city of Oradea and its metropolitan area have numerous resources that support the development of the tourism sector, contributing to economic growth and strengthening the cultural identity of the region. Local authorities have adopted a strategy to capitalize on these resources, focusing on modernizing tourism infrastructure, restoring architectural heritage, and promoting the city as a destination of national and international interest.

In this context, Oradea's administrative authorities consider several types of resources essential for the development of tourism. These include natural resources, mainly represented by the geothermal waters of Băile Felix and Băile 1 Mai, which promote spa and health tourism. These resorts attract thousands of visitors every year thanks to the therapeutic properties of the thermal waters and modern treatment facilities. At the same time, the city's exceptional architectural heritage, dominated by Art Nouveau influences, is another central pillar of tourism development.



Figure 1. List of Strategic Objectives for 2023 within the Integrated Urban Development Strategy of Oradea Municipality 2017-2023
(Computed by the authors)

Oradea stands out nationally for its large number of restored buildings, which transform it into a veritable open-air urban museum. In addition, the local administration is constantly investing in tourism infrastructure, modernizing accommodation, the public transport network, and leisure facilities. Last but not least, cultural and sporting events, organized periodically, play an essential role in attracting tourists and strengthening the city's tourism brand.

Thanks to these resources, several forms of tourism are practiced in Oradea and its metropolitan area, each having a significant impact on the local economy. Spa and health tourism is one of the most developed, supported by the nearby thermal resorts, which offer excellent conditions for treatments and relaxation. Cultural and heritage tourism is also a major attraction, given the municipality's impressive architectural heritage. Iconic buildings such as Oradea Fortress, Black Eagle Palace, and Moon Church are landmarks for visitors.

At the same time, business and event tourism has developed considerably, thanks to modern infrastructure that allows for the organization of international conferences, fairs, and symposiums. Oradea has become a meeting point for the business community and international organizations interested in economic and commercial collaborations. In addition to these established forms of tourism, the city also promotes leisure and sports tourism, offering numerous facilities for outdoor activities, horse riding, sport fishing, and international competitions.

Another important component of local tourism is religious tourism, supported by the presence of historic places of worship, which attract both believers and enthusiasts of religious architecture. In addition, thanks to its favourable geographical position, Oradea is also an important point on the transit tourism map, being located close to the Hungarian border and on the main European tourist routes.

Through constant investments in modernizing its tourism infrastructure and diversifying its tourism offerings, Oradea is consolidating its position as an attractive destination for both Romanian and foreign visitors. Local authorities continue to implement projects aimed at capitalizing on these resources and transforming the city into a modern tourist center with a significant economic and cultural impact.

The development and promotion of tourism is a strategic priority, given that the municipality of Oradea has a remarkable cultural and

historical heritage, which has already been significantly enhanced. The region benefits from well-structured reception and accommodation facilities, a remarkable natural environment that supports a diverse range of tourist attractions accessible throughout the year, and valuable balneoclimatic resources. These elements are complemented by real opportunities to strengthen the image and prestige of local culture and sports.

However, the hospitality industry in the area is currently failing to exploit its competitive advantages to the full and achieve a level of development commensurate with the region's tourism potential. From this perspective, tourism development must be understood as an integrated process based on the coherent management of all available resources. This involves not only capitalizing on the actual tourist attractiveness, but also stimulating related activities, such as the production of goods and services specific to the hospitality industry, training and qualifying the workforce, and developing the professional skills necessary to support competitive and sustainable tourism.

4.2. Comparative aspects on tourism development strategic approach for Oradea municipality

A comparison of the two strategies highlights a clear process of maturation in urban planning at the level of Oradea Municipality and its metropolitan area. While the document for the period 2017–2023 included a relatively limited set of objectives, focused mainly on addressing specific needs and defining general directions, the 2021–2027 strategy stands out for its complex structure, articulated around strategic objectives and well-defined areas of intervention. This shift from a general approach to a much more detailed one reflects both the experience gained in the previous phase and the need to respond to increasingly diverse and sophisticated challenges. At the same time, the emphasis on mobility, digitalization, sustainability, and tourism development confirms Oradea's orientation towards European standards of urban development and the consolidation of its position as a regional hub of attractiveness.

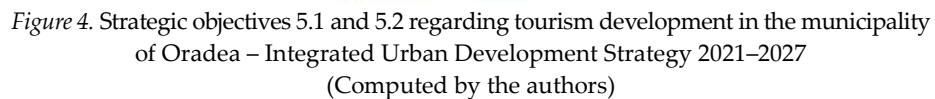
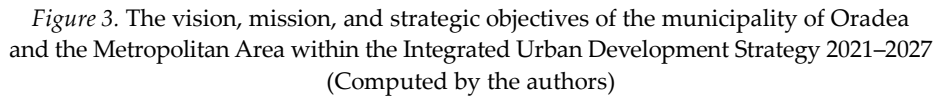
Within the framework of the former Integrated Urban Development Strategy of Oradea Municipality for the period 2017–2023, Chapter VI played a central role in defining the vision, mission, and strategic objectives

Subchapter 8.3 of the Integrated Urban Development Strategy of Oradea Municipality and the Metropolitan Area for the period 2021–2027 outlines a more complex strategic vision for development for the year 2027.

Subchapter 8.5 focuses on the Strategic Objectives and Specific Axes of Development and identify tourism as a major essential domain of interventions. Strategic priorities 5 (Figure 4) were selected by their focus on developing and promoting tourism, an area perceived as playing an essential role in diversifying and revitalizing the local economy. Priorities were based on capitalizing the existing tourism potential of the municipality of Oradea and its metropolitan area, including natural resources, cultural, historical, and architectural heritage, as well as elements of intangible heritage. Through the envisaged measures and interventions, the strategy aims to transform tourism into a sector with a significant economic impact, capable of stimulating investment, generating jobs, and contributing to the overall attractiveness of the area for both visitors and the local community.



Figure 2. The missions, general objectives, and strategic objectives of the Integrated Urban Development Strategy of Oradea Municipality 2017-2023
(Computed by the authors)



The strategic objective 5.2 refers to the development of tourism management capacity and highlights the importance of coordinating and integrating existing resources in the field of tourism. The tourism potential of Oradea and its metropolitan area cannot be effectively exploited without

a coherent management approach that connects local objectives and opportunities into unified, attractive, and competitive packages for visitors. Equally, the involvement of service providers in the hospitality industry is essential, as their performance and quality directly influence tourist satisfaction and, implicitly, the income generated for employees and the community. To support these efforts, the objective is to strengthen the tools necessary for effective destination management by integrating marketing, promotion, and tourist information functions in line with the principles of sustainable development.

A detailed analysis of section 9.1. "Complete list of interventions – Project portfolio" of the Integrated Urban Development Strategy of Oradea Municipality reveals a comprehensive strategic approach to the development of the city and the metropolitan area for the period 2021-2027. The document highlights a series of projects with a major impact on urban infrastructure, the local economy, tourism, mobility, and sustainability.

At this planning stage, the local administration has established a portfolio of 861 projects, each of which is intended to contribute to the city's development in multiple directions, with tourism benefiting from 31 dedicated projects. These projects focus on restoring and promoting historical heritage, modernizing tourism infrastructure, and creating new attractions to make the city more appealing to visitors.

Among the main objectives included in this action plan there are the restoration of buildings of historical value, the development of digitalization in tourism, the improvement of leisure infrastructure, and the strengthening of regional partnerships to promote Oradea as a tourist destination. The implementation of these projects is also linked to financing mechanisms designed to ensure the long-term sustainability of investments.

The sources of funding identified for the implementation of these projects are diverse, including non-reimbursable European funds, such as the Regional Operational Program (ROP), the National Recovery and Resilience Program (PNRR), Interreg RO-HU, as well as national funding through programs such as the National Local Development Plan (PNDL). In addition, there is the local budget and public-private partnerships, designed to support the sustainability of long-term investments.

5. Conclusions

In recent years, Oradea has adopted new tourism development and destination management strategies to develop the city and capitalize on its cultural assets. The city has become stronger as an urban tourist destination due to the funds invested in developing tourist infrastructure, restoring historic buildings and promoting the image of the city. The city has achieved better national and international recognition thanks to its improved urban tourist assets, which make it more competitive in the market.

By reporting local strategies to the conceptual framework of sustainable development, it becomes possible to analyse the extent to which strategic objectives include priorities such as the development of tourism infrastructure, the international promotion of destination, the protection of cultural heritage and the involvement of the local community in the tourism development process. Thus, the comparative analysis of the development strategies of Oradea offers a relevant perspective on the evolution of strategic priorities and on how local tourism policies adapt to the new trends of sustainable tourism development at global level.

The case study of the municipality of Oradea demonstrates how strategic planning can support the development of tourism through the capitalization of cultural, historical and natural resources, as well as through investments in tourism infrastructure and destination promotion. The comparative analysis of the Integrated Urban Development Strategies for the periods 2017–2023 and 2021–2027 reveals a clear evolution in the planning process, reflected in a more complex structure of objectives, a stronger orientation towards sustainable development and a greater emphasis on tourism as a driver of local economic growth.

Continuing a first part of a more extended study (Crețu and Lequeux-Dincă, 2025) the results indicate that tourism represents a strategic sector for the municipality of Oradea which mainly supports for this domain the valorisation of its architectural heritage, the development of spa and leisure tourism, and the strengthening of the city's image as an urban tourist destination. At the same time, the portfolio of development projects included in the local strategy highlights the commitment of public authorities to modernize tourism infrastructure, diversify tourism services and increase the visibility of the destination on international markets.

The research highlights the essential role of strategic planning in the sustainable development of tourism destinations, particularly in the context of increasing competition between cities seeking to strengthen their attractiveness on national and international tourism markets. The theoretical framework emphasizes that tourism development requires coherent long-term strategies that integrate economic, social and environmental objectives and ensure the efficient use of tourism resources.

From a scientific perspective, the present study provides a synthetical image of the main strategic objectives concerning tourism development for Oradea municipality, illustrating most recent local development strategies that influence the evolution of tourism for this urban destination. However, the research is limited mainly to the analysis of strategic planning documents and secondary sources, without including extensive empirical data regarding tourist flows or visitor perceptions.

Future research directions may focus on the evaluation of the concrete impact of these strategic initiatives on tourism performance indicators, such as tourist arrivals, economic benefits generated by tourism, or the perception of visitors regarding the attractiveness of the destination. Such analyses would provide a deeper understanding of the effectiveness of tourism development strategies and their long-term contribution to the sustainable development of urban destinations.

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**AGRICULTURE DE DÉCRUE, UNE ALTERNATIVE POUR LA SÉCURITÉ
ALIMENTAIRE DANS LA COMMUNE DE BALLOU
(HAUTE VALLÉE DU SÉNÉGAL)**

Résumé. En Afrique de l'Ouest, et notamment au Sénégal, l'agriculture dépend largement des précipitations, la rendant vulnérable aux changements climatiques. La commune de Ballou, située dans la Haute Vallée du fleuve Sénégal, incarne cette précarité hydrique et environnementale. L'étude met en évidence les effets positifs de la construction du barrage de Manantali sur l'agriculture de décrue « falo », notamment par l'élargissement des terres cultivables. Cette extension a favorisé une diversification des cultures maraîchères rentables telles que la patate douce et les légumes, contribuant à une nette amélioration des revenus des producteurs. Cette dynamique a aussi permis une meilleure disponibilité alimentaire et nutritionnelle au sein des ménages. Cette pratique traditionnelle représente une alternative pertinente face aux défis climatiques et alimentaires. Sa valorisation pourrait renforcer la résilience et le développement rural à Ballou. L'étude repose sur une approche mixte, combinant une enquête quantitative et qualitative pour mieux comprendre les dynamiques agricoles et sociales.

Mots-clés : agriculture de décrue, alternative, sécurité alimentaire, commune de Ballou

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1. Introduction

Dans un contexte mondial où l'insécurité alimentaire ne cesse de croître, particulièrement en Afrique subsaharienne, il est nécessaire d'étudier des alternatives agricoles durables adaptées aux conditions climatiques locales. Parmi celles-ci figure l'agriculture de décrue, une pratique ancestrale qui a permis aux populations des plaines inondables africaines de survivre (Dieye. M et al, 2020). Ce système, couramment pratiqué le long des grands fleuves ou des zones inondables, présente de nombreux avantages à la fois nutritionnels et économiques. En effet, pratiquée sur les rives gauches de la Haute Vallée du fleuve Sénégal, cette forme d'agriculture a longtemps constitué une ressource essentielle à la subsistance des populations locales, leur permettant de s'adapter efficacement aux contraintes environnementales et climatiques propres à cette région (Dieye. M et al, 2020). Elle favorise la diversification des cultures, ce qui améliore non seulement une alimentation plus variée et plus riche sur le plan nutritionnel, tout en assurant aux agriculteurs des revenus stables. Cette diversification représente une stratégie essentielle pour améliorer la résilience des communautés rurales face aux chocs climatiques.

Toutefois, en dépit des investissements et des politiques publiques visant explicitement le remplacement progressif des systèmes agricoles traditionnels, l'agriculture de décrue demeure une alternative viable pour améliorer la sécurité alimentaire, notamment dans la commune de Ballou. La place des cultures de décrue contraste nettement avec le faible niveau d'appui institutionnel concret dont elles bénéficient actuellement ; bien que plusieurs études aient souligné le potentiel économique et social de cette pratique agricole ancestrale (Bader. J.C et al, 2020). Cette étude démontre que l'agriculture de décrue mérite un soutien plus fort et durable, car elle constitue une solution pertinente et résiliente pour la sécurité alimentaire, surtout dans la commune de Ballou. Malgré l'érection du barrage de Manantali, les communautés rurales de la Haute Vallée du Sénégal continuent d'exploiter activement les berges du fleuve, chaque année lorsque les conditions de décrue sont favorables (Fall, C.S. et al, 2020). C'est une stratégie agricole résiliente qui joue un rôle clé dans la sécurité alimentaire. Ce mode de production agricole diversifié permet aux populations locales d'assurer non seulement une subsistance alimentaire stable, mais

également de diversifier leur alimentation et d'améliorer sa qualité nutritionnelle. Cette diversification permet d'assurer une alimentation variée et équilibrée, réduisant la dépendance à une seule culture, limitant les risques de pénurie alimentaire. Ainsi, la vente de produits variés permet aux cultivateurs d'avoir plusieurs sources de revenus à différents moments de l'année. Ces revenus renforcent leur capacité à faire face aux besoins sociaux et renforcer la sécurité alimentaire.

Le concept de sécurité alimentaire a connu une évolution importante au fil du temps dans le temps et a fait l'objet de multiples définitions au sein de la communauté internationale. Initialement centré sur la disponibilité fiable de nourriture, il englobe aujourd'hui quatre dimensions majeures aux connotations spatiales et politiques : la disponibilité des aliments, la stabilité de cette disponibilité, l'accès aux aliments et leurs utilisations. Selon la FAO (2010), la disponibilité d'aliments renvoie à une offre suffisante pour satisfaire, en moyenne, les besoins de consommation des populations. La stabilité vise à limiter les risques de pénurie pendant les années ou les saisons difficiles. La notion d'accès met en évidence le fait que, même en cas de disponibilités abondantes, certaines personnes continuent de souffrir de la faim en raison de leur pauvreté. L'utilisation fait références aux bonnes pratiques de préparation, à la diversification alimentaire et à une répartition adéquate des ressources alimentaires au sein des ménages. Notre étude portera sur la disponibilité et l'utilisation.

L'objectif de cet article est d'analyser dans quelle mesure l'agriculture de décrue peut représenter une alternative crédible et durable pour renforcer la sécurité alimentaire dans la commune de Ballou. Deux interrogations centrales structurent notre démarche scientifique : quelle est la contribution de l'agriculture de décrue à la sécurité alimentaire locale, et comment les populations locales perçoivent-elles cette activité agricole face aux mutations environnementales et socioéconomiques actuelles ?

Le plan va se présenter comme suit : dans un premier temps, nous mettrons l'accent sur l'agriculture de décrue en tant que potentiel agricole favorable à une alimentation diversifiée, ensuite nous aborderons l'émergence de nouvelles spéculations ainsi que la dynamique de la production agricole, en fin nous procéderons à une analyse des revenus issus de l'agriculture de décrue et la sécurité alimentaire.

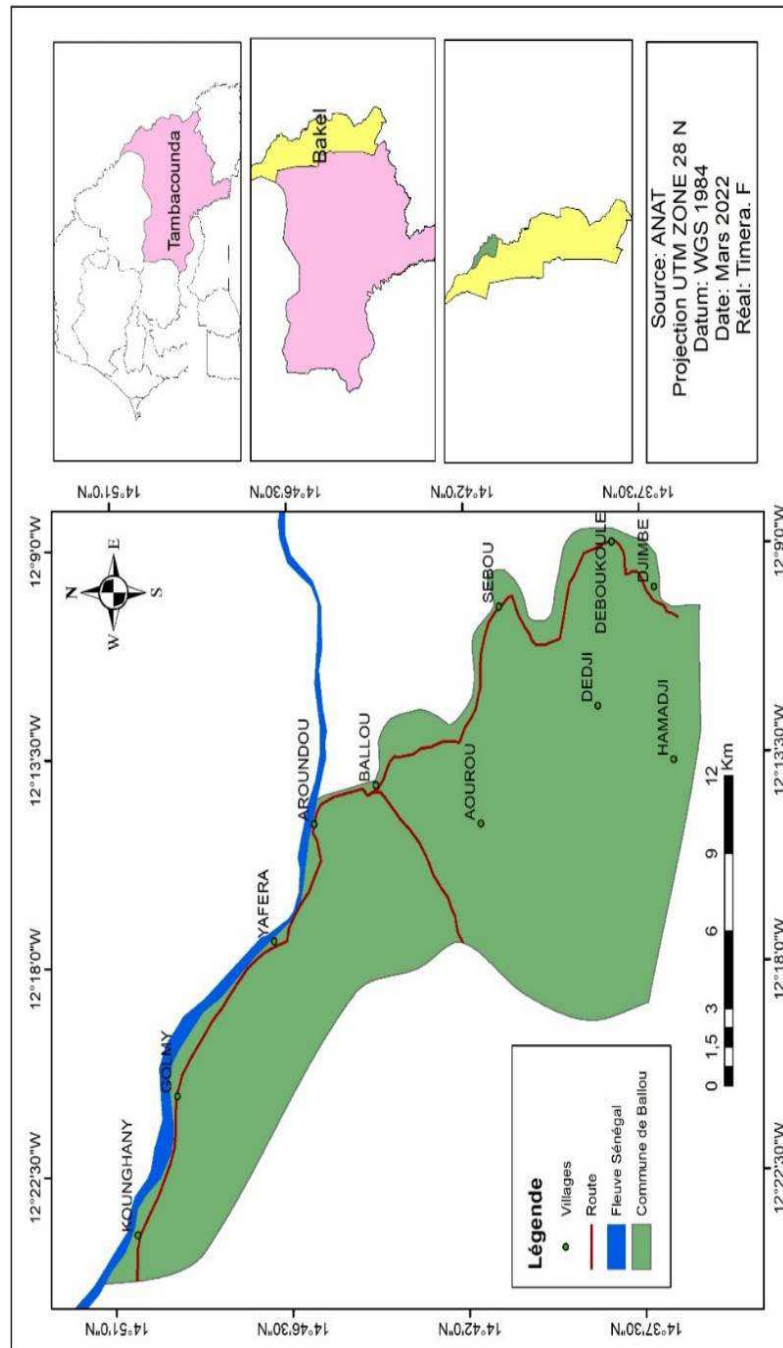


Figure 1. Localisation de la Commune de Ballou

2. Site et methodes

2.1. Zone d'étude

La commune de Ballou se situe dans la Haute Vallée du fleuve Sénégal, plus précisément dans le département de Bakel, à l'est du Sénégal (Fig. 1). Elle couvre une superficie de 245 634 km². La commune compte une population de 21 346 habitants répartis en 11 villages (ANSD, 2013).

Ces données démographiques ont été utilisées puisque l'enquête s'est déroulée en 2022, période où le recensement général de 2023 n'avait pas eu lieu. Le site est caractérisé par une agriculture à forte composante pluviale et décrue, rythmée par les crues saisonnières du fleuve. Pour accompagner l'analyse spatiale du territoire étudié, une carte de localisation a été réalisée à l'aide du logiciel ArcGIS, en mobilisant les données issues de l'Agence Nationale de l'Aménagement du Territoire (ANAT).

2.2. Méthodologie

La démarche méthodologique adoptée dans le cadre de cet article repose sur une approche mixte combinant l'enquête quantitative et qualitative. Ainsi, la collecte des données empiriques s'est appuyée sur un questionnaire administré aux producteurs agricoles afin d'identifier les types de spéculations cultivées en décrue, d'estimer les rendements obtenus, et d'évaluer les revenus générés. Ce questionnaire a également permis de recueillir les perceptions des ménages sur la dynamique spatiale, l'utilité des cultures de décrue et leur rôle dans la sécurité alimentaire. De plus, il est difficile d'obtenir des données précises sur les revenus réels des producteurs de patate douce, en raison de l'absence de mécanisme formels de suivi.

L'échantillonnage a ciblé les quatre villages riverains du fleuve Sénégal, les plus concernés par la pratique de l'agriculture de décrue. Contrairement aux villages riverains, les autres localités de la commune, éloignées du fleuve, ne bénéficient pas des conditions favorables à la pratique de l'agriculture de décrue. Les villages concernés par l'étude comptabilisent 864 ménages au total, selon les données du recensement

général de la population (ANSD, 2013). Un échantillon au 1/20^e a été retenu, soit 174 ménages enquêtés, répartis proportionnellement entre les villages concernés. Les villages de Golmy et Kounghany ne disposent pas de commission chargée de la gestion des données. Ainsi, pour ces villages, nous avons uniquement réalisé des entretiens. Le tableau ci-dessous (tableau 1) présente la répartition de l'échantillon :

Tableau 1

Echantillon des villages enquêtés

Villages	Ménages total	Effectifs enquêtés	Pourcentages
Aroundou	188	38	22%
Yafera	139	28	16%
Golmy	319	64	37%
Kounghany	218	44	25%
Total	864	174	100%

Source : ANSD, 2013

Ces données issues de terrain, ont été saisies et exploitées à l'aide de l'outil KoboCollect, facilitant ainsi la structuration des réponses et l'exploitation statistique des résultats. Ces données ont, en outre, été enrichies par la réalisation d'entretiens semi-directifs conduits auprès d'acteurs locaux clés notamment les chefs de village, les présidents de commissions agricoles, des exploitants expérimentés ainsi que des commerçants.

Des informations fiables ont été obtenues grâce aux registres des commissions locales chargées des transactions commerciales provenant des grandes villes telles que Dakar. Au total, 12 entretiens ont été conduits, répartis comme suit : les chefs de village de chaque localité concernée par l'échantillon, deux présidents de commission, quatre exploitants agricoles et deux commerçant gros porteurs.

3. Résultats

Les résultats de cette étude ont mis en évidence le potentiel considérable des cultures de décrue dans la commune de Ballou. Ils ont notamment révélé que l'extension progressive des surfaces agricoles a permis l'émergence de nouvelles spéculations, favorisant ainsi une diversification de la production.

Cette évolution a eu un impact direct et positif sur les rendements agricoles et sur le revenu des ménages, contribuant de manière significative à l'amélioration de la sécurité alimentaire dans la région.

L'agriculture de décrue constitue un mode de production ancestral profondément enraciné dans les pratiques agricoles de la commune de Ballou depuis plusieurs millénaires. La construction du barrage de Manantali en 1989, a eu un impact favorable sur ces espaces agricoles. Les superficies cultivées en décrue et particulièrement sur le falo varient en fonction de la hauteur d'eau et de la durée de l'inondation. Elles étaient très minimales avant la construction du barrage. La majeure partie des terres du falo était occupées par de sable fin non favorable à l'agriculture. Les paysans pratiquaient l'agriculture de décrue près des berges. Ces espaces étaient des jardins de case.

Le schéma ci-dessus montre que l'occupation des espaces agricoles sur le falo dans la commune de Ballou était très limitée en raison de l'importance du sable fin (Fig. 2). Il caractérise les espaces agricoles du falo en deux groupes que nous désignons les espaces agricoles avant l'édification du barrage de Manantali et les espaces nus non favorable à l'agriculture de décrue sur le falo. Les espaces nus représentent le sable fin près de 2/3 des terres agricoles.

Cependant, l'édification du barrage s'est traduite par la régularisation du régime du fleuve, le ruissellement des eaux pluviales et l'apport des affluents du Sénégal, les superficies cultivées dans le falo ont connu une évolution c'est-à-dire de nouveaux espaces ont apparus (Fig. 3). Les parcelles d'exploitation qui longeaient la partie convexe des méandres sur la rive gauche du fleuve ont évolué dans le temps et dans l'espace grâce aux dépôts limoneux. Les sédiments sur lesquels se forment les sols de la haute vallée se sont déposés récemment. Ils se composent d'un mélange en proportion variable d'argile, de limon et de sable (P. Boivin, I. Dia, A. Lericollais, et al, 1993). Selon les témoignages des anciens producteurs, cette partie convexe du fleuve permet aujourd'hui de pratiquer diverses activités agricoles sur de grandes superficies. En effet, lors des enquêtes de terrains, il a été constaté que le champ familial de Somanka mesurait 107 m de long avant la construction du barrage de Manantali. Après sa mise en place, de nouveaux espaces cultivables sont apparus avec une distance 394 m. Actuellement, la surface cultivée atteint 501 m de long. Ces ressources foncières du « falo » sont gérées de façon coutumière.

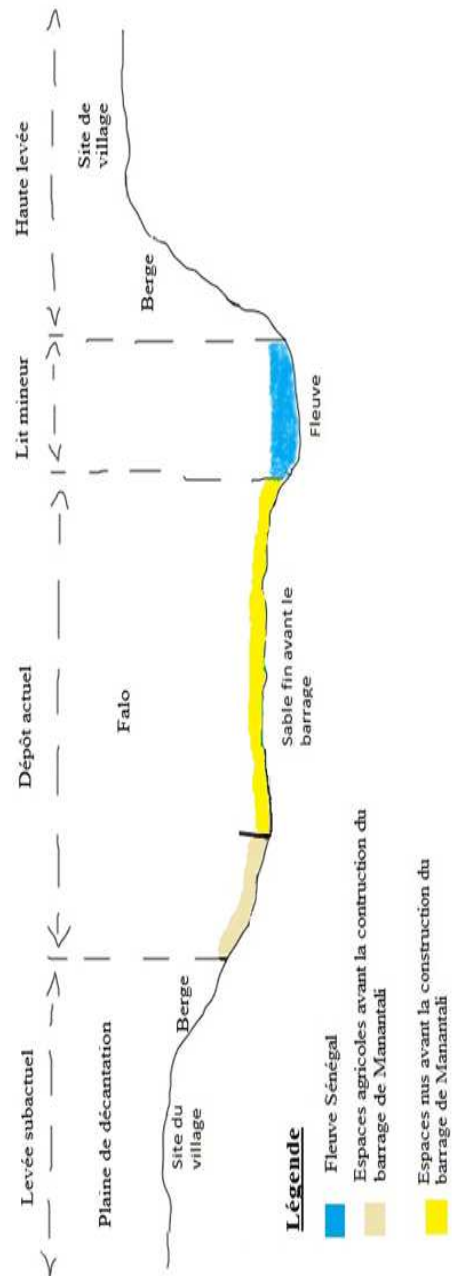


Figure 2. Coup schématique de la haute vallée du fleuve Sénégal avant l'édification du barrage : commune de Ballou
(Source : Fode TIMERA, 2022)

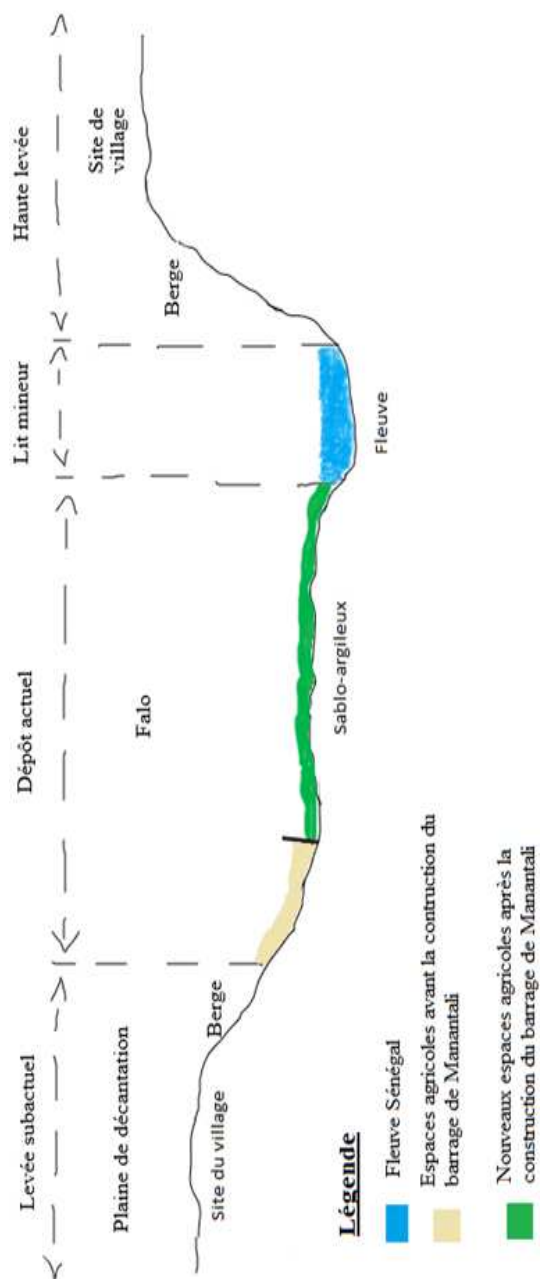


Figure 3. Coup schématique de la haute vallée du fleuve Sénégal après la construction du barrage : commune de Ballou
(Source : Fode TIMERA, 2022)

La dynamique des espaces agricoles de décrue du falo a favorisé l'émergence de nouvelles cultures de spéculation dans la commune de Ballou.

3.1. Emergence de nouvelles spéculations et la production agricole

Avant la construction du barrage de Manantali, l'agriculture pluviale constituait le pilier essentiel des activités agricoles dans la commune de Ballou. L'agriculture dans la zone du « falo » était centrée sur les cultures céréalières, en particulier le maïs, souvent cultivé en association avec le niébé, la courge et la patate douce rouge. Ces combinaisons culturelles permettaient d'optimiser l'usage des sols et d'assurer une alimentation diversifiée. Ces espaces, trop restreints, limitaient la production à une simple autoconsommation.

Après l'édification du barrage, l'agriculture dans le « falo » a connu des transformations importantes, caractérisée par l'introduction de nouvelles spéculations agricoles. Parmi ces nouvelles spéculations figurent notamment la nouvelle variété de patate douce, ainsi que des légumes à haute valeur nutritionnelle et marchande. Mais il convient de souligner que l'étude présentée dans cet article se concentre uniquement l'analyse de l'apport de la patate douce dans la sécurité alimentaire dans la commune. Cette diversification traduit une orientation vers l'intensification des cultures maraîchères, privilégiées par les producteurs en raison de leur rentabilité économique élevée et leur capacité à répondre à une demande locale croissante.

La diversification des spéculations a permis d'augmenter la production agricole. Cette dynamique a permis aux commissions villageoises de Yafera et d'Aroundou de disposer des données sur la production de patate douce. Il est important de préciser dès le départ que ces données nous donnent une idée sur les quantités de patate douce produite dans la commune de Ballou. Ces données ne reflètent qu'une fraction de la production réelle, faute d'information sur le nombre de sacs écoulés hebdomadaires par les commerçants itinérants « *Baana-Baana* ». Ainsi, les tableaux qui suivent présentent la production de patate douce collectées par la commission villageoise de Yafera et d'Aroundou pour la période allant de 2019 à 2022 (tableaux 2 et 3).

Tableau 2

La production de la patate douce dans le village de Yafera de 2019 à 2022

Années	2019	2020	2021	2022
Nombre total de sacs	3 140	3 651	3 381	1 981

Source : Commission du village de Yafera, 2022

L'analyse interannuelle de la production de patate douce dans le village de Yafera, entre 2019 et 2021, révèle une tendance globalement fluctuante. Le volume récolté a augmenté de 3 140 sacs en 2019 à 3 651 en 2020, grâce à la fertilité des terres et aux effets indirects de la pandémie de COVID-19, qui ont modifié les circuits de vente (la fermeture temporaire des marchés hebdomadaires « loumas » et la restriction des déplacements due à la fermeture des frontières nationales). Dans ce contexte exceptionnel, les producteurs agricoles n'ont eu d'autres alternatives que de vendre leur récolte directement aux commerçants itinérants (« sous-sous »). Cependant, en 2022, la production a chuté à 1 981 sacs (contre 3 381 en 2021), en raison de désaccords sur les prix entre producteurs et commerçants, ainsi que d'une concurrence accrue liée à la diversification des acheteurs sur les marchés locaux et régionaux. Ces commissions détiennent juste les données des commerçants venant de Dakar (« sous-sous »). Pourtant une grande partie de la production échappe à leurs statistiques, étant écoulée sur les marchés hebdomadaires, auprès de nouveaux commerçants ou directement entre particuliers. Afin de mieux cerner les dynamiques locales des cultures de décrue et de compléter l'analyse menée à Yafera, il est nécessaire d'examiner également l'évolution interannuelle de la production de patate douce dans le village d'Aroundou, situé dans la même zone agricole.

Tableau 3

La production de la patate douce dans le village d'Aroundou de 2019 à 2022

Années	2019	2022
Nombres totaux de sacs	3 251	1 555

Source : Commission du village d'Aroundou, 2022

Par ailleurs, l'analyse interannuelle de la production de patate douce dans le village d'Aroundou révèle une dynamique contrastée sur la période étudiée (2019-2022). Selon les précisions fournies par le président de la commission villageoise (D.D.), « *le village a accueilli huit (8) camions totalisant 3 251 sacs vendus durant l'ensemble de la campagne agricole de 2019* ». Cependant, on constate une baisse significative de la production en 2022 soit 1 555 sacs de patate douce. Les principales raisons expliquant cette tendance baissière restent identiques à celles identifiées précédemment à Yafera (désaccords sur les prix entre producteurs et commerçants, concurrence accrue liée à la diversification des acheteurs sur les marchés locaux et régionaux). Cette production participe largement à la formation des revenus agricole des producteurs et assure la sécurité alimentaire des ménages de la localité (Dramane Cissokho, 2022).

Avant la construction du barrage de Manantali, la production de la patate dans la commune de Ballou était nettement plus faible qu'aujourd'hui. Les estimations montrent que la quantité totale produite à cette période ne représentait 1/3 du volume actuellement récolté.

M.N.T, exploitant agricole à Yafera

3.2. Revenus agricoles de décrue et sécurité alimentaire

L'agriculture de décrue joue un rôle important dans la vie quotidienne des ménages, en particulier dans la commune de Ballou. La production issue de cette activité répond à deux besoins complémentaires essentiels : d'une part, à l'autoconsommation des familles agricoles, et d'autre part, elle génère des revenus monétaires essentiels aux ménages producteurs.

Tableau 4

Utilité des récoltes de la culture de décrue de patate douce

Libellés	Ménages interrogés	Pourcentage %
Vente	134	77%
Consommation	40	23%
Total	174	100%

Source : Enquête de terrain, 2022

Le tableau 4 met en lumière la répartition des usages des récoltes issues de la culture de décrue de patate douce dans la commune de Ballou. Deux principales destinations se dégagent de l'analyse : la vente et la consommation familiale. Sur un total de 174 personnes enquêtées, une nette majorité (77 %) produit principalement pour la vente tandis que 23 % destinent leur production à l'autoconsommation.

Dans la commune de Ballou, le revenu annuel ainsi que le prix d'un sac de patate douce varient fortement d'une année à l'autre, illustrant une instabilité du marché. Toutefois, les prix sont restés relativement stables entre 2020 et 2021. Le tableau suivant rend compte des revenus annuels de la patate douce dans le village de Yaféra.

Tableau 5

Revenus annuels de la patate douce à Yaféra entre 2019 et 2022

Années	2019	2020	2021	2022
Prix moyen d'un sac en FCFA	18 000F	20 000F	20 000F	16 000F
Sommes total reçu en FCFA	61 155 500	61 943 000	55 620 000	31 660 000

Source : Commission du village de Yaféra, 2022

L'analyse des données présentées dans le tableau 5 montre que le prix moyen d'un sac de patate douce de 2019 à 2020 a connu une hausse du prix moyen, ce qui a permis au village de réaliser un revenu annuel de 61 943 000 F CFA. Cependant, en 2021, ce revenu a chuté à 55 620 000 F CFA en raison de la diversification des circuits de vente, qui a entraîné une dispersion de la clientèle. En 2022, la situation s'est encore détériorée avec une forte baisse du prix moyen d'un sac (16 000 F CFA), entraînant un revenu total de 31 660 000 F CFA, soit près de la moitié de celui de 2020. La même tendance s'est observée à Aroundou comme le laisse apparaître le tableau suivant.

Tableau 6

Revenus annuels de la patate douce à Aroundou de 2019 et 2022

Années	2019	2022
Prix moyenne d'un sac	18 000F	16 000F
Sommes total reçu	59 912 000F	24 880 000F

Source : Commission du village d'Aroundou, 2022

L'examen du tableau 6 révèle l'évolution du prix moyen d'un sac de patate douce ainsi que les revenus totaux perçus dans le village d'Aroundou, entre les années 2019 et 2022. Durant cette période, le prix moyen d'un sac a enregistré une baisse sensible, passant de 18 000 F CFA en 2019 à 16 000 F CFA en 2022. Cette diminution tarifaire a eu des conséquences directes sur le revenu global des exploitants agricoles du village. Ainsi, les sommes reçues par la commission locale sont passées de 59 912 000 F CFA en 2019 à seulement 24 880 000 F CFA en 2022, traduisant une chute importante du revenu enregistré au niveau communal.

De plus, il est difficile d'obtenir des données précises sur les revenus réels des producteurs de patate douce. Malgré cette limite, une enquête de terrain à Ballou a permis de recueillir des données sur le revenu annuel moyen des individus ou familles concernés. Ces résultats sont présentés dans la figure 4, offrant un aperçu complémentaire des revenus générés par cette activité agricole.

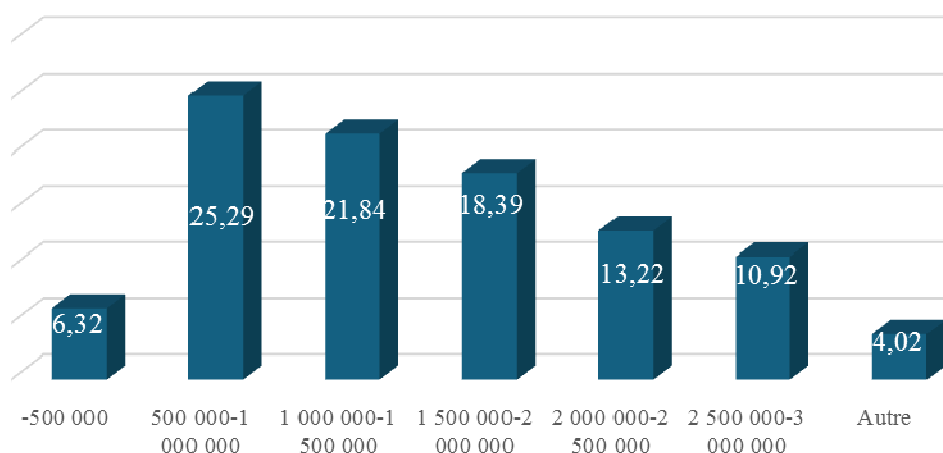


Figure 4. Revenus moyens annuels d'une campagne agricole de la patate douce
(Source : Enquête de terrain, 2022)

L'analyse de la figure 4 porte sur les revenus moyens annuels générés par la culture de patate douce dans la commune de Ballou. Les données obtenues sur le terrain par questionnaire montrent une grande variabilité des rentes, allant de moins de 500 000 F CFA à plus de 3 000 000 F CFA, selon la taille de l'exploitation, la main-d'œuvre mobilisée, et l'intensité

de la production. Ces résultats, issus par les interrogations sur le terrain et des témoignages locaux, montrent une croissance continue de cette activité. Ainsi, selon les témoignages des présidents de commission agricole, notamment A. B. T. du village de Yafera :

Deux grandes catégories de revenus se dégagent : entre moins de 500 00 F et 2 000 000 F CFA pour les producteurs individuels, et entre 2 500 000 F et 5 000 000 F CFA pour les familles exploitantes.

Aujourd'hui, la commercialisation de la patate douce constitue la principale source de revenu des producteurs locaux. Grâce à sa rentabilité économique élevée, cette spéculation agricole attire un nombre croissant de paysans qui y consacrent une partie importante de leurs efforts et ressources. Ainsi, les revenus générés par cette activité jouent un rôle essentiel dans la satisfaction des besoins sociaux des ménages de la commune de Ballou.

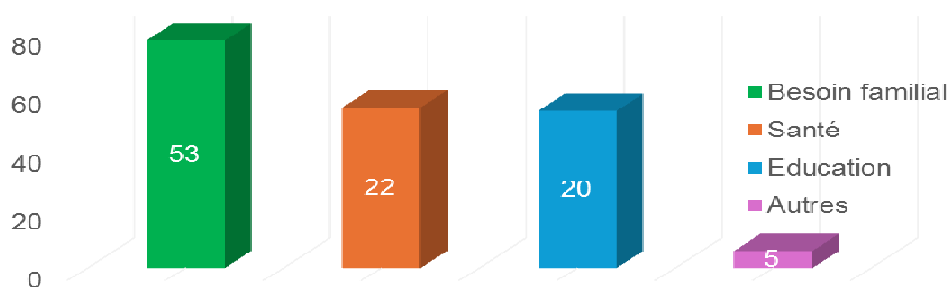


Figure 5. Apports des revenus agricoles de décrue
(Source : Enquête de terrain, 2022)

L'analyse détaillée de l'utilisation des revenus issus des cultures de décrue révèle une diversité des affectations, témoignant de l'importance économique et sociale de cette activité. Ces revenus sont principalement utilisés pour l'achat de denrées alimentaires (53%), les soins de santé (22 %) et la scolarisation des enfants (20 %). Par ailleurs, les 5 % restants servent à divers besoins comme les événements sociaux, le remboursement de crédits, ou encore l'épargne (Fig. 5).

Toutefois, la production et les revenus issues de l'agriculture de décrue occupent une place essentielle dans l'alimentation des ménages.

Elles jouent un rôle majeur dans la sécurité alimentaire. Cette dernière repose sur trois piliers : la disponibilité, l'accès et l'utilisation efficace des aliments. Dans la commune de Ballou, la disponibilité est principalement garantie par la production locale, en particulier l'agriculture de décrue pratiquée dans le falo. Elle permet aux ménages de disposer d'une diversité de produits alimentaires, en particulier des légumes frais. Ces produits complètent les aliments de base, constitués essentiellement de céréales (maïs, sorgho, mil, riz, etc.) et parfois de tubercules, selon les spécificités des différents villages enquêtés.

Les résultats de l'enquête montrent que tous les ménages interrogés perçoivent l'agriculture de décrue comme un moyen efficace pour prévenir les pénuries alimentaires, d'assurer l'autosuffisance et d'améliorer la qualité nutritionnelle grâce à la diversité des légumes produits. Cette pratique constitue ainsi un atout majeur pour la sécurité alimentaire à Ballou, en offrant une alternative locale. En effet, 99,9% des ménages enquêtés estiment que l'agriculture de décrue est essentielle à la sécurité alimentaire à Ballou.

4. Discussion

Les résultats de cette recherche menée dans la commune de Ballou mettent en lumière le rôle stratégique et incontournable de l'agriculture de décrue. Ce rôle s'avère particulièrement important dans un contexte sahélien caractérisé par la vulnérabilité climatique, l'instabilité des systèmes de production et la marginalisation des agricultures traditionnelles. En effet, à l'instar des autres grandes vallées soudano-sahéliennes telles que celles du Niger ou du Logone-Chari, la vallée du fleuve Sénégal dispose d'un potentiel agricole remarquable. Cette richesse lui confère un enjeu économique considérable, non seulement à l'échelle nationale mais également dans les dynamiques transfrontalières qui lient le Sénégal à ses voisins riverains, notamment la Mauritanie et le Mali (Mané Landing, 1996). L'étude révèle qu'à la suite de la mise en œuvre du barrage de Manantali, les producteurs ont opéré une transformation significative de leurs pratiques agricoles.

La construction du barrage de Manantali a bouleversé la dynamique hydrologique du fleuve, tout en soulignant que les terres de décrue qui étaient marginalisées demeurent intégrées dans les stratégies agricoles des ménages jouant un rôle essentiel pour les populations les plus vulnérables (Poussin. J. C ; Dia, d et al. 2020). Cette transformation s'est traduite par une extension des terres de décrue (le *falo*) et une diversification vers des spéculations maraîchères à forte valeur ajoutée telles que la patate douce, le poivron, la tomate ou encore l'aubergine. Cette diversification a permis une amélioration sensible des rendements et une augmentation du revenu des ménages, certains atteignant des rentes annuelles de plus de 3 000 000 F CFA. Ces cultures sont souvent pratiquées par les producteurs locaux le long des berges, renforçant leur autonomie financière (Laurent Bruckmann, 2018). Parallèlement, la consommation domestique des produits de décrue a renforcé la sécurité alimentaire au niveau local, tant en termes de disponibilité que de qualité nutritionnelle. Les données révèlent également que 77 % des producteurs vendent leur récolte sur les marchés locaux ou régionaux, et que 23 % l'utilisent pour l'autoconsommation, notamment lors des périodes de soudure. Elles corroborent avec celles de Laurent Bruckmann, (2018) qui a montré que l'agriculture de décrue permet de sécuriser l'alimentation des familles. Ces apports stabilisent les revenus et réduit les risques liés à la dépendance à un seul système. Ainsi, Ndiaye 2017, montrent que la culture de patate douce comme facteurs positives influents sur le revenu agricole des ménages en complétant ainsi l'introduction de cultures maraîchères à haute valeur ajoutée stimulant les revenus.

Ces résultats trouvent un écho dans plusieurs travaux récents issus de la littérature scientifique. Ainsi, l'étude de Traoré B et al (2023), menée dans le cercle de Yélimané au Mali, souligne également la pertinence de l'agriculture de décrue pour renforcer la sécurité alimentaire en milieu sahélien. Les auteurs démontrent que ce système, en tirant profit de l'humidité résiduelle post-crue, permet d'étendre la période d'autosuffisance des ménages ruraux et d'atténuer leur dépendance à l'égard de l'aide alimentaire. Leurs observations rejoignent celles faites à Ballou sur la capacité de l'agriculture de décrue à générer des rendements stables dans un environnement à faible pluviométrie, tout en limitant le recours aux intrants externes.

Par ailleurs, les conclusions de Diop A et al (2022) sur les activités agropastorales dans la région de Matam, au nord du Sénégal, confirment que les systèmes agricoles extensifs et résilients comme la décrue constituent des piliers incontournables de la sécurité alimentaire et de la résilience communautaire face à la variabilité climatique. Les auteurs appellent à une meilleure prise en compte de ces pratiques dans les politiques agricoles, une recommandation qui fait écho à la situation observée à Ballou, où l'absence d'intégration institutionnelle freine le potentiel de développement de cette agriculture.

De manière complémentaire, l'étude conduite au Tchad par Magrin et al. (2015) sur les dynamiques pastorales et les pratiques agricoles des pasteurs sédentarisés autour du lac Fitri montrent que des populations autrefois spécialisées dans l'élevage adoptent aujourd'hui des cultures maraîchères saisonnières afin de stabiliser leurs revenus et assurer leur sécurité alimentaire. Cette reconversion vers une agriculture de décrue, motivée par la rareté des ressources pastorales et les mutations écologiques, révèle une dynamique d'adaptation comparable à celle observée à Ballou. Dans les deux cas, l'agriculture saisonnière sur terres de décrue devient un vecteur de transition socioéconomique, combinant production vivrière et intégration au marché.

La convergence de ces résultats met en évidence une réalité empirique forte : l'agriculture de décrue, longtemps considérée comme marginale, constitue un levier efficace pour répondre aux défis combinés de la sécurité alimentaire, de la pauvreté rurale et du changement climatique. Bien que les politiques agricoles formelles négligent souvent la décrue, mais plusieurs dizaines de milliers de ménages (34 588 en 2013, soit 6,6% des ménages ruraux) perçoivent encore cette activité comme essentielle à leur subsistance, surtout en cas de bonne crues (Fall. C. S. et al 2020). Pourtant, son potentiel reste largement sous-exploité en raison du manque de reconnaissance dans les stratégies agricoles nationales.

La faible structuration des filières, l'instabilité des prix, l'absence d'infrastructures de stockage ou d'accès au crédit, ainsi que les conflits d'usage des terres, sont autant d'obstacles qui limitent la durabilité de ces systèmes agricoles. En définitive, les résultats de cette recherche, confrontés à ceux de travaux menés dans d'autres contextes sahéliens, renforcent l'idée que la décrue ne doit plus être considérée comme une

survivance du passé, mais bien comme une pratique agricole moderne, efficiente et résiliente.

5. Conclusion

À l'issue de cette recherche, il apparaît de manière indiscutable que l'agriculture de décrue constitue un pilier fondamental de la sécurité alimentaire et du développement rural dans la commune de Ballou. Les résultats, issus d'enquêtes quantitatives et qualitatives, confirment l'existence de profondes transformations depuis la mise en service du barrage de Manantali. Ces changements ont favorisé l'extension des superficies de décrue ainsi que la diversification des spéculations agricoles. Cette dynamique a induit une hausse significative des rendements agricoles, une amélioration de la qualité nutritionnelle de l'alimentation, et une croissance notable des revenus des producteurs, contribuant ainsi à renforcer l'autonomie alimentaire des ménages et leur insertion dans les circuits commerciaux régionaux.

Loin d'être une pratique du passé, l'agriculture de décrue s'impose aujourd'hui comme une composante essentielle des futurs ruraux africains. En capitalisant sur ses atouts et en comblant les déficits d'appui dont elle souffre, elle peut devenir l'un des piliers majeurs de la souveraineté alimentaire et du développement local dans les zones les plus exposées aux crises globales.

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**GEOMORPHOLOGICAL ANALYSIS AND HUMAN SETTLEMENT
DISTRIBUTION IN THE LOWER DOFTANA RIVER BASIN (ROMANIA).
A CASE STUDY
OF THE SECIURI-BREBU MEGIEȘESC-DOFTANA-CÂMPINA ALIGNMENT**

Abstract. This article explores the relief characteristics of the Lower Doftana Basin (Romania) along the alignment of the Seciuri - Brebu Megieșesc – Doftana - Câmpina localities, and their implications for settlement distribution. The study is based on a Digital Elevation Model derived from 1:25 000 topographic data, complemented by landslides susceptibility data from ELSUS v.2 datasets and population statistics collected through Romania's 2021 Census. The results obtained show that the distribution of human settlements is influenced by relief, with the highest population concentrations being in sectors with relief energy and a medium to low susceptibility to landslides.

Keywords: morphography, morphometry, Doftana River Basin, GIS, relief-settlement relation

1. Introduction

The relation between natural landforms and human spatial organization represents a key topic in both physical and human geography. Geomorphological conditions play an important role in settlement distribution and density, land-use dynamics and infrastructure planning. The morphology of the terrain, hypsometry, geodeclivity, slope orientation and other characteristics

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of the relief influencing the accessibility, exposure and suitability for the land use (Haggett 2001). The Subcarpathians from Romania represent a complex geographical region with steep and moderate slopes and highly fragmented relief, conditions that significantly influence settlement patterns and regional organization. According to Baltălungă (2017), although the Subcarpathian is quite fragmented, it still has accessible corridors that have favored the development of human settlements in valleys and depressions. The great Romanian geographer Ion Conea, in 1931, stated about the Subcarpathians that “they seem to have been created from the beginning to shelter human settlements”. The Lower Doftana River Basin is one of the examples of the Subcarpathian area where we can capture the interaction between relief – settlements – human activities.

Regarding the Doftana River Basin, the scientific literature is marked by the comprehensive geomorphological study conducted by Armaş (1999). In this work, the author analyses key geomorphological components: morphographic and morphometric elements, tectono-structural and petrographic potential, genetic types of relief, evolution of the hydrographic network, current relief modeling processes, geomorphological risk. Previous geomorphological investigations and additional data on the study area are mainly included in studies addressing the Subcarpathian sector of the basin or regional syntheses of the Curvature Carpathians and adjacent areas. Armaş (1999) offers a detailed research history of the Doftana River basin, starting with the first references in the studies of the geographer Emmanuel de Martonne (1907) up to the geographical research of professor Mihai Ielenicz (1981 quoted by Armaş I. 1999). Despite its geographical importance, the area has received limited attention in terms of quantitative geo-morphometric analysis linked to spatial development.

The present study aims to identify the morphographic and morphometric characteristics of the Lower Doftana Basin, on the alignment of the Seciuri – Brebu Megieşesc – Doftana – Câmpina localities, and to explore their implications for settlement distribution.

2. Study area

The study area is located in the southeastern part of Romania, in the historical province of Muntenia, occupying the northwestern part of Prahova County

(Fig. 1). From a hydrographic point of view, the study area extends along the lower course of the Doftana River, a left tributary of the Prahova River. The area includes 18 km of the river's length and about 53 km², covering its lower sector, as determined using Geographic Information System (GIS)-based analysis.

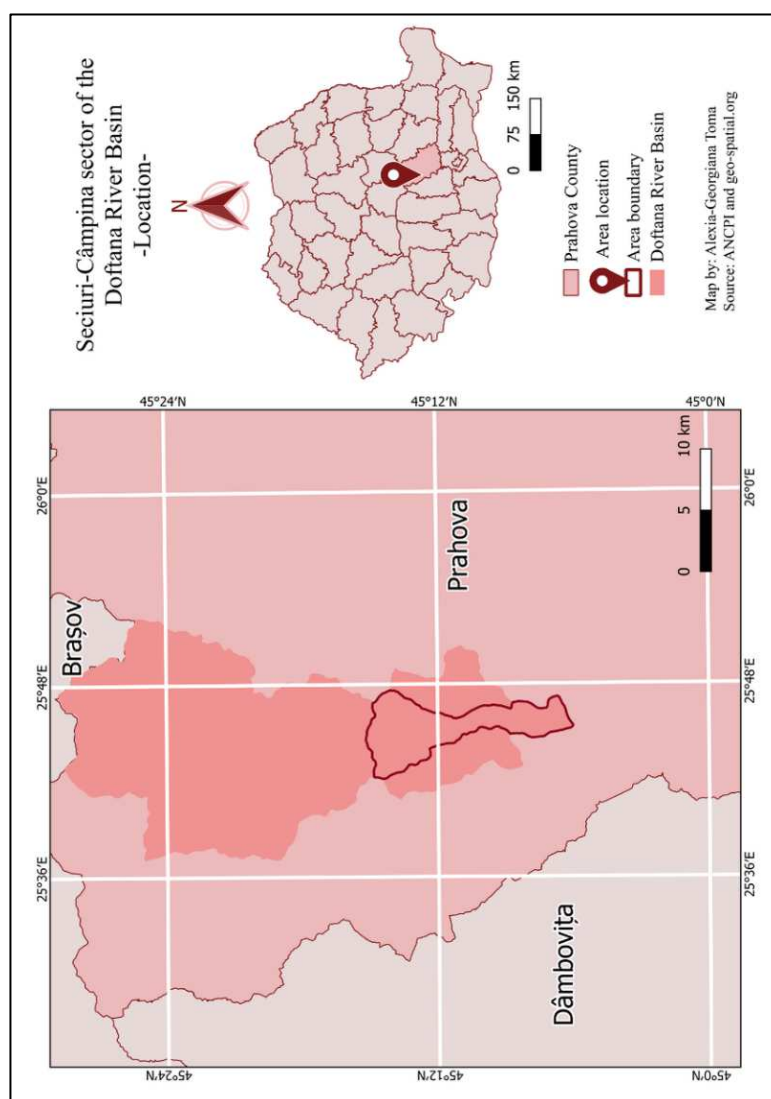


Figure 1. Location of the study area
(Source: ANCPI and geo-spatial.org)

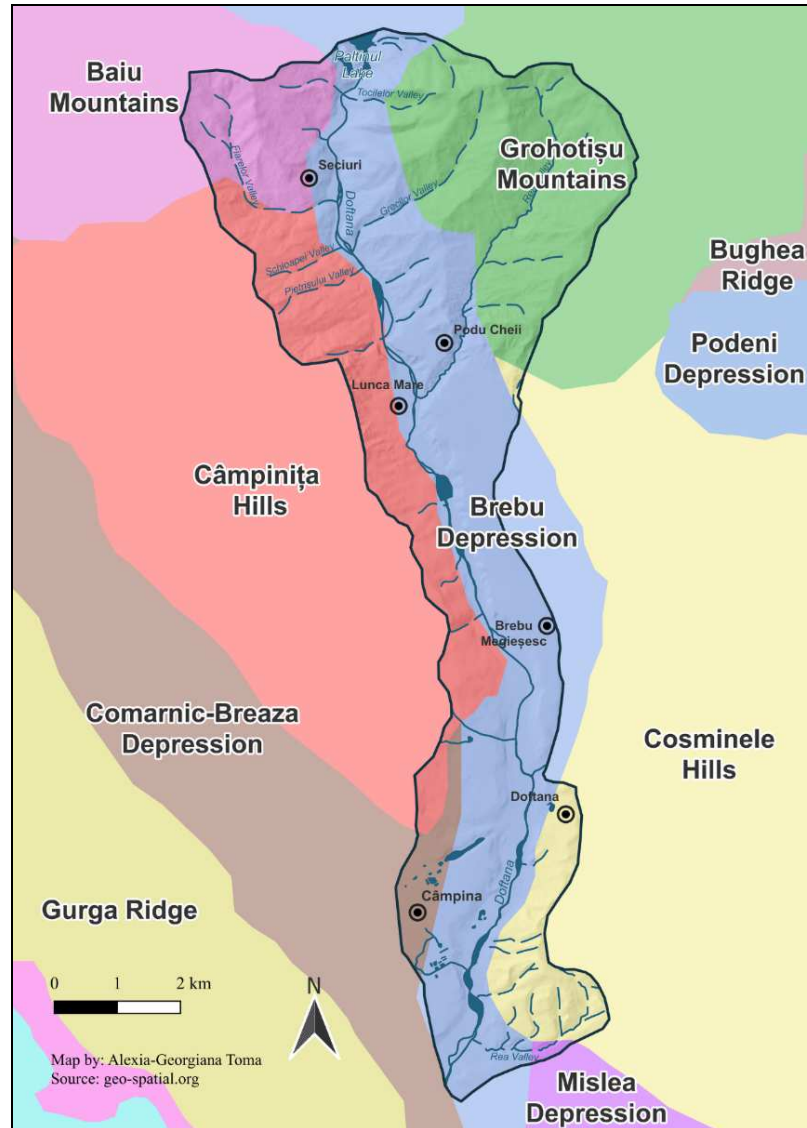


Figure 2. Distribution of relief units
(Source: geo-spatial.org)

Geomorphologically, the area overlaps primarily with the Curvature Subcarpathians (specifically the Prahova Subcarpathians) and a smaller portion of the Curvature Carpathians (namely the Baiu Mountains and Grohotiș Mountains). The relief units intersected include: Brebu Depression

throughout the study are in the north-south direction, Baiu and Grohotiș Mountains in the northwest and northeast, respectively, Câmpinița Hills to the central-west, Cosminele Hills to the east, Comarnic-Breaza Depression to the southeast, a small portion of the Mislea Depression to the south. The arrangement of these relief units reveals the geomorphological complexity of the area: mountainous region in the north (Baiu and Grohotiș Mountains), hilly region in the center, a transition zone from hills to plains in the south (Fig. 2).

The Doftana Valley runs transversely over an anticlinal-synclinal alignment, and the orientation of its tributaries is longitudinal (Armaș 1999). Clayey and marl-clay rocks, found in over 12% of the area (Fig. 3 a), play an essential role in the emergence of geomorphological processes. Combined with steep slopes and water infiltration into clay and schist layers, they create favorable conditions for landslides. Most of the area (72%) is covered by schists, sandstones, marls, and clays. Salt diapirs, gypsum, clay-schists, and sandstones cover less than 2%. Gravels and sands make up about 26% (Fig. 3 a) of the region, especially near rivers and streams. These deposits largely correspond to the fluvial terraces of Câmpina and Brebu and are composed of recent and subrecent alluvium, as well as Meotian sediments. The mountainous area consists of Senonian, Paleocene and Eocene sedimentary formations, together with Oligocene and Senonian flysch deposits (Fig. 3 b). According to Armaș (1999) "relief influences the intensity of current geomorphological processes through its degree of fragmentation, which determines the proportion of slopes in valleys, interfluvies, and riverbeds, as well as their differential exposure to energetic fluxes crossing the system." Following the 1977 earthquake, measurements confirmed that south-facing slopes retreated 5–7 times more than north- or west-facing slopes (Armaș 1999).

The studied area includes six settlements: Seciuri, Podu Cheii, Lunca Mare, Brebu Megieșesc, Doftana and Câmpina (Fig. 4 a). The built-up areas represent 16% of the analysed area, which shows a development of the settlements adapted to the local conditions of relief and accessibility. The largest share is held by forested areas, which represent 34% of the analysed area. The second place is occupied by agricultural lands (20%), which are concentrated especially in low and relatively stable sectors (Fig. 4 b).

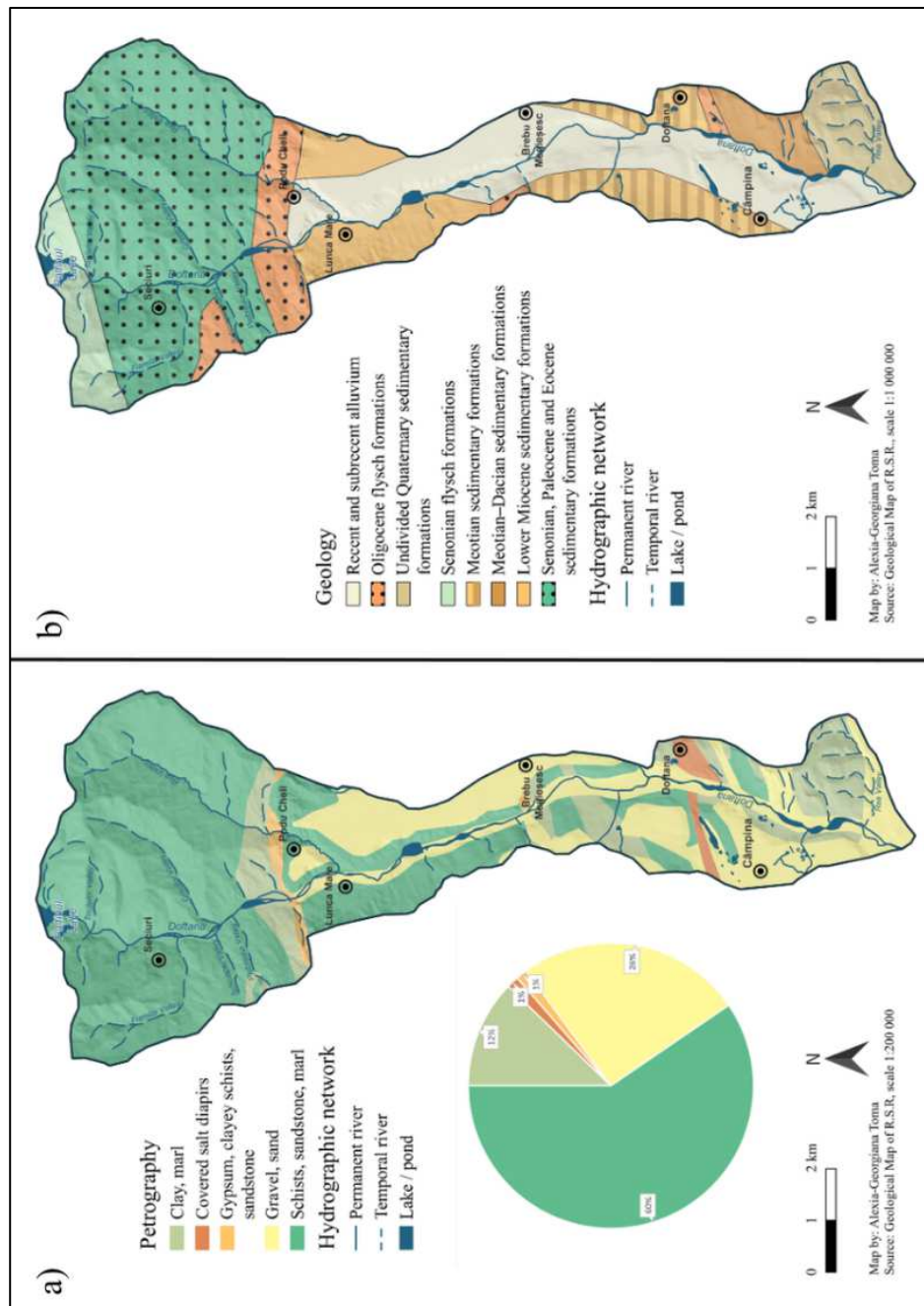


Figure 3. a) Petrography map b) Geology map
(Source: Geological Map of R.S.R., scale 1:200 000 and 1:1 000 000)

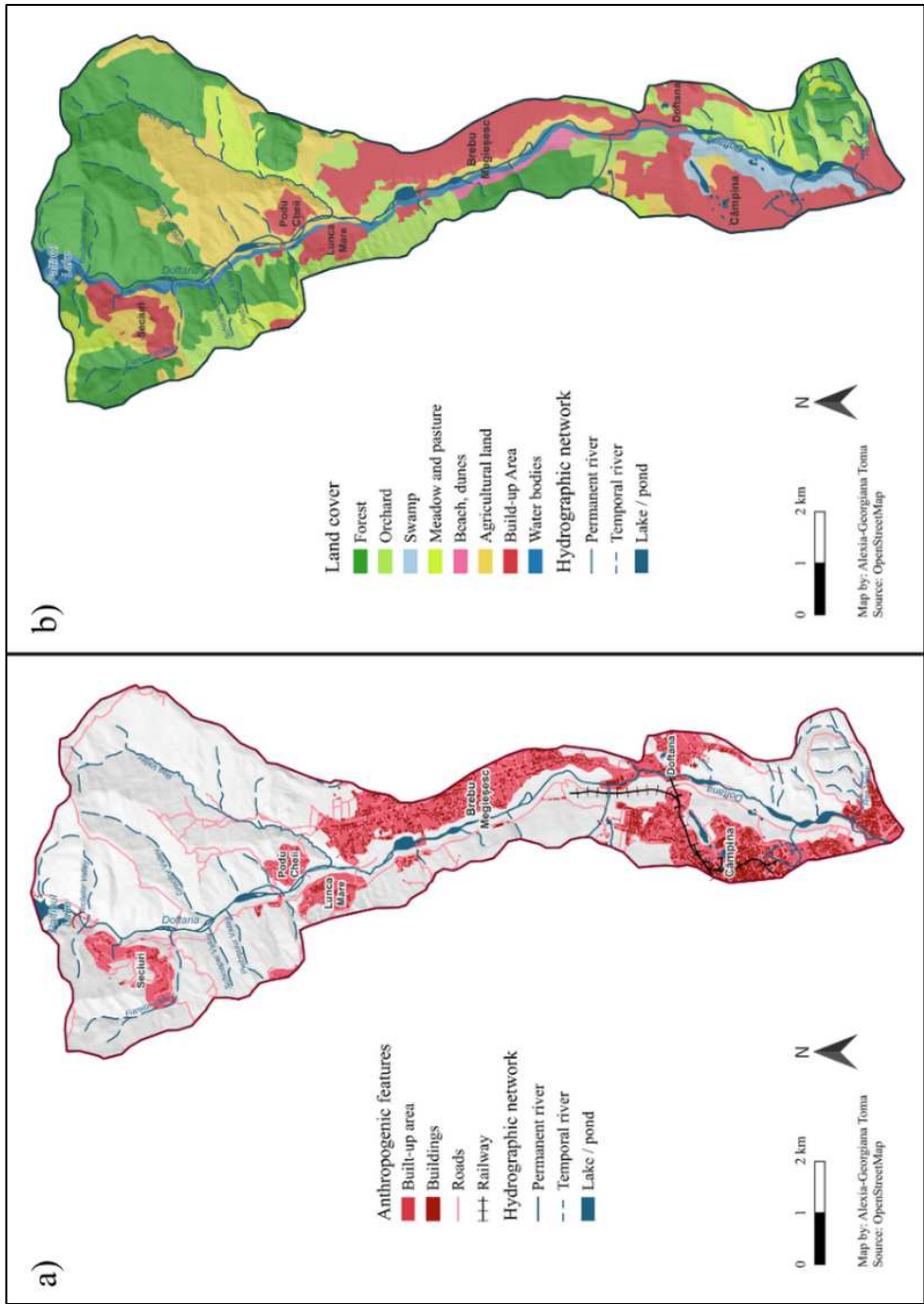


Figure 4. Distribution of the human settlements
(Source: OpenStreetMap)

The anthropic factor influences the relief through economic activities carried out in the area. In the studied zone, the main human interventions impacting the relief include construction of settlements, deforestation and soil pollution with hydrocarbons, due to the exploitation of numerous local oil fields. According to Armaş (1999), there are two categories of anthropogenic geomorphological landscapes: a lightly human-modified agro-pastoral landscape, typical of the mountainous area and a strongly a human-modified agro-industrial landscape, typical of the Subcarpathian zone. To this second category, we can also add the urban-industrial landscape found in the city of Câmpina.

3. Methodology

The methodology focuses on analysing the relief and their implications for settlement distribution and organisation, using geospatial data (table 1) and Geographic Information System (GIS) techniques. The first stage involves creating a Digital Elevation Model (DEM) based on the contours lines and altimetric points from the 1:25.000 Romanian Topographic Map.

Triangulated Irregular Network (TIN) interpolation method was used to combine the two datasets, which resulted in the DEM used for the analysis, with a spatial resolution of 25 meters. The Topographic Map of Romania, scale 1:25.000 is available on the OpenGIS Server for students, teachers and researchers from Faculty of Geography (University of Bucharest) following an agreement between the institution and the Military Topographic Directorate (currently Defense Geospatial Information Agency "Division General Constantin Barozii").

In the second stage, based on the DEM, the main landforms were extracted and a series of morphometric parameters (hypsoetry, geodeclivity, slope aspect, relief energy and fragmentation density), were calculated. The relief classification included in the study utilises an algorithm developed by Jasiewicz and Stepinski (2013), which calculates the forms using a machine-vision technique called geomorphons.

Table 1

Datasets used in the analysis

Dataset	Format	Source
Contour lines	Vector – ESRI Shapefile	Topographic map of Romania 1:25 000 (1975-1980) – Military Topographic Department (currently Defense Geospatial Information Agency “Division General Constantin Barozii”)
Altimetric points		
Landslide susceptibility	Raster	European Landslide Susceptibility Map version 2 (ELSUS v2) – ESDAC European Commission – https://esdac.jrc.ec.europa.eu/
Geology	Vector – ESRI Shapefile	Geological Map of Romania 1:1 000 000 (1978) – Geological Institute
Petrography	Vector – ESRI Shapefile	Geological Map of Romania 1:200 000 (1960-1968) – Geological Institute
Geomorphology	Vector – ESRI Shapefile	Geomorphological Map of Romania 1:1 000 000 (1976) – Geography Institute; Armas I. (1999)
County boundaries of Romania	Vector – ESRI Shapefile	National Agency for Cadastre and Land Registration (ANCPI)
Land use	Vector – ESRI Shapefile	OpenStreetMap (OSM) – https://extract.bbbike.org/
Buildings		
Roads		
Railways		
Settlements		
Population Data	Raster	The National Institute of Statistics of Romania – The Romania’s 2021 Census – data processed by geo-spatial.org

Source : Author’s own elaboration based on data from multiple sources

The algorithm can be accessed through the *r.geomorphon* module. It results in 10 classes based on the distribution and structure of the values of neighboring pixels: flat, peak, ridge, shoulder, spur, slope, pit, valley, footslope, hollow (Ioniță et. al. 2024). Hypsometry was obtained by classifying the DEM into hypsometric intervals, set every 100 meters. The geodeclivity and slope aspect were calculated using the *r.slope.aspect* module, which calculates values based on a 3x3 neighborhood in the raster elevation map (GRASS Development Team, 2022). For the classification of the geodeclivity in slope classes we used the Grigore’s classification from 1979 (cited by Săndulache, 2015). The relief energy and fragmentation density were calculated by the method of squares.

For the assessment of landslide susceptibility, we employed the ELSUS v.2 dataset, which was developed using the same semi-quantitative methodology applied in ELSUS 1000. This approach integrates landslide frequency ratio information with a spatial multi-criteria evaluation model based on three thematic predictors: slope angle, shallow subsurface lithology, and land cover. The updated map also incorporates an expanded landslide inventory, providing approximately 30% more locations for model calibration, map validation, and classification, and a revised lithological dataset derived from the International Hydrogeological Map of Europe (IHME). The latter covers a large portion of Europe at a spatial resolution of 200 m (Wilde et al. 2018).

All maps for this study were created in the Dealul Piscului 1930/ Stereo 70 projection (EPSG:31700). The software programs used for the study are QGIS (version 3.26) and GRASS GIS (integrated into QGIS) for generating maps and numerical data, Microsoft Excel for graphical representation of numerical data, Inkscape and Canva for graphic refinement of the results.

4. Results

4.1. *Landforms classification map*

The landforms classification map shows an integrated view of the geomorphological structure of the study area. The largest part of the studied surface is covered by slopes (52%), indicating a fragmented relief, with high potential for slope processes (torrentity, landslides). Totally flat surfaces occupy approximately 8% of the area, being located especially on terraces and floodplain sector, areas favorable for settlements and agricultural activities (Fig. 5 a). The main valley is that of the Doftana River, located in the center of the study area. On both sides are valleys of temporary or seasonal rivers, as well as valleys of permanent rivers, a total of 22. Of these, only four are valleys of permanent rivers. The most important secondary valleys here are: Valea Fiarelor, Valea Șchioapei, Valea Pietrișului on the right bank, and Valea Tocilelor, Valea Grecilor, and Valea Rea on the left bank.

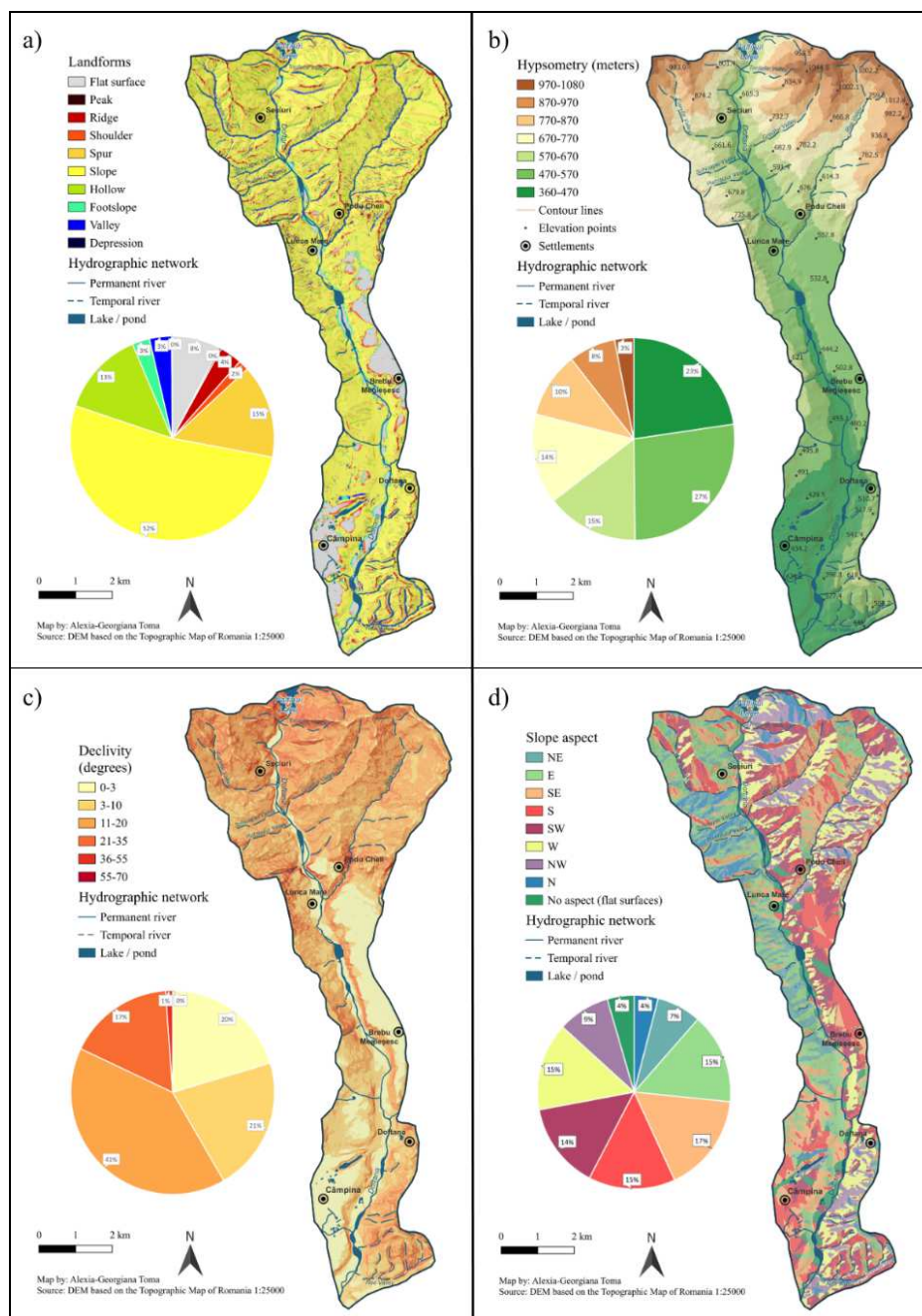


Figure 5. a) Landforms; b) Hypsometry; c) Slope; d) Slope aspect
(Source: DEM based on Topographic Map of Romania 1:25 000)

Within the study area, two types of interfluves can be found: flat and rounded (Armaş 1999). "Flat interfluves, initially much broader, are gradually transformed, through the branching and headward (regressive) advance of tributaries, as well as through slope evolution, into rounded sectors or even into a series of erosion remnants separated by wide saddles" (Armaş 1999: 94). In the studied area, these interfluves are located in the central and southwestern parts (identified on the map as flat surfaces), and today they form the main interfluves: Prahova–Doftana, Doftana–Lupa, and Lupa–Mislea (Armaş, 1999). Rounded interfluves are represented by the remaining interfluves in the territory.

4.2. Morphometric characteristics

The hypsometric map highlights the altimetry of an area, divided into hypsometric classes. It is based on the absolute elevation indicated by contour lines, which allows the assessment of the heights of each relief step (Săndulache 2015). Depending on the general distribution of altimetric values at the level of the lower Doftana River basin and the maximum difference of 1044.5m, regular hypsometric intervals were chosen, in principle, every 100 meters. So, according to the Fig. 5 b), in the studied area, the highest elevations (1044.5 m, the highest spot height, and 1,080 m, the highest altitude deduced from contour lines, both in the Grohotișu Mountains) are found in the northern part, in the transition zone between mountains and hills. At the transition between hills and plains, in the Doftana River valley, the lowest altitudes are found (377.4 m, the lowest spot height, and 365 m, the lowest altitude deduced from contour lines) within the area. The average altitude is 715 m. The largest surface area (27%) falls within altitudes of 470–570 m. Moreover, although elevations reach 1.080 m, half of the area lies below 570 m.

Regarding geodeclivity, there is a predominance of surfaces with moderate or sharp inclination, which reflects a fragmented hilly and mountainous relief. Slope classes between 11°-20° and 21°-35° represent approximately 58% of the total, highlighting a strong geomorphological potential with possible linear erosion, landslides and/or solifluction (Săndulache 2015). Steeper slopes are found almost entirely in the transition

zone between the mountains and the hills, in the northern part of the area. Another zone with somewhat steeper slopes is found in the southeast, in the Cosminele Hills. They cover approximately 18% of the area and do not exceed inclinations greater than 55° . Very slightly inclined surfaces, respectively with a small inclination (below 10°) amount to 41% of the total analyzed surface. These are concentrated especially along the Doftana River, in the floodplain sector, but also on the bridge of its two terraces, where the localities of Cămpina and Brebu Megieșesc are located (Fig. 5 c).

The aspect of slopes determines the duration of sunlight received by surfaces. Together with slope steepness, slope aspect influences the thermal regime of the surfaces. The thermal regime is an important factor in the organization of agricultural activities. Slope aspect also determines vegetation inversions, the layout of technical works, landform modeling, and more (Săndulache 2015). According to their orientation, slopes are classified into four categories: sunny – S, SW (28%); semi-sunny – SE, W (21%); semi-shaded – E, NW (21%); shaded – N, NE (30%) (Fig. 5 d). From the strict perspective of slope aspect, the left bank of the Doftana within the study area is the most favorable for agriculture, as it is the sunniest.

The depth of relief fragmentation represents the difference between the maximum and minimum altitude (m) within each square (1 km^2). Relief energy has its highest values, over 546 m/km^2 , in the northern part of the area, closest to the mountainous region. Minimum values appear in areas with the smallest slopes, which coincide with the most humanized zones. Thus, the northern part has very high relief energy, while the southern part has very low relief energy. The central area serves as a transition between the two. High relief energy values cover 30% of the area (Fig. 6 a), making them the most common at the level of the entire study area.

Relief dissection density represents the ratio between the length of the hydrographic network (km) and the area (1 km^2), highlighting the morphodynamic potential of the relief. Low values, $0\text{--}4 \text{ km/km}^2$, are usually recorded in flat areas (Fig. 6 b), which correspond to the terraces of the Doftana River. These values are the most frequently found across the study area (28%). The highest values are recorded at the upper limit of the area and in the southeastern part, reaching maximum values of 18 km/km^2 .

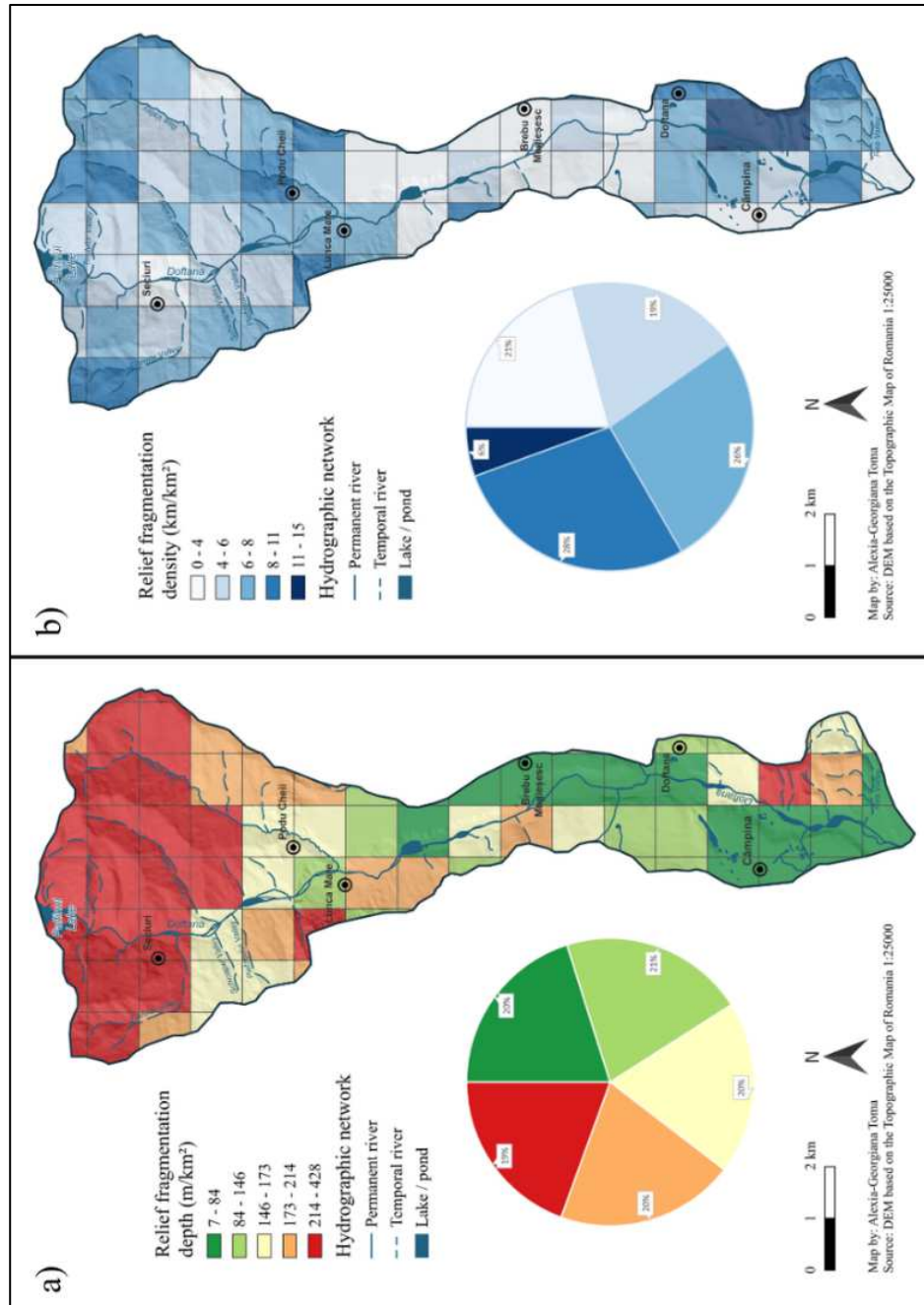


Figure 6. a) The depth of relief fragmentation; b) The relief fragmentation density (Source: DEM based on Topographic Map of Romania 1:25 000)

They occupy only 15% of the area (Fig. 6 b), making them the rarest values found on the map. Overall, the relief dissection density is relatively uniform throughout the study area. However, lower values tend to be slightly more common than higher ones.

4.3. Landslides susceptibility

The studied area is characterized by moderate altitude (over 800-1000 m) and a lithological complex formed by layers of hard rock such as sandstone, which alternate with layers of soft rock (marls and clays). Also, according to Rujoiu-Mare et al. (2016) the region is crossed by a dense network of faults and presents a highly fragmented relief, on which significant anthropogenic interventions and a varied land cover are superimposed. All these characteristics influenced an intense spatial pattern of geomorphological processes (Fig. 7). Landslides are one of the most dynamic, active and intense processes in the Subcarpathian region, representing a significant issue in territorial management and spatial planning (Rujoiu-Mare et al. 2016).

In the low-altitude area the floodplain and the terraces of the Doftana River are present. In this area, landslides occur at the contact between the terrace slopes and the floodplain (Fig. 8 a). As highlighted by Posea (2006a), “the hilly region is characterized by steep slopes and pronounced fragmentation, accompanied by landslides and intense soil erosion. These degradation processes are further intensified by the predominance of soft rocks (clays, marls, sands), as well as by deforestation, intensive grazing, and, in some cases, plowing”). In the vicinity of the locality of Seciuri lies the Doftana Gorge (Fig. 9 b), characterized by steep slopes affected by surface erosion and shallow landslides or shallow debris slides. Eroded slopes are also present south of the Doftana Gorge, in the vicinity of the locality of Lunca Mare, at the confluence of Doftana River with Rea Valley (Fig. 9 a).

The landslides susceptibility map for the analyzed area reveals a qualitative overview of areas with five susceptibility classes: very low, low, medium, high and very high (Fig. 8 b).

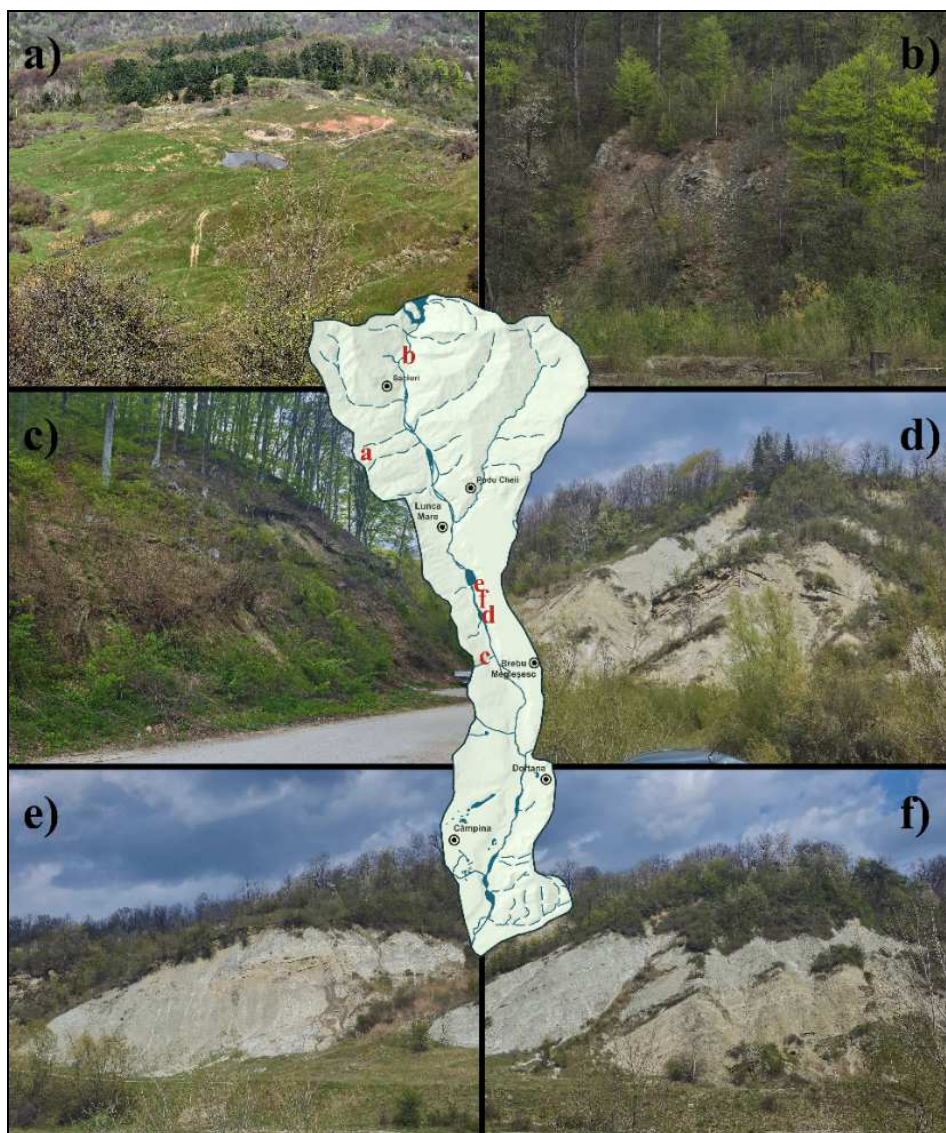


Figure 7. Active geomorphological processes observed in the study area (April 2026):
a) Landslide; b) Shallow debris slide; c) Shallow landslide; d, e, f) Surface erosion and gullies
(Source: own elaboration)

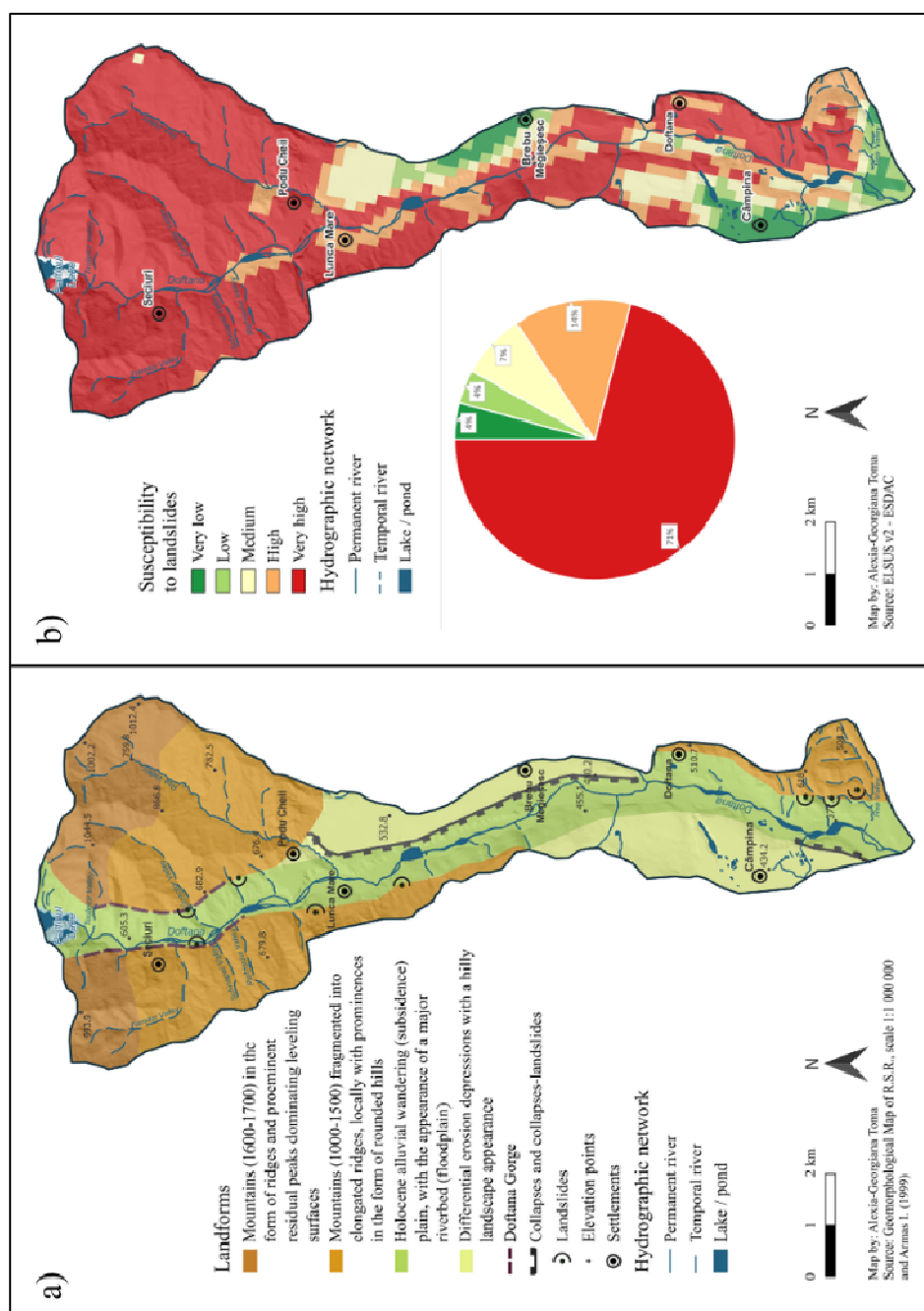


Figure 8. a) General Geomorphological Map; b) Landslide susceptibility map
(Source: Geomorphological Map of R.S.R., scale:1 000 000, Armas I. (1999) and ELSUS v2 – ESDAC)

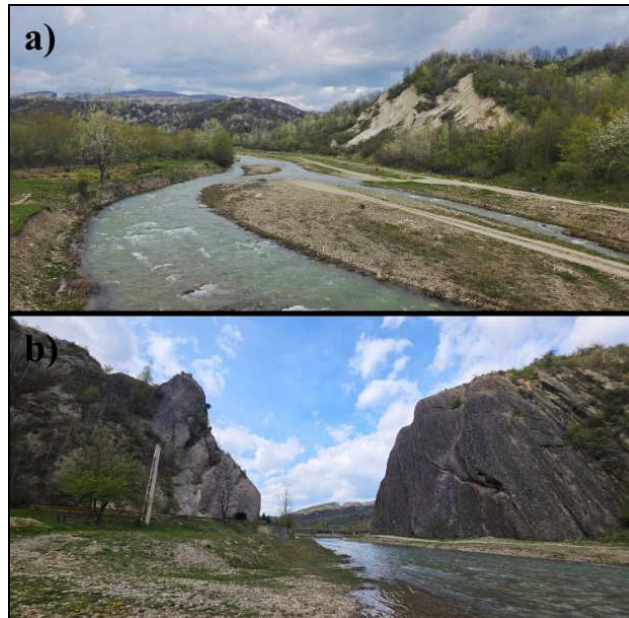


Figure 9. a) Doftana floodplain near Lunca Mare; b) Doftana Gorge (April 2026)
(Source: own elaboration)

The areas with very low landslide susceptibility match to the stable areas represented by the terrace treads such as Brebu and Cămpina terrace where localities with the same names are developed. On the other hand, terrace fronts are susceptible to landslides but also to other geomorphological processes preceding landslides (such as deep erosion, torrentiality). For example, in the Brebu terrace area, slopes are strongly affected by rill erosion and dissection, forming gullies and ravines, which may evolve into massive landslides and unstable zones called “badlands.” These landslides contribute to the transfer of material into the riverbed (Armaş 1999).

5. Discussion

The relationship between relief and human spatial organization is an essential aspect of regional geography, especially in areas where geomorphological processes actively influence land stability and accessibility. In the study

area, morphological (morphographic and morphometric) characteristics play an important role in the distribution and density of settlements. They also reflect the functional relationship between the slopes and Doftana Valley. Slopes act as sources of materials as a result of erosion processes and mass movements, while the valley and riverbed as the main axes of transport and accumulation. This interaction directly influences the spatial constraints and opportunities for human settlements. Similar aspects have been identified in neighboring Subcarpathian regions, such as the Prahova Valley (Vartolomei and Armaş 2010). Table 2 shows how the relief characteristics control the distribution and development of localities. Settlements located in mountainous units (Seciuri, Lunca Mare) have high average altitudes and a higher relief energy, factors that lead to very high susceptibility to landslides. These conditions represent a significant constraint in the development of localities and infrastructure. For example, at the level of the administrative unit of Şotrile, which includes the villages of Seciuri and Lunca Mare, the population is under 3500 inhabitants as shown by the population distribution map (Fig. 10).

A similar pattern is observed in the case of Doftana village, which is part of Telega commune. The area is characterized by a hilly relief and a high susceptibility to landslides, which leads to a limitation in the expansion of settlements and a smaller number of inhabitants.

In contrast, localities such as Brebu Megieşesc and Câmpina, located on fluvial terraces, benefit from low altitudes, slopes and lower relief energy, which favors the development of settlements, land stability and a medium to low susceptibility to landslides. Between the two, the larger population is concentrated in Câmpina – the most important locality from the study area due to its urban functionality and position in the proximity of a major circulation axis (DN1) with access to the Prahova Valley – one of Romania's major tourism and transport corridors. Brebu Megieşesc is part of the Brebu Territorial Administrative Unit (TAU), which includes three other villages, including Podu Cheii. In the Subcarpathian sector, the expansion of settlements influences the occurrence of geomorphological processes such as landslides. Older buildings are typically located on terraces, while newer constructions are scattered across peripheral and hilly areas and only rarely on terraces, thus becoming a contributing factor to landslide development (Vartolomei and Armaş 2010).

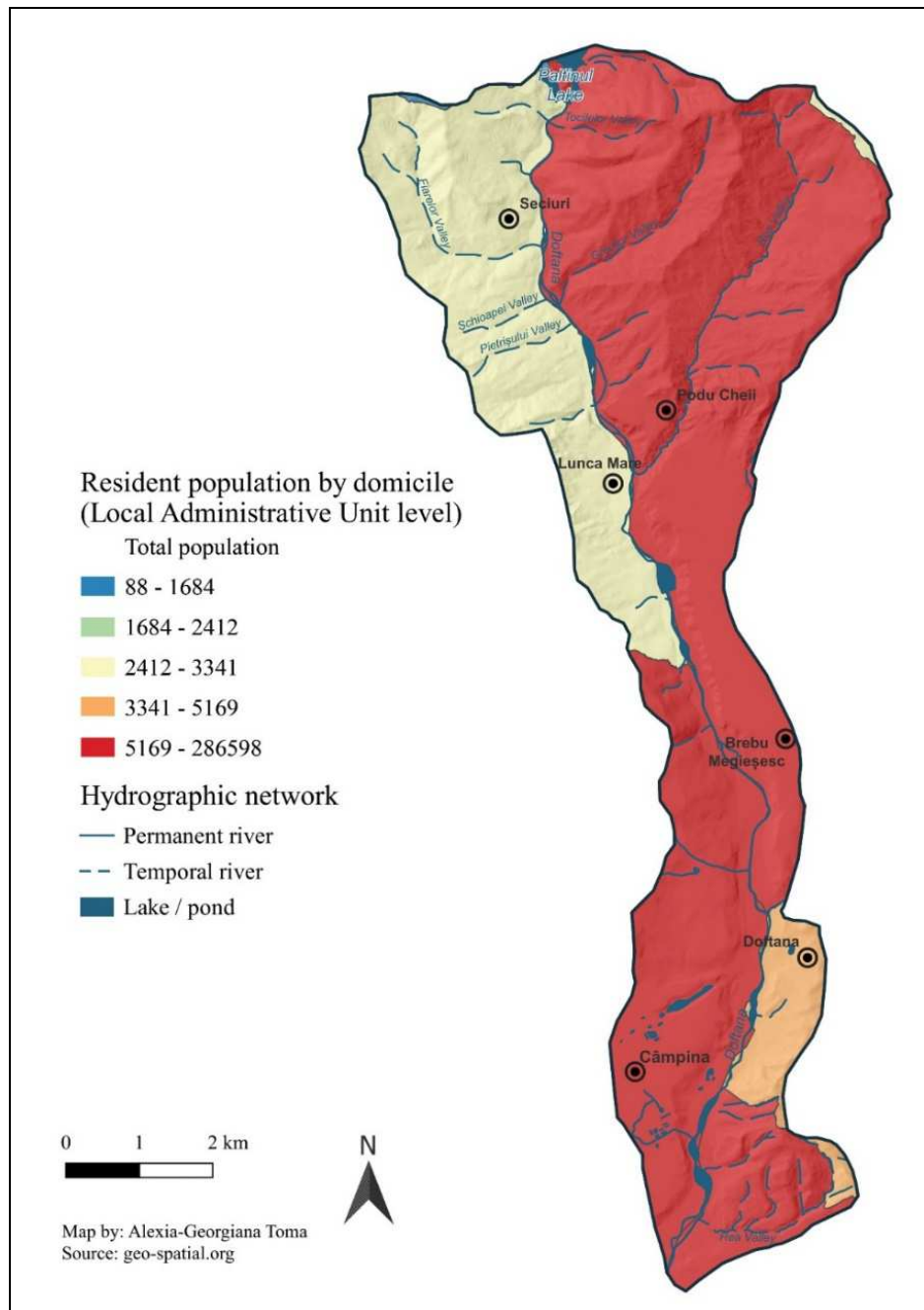


Figure 10. Resident population by domicile (in 2021)
(Source: geo-spatial.org)

Table 2

Statistical summary of geomorphological parameters and land cover at localities level

Locality	Relief Unit	Mean Altitude (m)	Mean Slope (°)	Mean Relief Energy (m/km ²)	Land Cover	Land Slides Susceptibility
Seciuri	Mountains	670.6	17.6	627	Built-up area, Agricultural, Water, Forest	Very high
Podu Cheii	Depression	556.7	8.4	379	Built-up area, Agricultural	Very high
Lunca Mare	Hills	515.8	9.4	485	Built-up area, Orchards, Water	Very high
Brebu Megieșesc	Depression	501.9	4.3	195	Built-up area, Orchards, Agricultural, Water	Medium
Doftana	Hills	467.0	10.5	352	Built-up area, Orchards	Very high
Câmpina	Depression	431.5	2.3	152	Built-up area, Agricultural, Orchards, Marshes, Water	Low

Source: Author's own elaboration based on GIS analysis

Overall, this comparative interpretation highlights the fact that relief is among the natural factors that can favor or constrain population concentration in mountainous and hilly areas.

To protect settlements, several measures can be implemented for slowing down or preventing landslides, the greatest hazard in the area: “contour ploughing, avoiding overgrazing, constructing gently inclined terraces with reinforced fronts or planted with shrubs and provided with drainage ditches, and afforestation” (Posea 2006b). Furthermore Posea (2006b) emphasizes that, in some cases a landslide can be prevented by just a few well-placed drainage ditches that ensure the runoff of water which could otherwise trigger slope failure.

6. Conclusions

The present study shows the role of geomorphological conditions in population concentration and settlement distribution. The Lower Sector of the Doftana River Basin is characterized by moderate altitudes, which decrease from north to south (from 1080 to 365 meters). The same trend can be observed for the slopes, as well as for the depth of the relief fragmentation. Although some human settlements (Seciuri, Podu Cheii) are present in areas with higher relief energy and very high susceptibility to landslides, the majority of the population is concentrated in localities (Câmpina, Brebu Măgheșesc) situated in areas with a more stable relief (flat surfaces, gentle slopes, low relief dissection) and a medium to low susceptibility to landslides. Datasets from multiple sources were used for this analysis: from National Topographic Map to European Landslide Susceptibility Datasets, from OpenStreetMap to the 2021 Romanian Census. All of these data used in the analysis helped to highlight the fact that the relief characteristics and geomorphological processes (such as landslides) influence the accessibility, exposure and distribution of the human settlements.

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CHALLENGES CONFRONTING PHYSICAL PLANNING ADMINISTRATION IN SOUTHWESTERN NIGERIA

Abstract. This study examined challenges confronting physical planning administration in Southwestern Nigeria. This may not be unconnected with the institutional set-up of the study area. This study would suggest the elimination of administrative practices that are harmful to the physical environment for effective physical planning administration across states. Both primary and secondary data were utilized for the study. The primary data used for the study were generated from field survey through quantitative and qualitative techniques. Lagos and Osun States will be randomly selected from the two planning administration systems in South Western States. This research work therefore utilized 0.5% of the household size in the selected local governments which translates to a sample size of 2,682 persons. Both descriptive statistics and inferential tools were utilised for the study. shows that the most important challenges of physical planning administration in Lagos were: poor monitoring (MIS = 4.09); lack of a development plan (MIS = 3.96); inadequate office accommodation (MIS = 3.64); poor funding (MIS = 3.62); and other challenges of physical planning administration in the study area are also fairly high. The governments at all levels should maximally leverage their powers to surmount the challenges confronting physical planning administration in Southwestern Nigeria, such as bribery and corruption, poor staff strength, inadequate tools and equipment, political interference, overlapping functions, shortage of experienced and qualified personnel, poor funding, and inadequate office accommodation. Based on the findings, it can be concluded that stakeholders in physical planning administration were distributed across the offices of the MDAs in Lagos State, Ondo State and Osun State.

Keywords: physical planning, compliance, regulations, administration

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1. Introduction

The state of any nation's physical environment determines its economic and social well-being (Adeyemi, 2016). It has been confirmed that coordinated development occurs in sophisticated nations. The physical environment is plagued by physical planning issues in emerging countries like Nigeria. These include haphazard development, poor waste management, insecurity, inadequate infrastructure, inappropriate land uses, rural-urban migration, and the growth of ghettos, slums, and squatter settlements, among other things. If the situation continues, it would not only deplete the physical environment's capacity for energy production, but it will also negatively impact the citizens' health and wellness. In essence, an efficient physical planning and administration promotes a functional physical environment. In other words, efficient physical planning administration must be sought to guarantee that activities related to physical planning are carried out without endangering the interests of the present and future generations (Wahab, Egunjobi & Falola, 2014; Le-ol Anthony & Ihunwo, 2022; Jelili, Ajibade & Alabi, 2023).

The implementation of physical planning has not resulted in the spatially efficient development of urban areas of the country not to talk of the rural areas. This is due to the fact that in the face of environmental decay and degradation, physical planning administration has not assumed the role of a preventative medicine. In addition, Nigerian planning officials have primarily concentrated on the curative aspects of the anomalies of urban growth over the years (Olowoporoku, et al., 2017; Adeoye, Ayanda, and Ajayi, 2023). The regulatory and administrative structures that govern physical development are being blamed for Nigeria's chaotic physical environment (Abubakar et al., 2022). The proliferation of shanties and squatter settlements, lack of basic social infrastructure, poorly built roads, residents' lack of awareness of the value of physical planning, political interference and other factors are examples of ineffective physical administration in the South-western States. There is a need to examine physical planning activities in the composite States of the Southwestern Nigeria. This would give room for the evaluation of administrative practices in each state and composite states. Apart from this, it would suggest the elimination of administrative practices that are harmful to the physical

environment for effective physical planning administration across States (Adeniyi, 2015; UN-HABITAT, 2019).

Despite efforts made by scholars, governmental and commercial institutions, community-based organizations, and private individuals in the past to proffer solutions to physical planning difficulties, physical planning challenges still persist. Information on what could be done to establish foundations for successful development and guarantee effective and efficient administration of physical planning in the nation is hardly available. The physical environment is beset by issues with physical planning as against ideal situation (Wahab, 2017; Mandeli, 2019; Adedeki, Junaid and Sanni, 2023).

Many environmental problems require that solution be explored from multiple-point of ignorance (Isife, 2012). To make wise decisions about how to tackle the foregoing and arrange spaces, policy makers need the indigenous knowledge and practices of physical planning and administration. Sadly, it appears that these policies are not being put into action. The execution of physical plans and policies and mechanisms for regulating physical growth has long since lost their effectiveness. Equally, the required financial contributions on the implementation of physical planning over time seem not to be given priority in governance. Therefore, it is essential to conduct a comprehensive study of the planning and management of the totality of physical environment.

This study will reflect the concern of the public about the way their city develops and possible factors for non-implementation of physical planning plan and policies. Also, the challenges confronting officers saddled with the administration of physical planning in the States will be exposed for government intervention. Effective administration of land is an integral factor in promoting a healthy environment not only in urban centres but also the hinterlands. Therefore, pin-pointing the challenges of planning administration is the first step towards ensuring a liveable and sustainable environment in the study area.

The findings from the study will help to create policies for slum prevention, water and electricity supply, environmental quality, and environmental health, among other things. In addition, this study could be used as a template for effective development planning in other States across the nation and abroad that have comparable physical and socioeconomic

characteristics. Based on the aforementioned, it is currently seen necessary to conduct research of this kind to evaluate challenges of physical planning administration in Southwestern Nigeria utilizing the selected states (Lagos, Ondo and Osun) as a case study.

2. Methodology

Two types of data were obtained for the study. These are primary and secondary data. The primary data used for the study were generated from field survey through quantitative and qualitative techniques. Secondary data were extracted from the urban and regional planning laws, development plans of the cities, documentary and records of planning agencies, journals books and internet. Data extracted were majorly the financial contribution of Government as capital votes and the ones released for the implementation of physical planning. Maps and estimated number of houses as well as population figures were also obtained from secondary sources.

The South West region comprising of Lagos, Ogun, Oyo, Osun, Ondo and Ekiti is selected for this study because it is the most urbanized of all the geo-political regions in Nigeria (Nwaka, 2005). Adeyemi (2016) revealed that administration of physical planning in Lagos, Ogun, Ondo and Ekiti States is close due to its centralized planning system, while in Oyo and Osun States still operate Local Planning Authority System. Lagos and Osun States will be randomly selected from the two planning administration systems in South Western States. Structured questionnaire was administered to the household head notably, the landlord. In case the landlord is unavailable, the questionnaire will be administered to tenant who has been resident in the house for a considerable number of years. This research work therefore utilized 0.5% of the household size in the selected local governments which translates to a sample size of 2,682. Information obtained among others are socio economic characteristics of the developers and residents but as well as their perception on how physical planning administration affect level of enforcement and compliance to existing planning laws in the study areas. Both descriptive statistics and inferential tools were utilised for the study.

3. Results

3.1. Challenges Confronting Physical Planning Administration in Southwestern Nigeria

This section discusses the challenges confronting physical planning administration in southwestern Nigeria, with particular reference to the sampled states. The challenges identified include and are not limited to bribery and corruption; poor staff strength; inadequate tools and equipment; political interference; overlapping function; shortage of experienced and qualified personnel; nature of residence; poor funding inadequate office accommodation lack of development or landing or master plan poor monitoring delay in response to petitions; and delay in the processing of approval development plans. The challenges are rated on a 3-point Likert scale: high, fairly high, and not high.

As contained in Table 1, challenges are evident in all physical planning institutions in the sampled states. In Lagos State, it was revealed that 2.90% and 1.50% of responses confirmed that the challenges are respectively high and fairly high. This implies that 20.7% opined that the challenges are not high. Attempts at looking at the responses gotten from Ondo state that the challenges rated high, fairly high, and not high are represented by 55.2% 16. 3% and 23.6% respectively. Similarly, perceptions of the staff of physical planning institutions in Osun state indicate that the challenges of physical planning are pronounced. 71.8%, 8.5%, and 19.7% of the responses indicate challenges are respectively high, fairly high, and not high.

Further findings revealed that Osun State has a higher prevalence of these challenges than other studied states. This may not be unconnected with the institutional set-up of the state. Further investigation reveals that the challenges of poor staff strength; inadequate tools and equipment and political interference are high in Lagos State compared to other challenges. This may be attributed to the urbanization trend and high population density in the state. Similarly, the challenges of poor staff strength and inadequate tools and equipment are rated high on the Likert scale in Osun state. Other challenges are a shortage of experienced and qualified personnel; absence of enabling law; poor funding; inadequate office accommodation; and lack of development/ land use/ master plan. The responses indicate prevalence of these challenges in Osun state may not divulge from the non-domestication of urban and regional planning laws like other sampled states.

Table 1

Challenges of Physical Planning Administration in Southwestern Nigeria

Challenges	Lagos			Ondo			Osun			Total
	High	Fairly high	Not high	High	Fairly high	Not high	High	Fairly high	Not high	
Bribery & corruption	60	12	38	5	2	11	4	1	16	149
Poor staff strength	110	0	0	16	1	1	21	0	0	149
Inadequate tools & equipment	110	0	0	12	1	5	21	0	0	149
Political interference	110	0	0	15	1	2	18	2	1	149
Overlapping functions	64	11	35	10	2	6	5	7	9	149
Shortage of Experienced and Qualified Personnel	101	9	0	13	1	4	21	0	0	149
Absence of Effective Enabling Laws	42	47	21	5	5	8	21	0	0	149
Recalcitrant Nature of the Residents	81	22	7	13	14	1	18	1	2	149
Poor funding	27	64	19	16	2	0	21	0	0	149
Inadequate office accommodation	35	12	63	12	2	4	21	0	0	149
Lack of Development	43	62	15	6	9	3	21	0	0	149
Poor monitoring	21	28	61	3	2	13	10	2	9	149
Delay in Response to Petitions	48	25	37	4	5	9	3	6	12	149
Delay in Approval of Development plan	39	38	33	9	4	5	6	6	9	149
Total	891	330	319	139	41	72	211	25	58	141

Source: Authors' Field Survey, 2024

The suggested solution to this physical planning problem(s), according to the respondents, are capacity building and professional development initiatives may be required to enhance the expertise of planners and address emerging planning challenges effectively. The data suggests that while Osun's planners may possess academic qualifications, ongoing training and skill development programs may be necessary to address evolving planning needs and ensure the effective implementation of planning policies. Community engagement and participation are paramount in Osun State's planning process, in particular, meaningful involvement of stakeholders, particularly local communities and civil society organizations as well as public enlightenment on physical planning are crucial according to the study.

3.2. Ranking of the Challenges Confronting Physical Planning Administration in Southwestern Nigeria

Based on MIS analysis, the most important challenges of physical planning administration in Southwestern Nigeria and the ranking of the challenges across the sampled states were revealed. Table 2 shows that the most important challenges of physical planning administration in Lagos were: poor monitoring (MIS = 4.09); lack of a development plan (MIS = 3.96); inadequate office accommodation (MIS = 3.64); and poor funding (MIS = 3.62); Other challenges of physical planning administration in the study area are also fairly high. These range from lack of cooperation from the public (MIS = 3.48), to bribery and corruption (MIS = 3.24). This study aligns with previous studies that revealed that physical planning agencies in Lagos face challenges in effectively regulating residential building permits and enforcing physical planning regulations. The lack of awareness among developers about planning regulations, limited public enlightenment beyond the approval process, and hindrances like inadequate funding, corruption, and a lack of planning tools hinder the effectiveness of development control measures in areas like Festac Town (Alabi & Bako, 2018; Daramola et al., 2022). Additionally, the importance of having well-thought-out national development plans, strong development control, and adherence to building codes is highlighted as crucial for sustainable urban and rural development in Nigeria (Okoro, 2014). The presence of planning laws and ordinances

is essential, but their implementation is key to preventing chaos and crises in society (Aluko, 2011).

Table 2

Ranked Challenges of Physical Planning Administration in Lagos State

S/N o	Challenges of Physical Planning Administration	MIS	Rank	Decision
1	Poor monitoring	4.09	1 st	High
2	Lack of development plan	3.96	2 nd	High
3	Inadequate office accommodation	3.64	3 rd	High
4	Poor funding	3.62	4 th	High
5	Lack of cooperation from the public	3.46	5 th	High
6	Absence of effective enabling law	3.41	6 th	High
7	Overlapping of functions	3.34	7 th	High
8	Lack of experience staff	3.27	8 th	Fairly High
9	Political interference	3.21	9 th	Fairly High
10	Inadequate tools	3.01	10 th	Fairly High
11	Poor staff strength	2.85	11 th	Fairly High
12	Bribery and corruption	2.72	12 th	Fairly High

Source: Authors' Field Survey, 2024.

In Ondo State, as presented in Table 3, the primary challenges of physical planning administration in the study area are: a lack of public cooperation (MIS = 3.84), a lack of experienced staff (MIS = 3.76), the absence of an effective enabling law (MIS = 3.69), the absence of a development plan (MIS = 3.68), the overlapping of functions (MIS = 3.63), poor monitoring (MIS = 3.60), and inadequate office accommodation (MIS = 3.57). Other physical planning administration challenges in the study area are also fairly high. These range from political interference (MIS = 3.48) to poor staff strength (MIS = 3.24). In support of these findings, the studies of Olajuyigbe and Rotowa (2011); Aribigbola (2011) revealed that the challenges of physical planning administration in Ondo State, Nigeria, are multifaceted. Issues include inadequate staffing and resources, lack of approved layout plans, absence of urban development policies, ineffective development control, dearth of spatial information, rapid urbanization leading to property ownership changes, and environmental degradation from oil exploration. Studies highlight the need for more staff recruitment, master

plans, urban development policies, capacity building, spatial data acquisition, and strict enforcement of planning laws to ensure sustainable city development, efficient physical planning, and good urban governance in the region.

Table 3

Ranked Challenges of Physical Planning Administration in Ondo State

S/No	Challenges of Physical Planning Administration	MIS	Rank	Decision
1	Lack of cooperation from the public	3.84	1 st	High
2	Lack of experience staff	3.76	2 nd	High
3	Absence of effective enabling law	3.69	3 rd	High
4	Lack of development plan	3.68	4 th	High
5	Overlapping of functions	3.63	5 th	High
6	Poor monitoring	3.60	6 th	High
7	Inadequate office accommodation	3.57	7 th	High
8	Political interference	3.48	8 th	Fairly High
9	Bribery and corruption	3.40	9 th	Fairly High
10	Poor funding	3.27	10 th	Fairly High
11	Inadequate tools	3.25	11 th	Fairly High
12	Poor staff strength	3.24	12 th	Fairly High

Source: Authors' Field Survey, 2024

In Ondo State, as presented in Table 4, the most important challenges of physical planning administration in Osun State are: bribery and corruption (MIS = 3.95); lack of experience staff (MIS = 3.90); overlapping of functions (MIS = 3.77); absence of effective enabling law (MIS = 3.73); and poor monitoring (MIS = 3.57). Other challenges of physical planning administration in the study area are also fairly high. These range from inadequate office accommodations (MIS = 3.43) to challenges such as poor funding (MIS = 2.98). This supported the findings of previous studies on the challenges of physical planning administration in Osun state, Nigeria, as highlighted in the research papers, include issues such as inadequate staffing and resources, low compliance with development regulations, rapid urban expansion leading to encroachment on road setbacks, and a lack of proper enforcement mechanisms.

Table 4

Ranked Challenges of Physical Planning Administration in Osun State

S/No	Challenges of Physical Planning Administration	MIS	Rank	Decision
1	Bribery and corruption	3.95	1 st	High
2	Lack of experience staff	3.90	2 nd	High
3	Overlapping of functions	3.77	3 rd	High
4	Absence of effective enabling law	3.73	4 th	High
5	Poor monitoring	3.58	5 th	High
6	Inadequate office accommodation	3.43	6 th	Fairly High
7	Poor staff strength	3.43	7 th	Fairly High
8	Lack of cooperation from the public	3.41	8 th	Fairly High
9	Inadequate tools	3.33	9 th	Fairly High
10	Lack of development plan	3.31	10 th	Fairly High
11	Political interference	3.29	11 th	Fairly High
12	Poor funding	2.98	12 th	Fairly High

Source: Authors' Field Survey, 2024.

Studies in Osun state, particularly in Ile-Ife, reveal a high number of buildings not complying with road setback regulations, indicating a need for better monitoring and control (Ibrahim & Toyobo, 2014; Oluwaseyi, 2019). Additionally, the lack of manpower and technical resources hinders planning activities, leading to ineffective development control (Akingbade et al., 2022).

4. Conclusions

Findings were also made on the challenges confronting physical planning administration in Southwestern Nigeria, with particular reference to the sampled states. The identified challenges included and were not limited to bribery and corruption; poor staff strength; inadequate tools and equipment; political interference; overlapping function; shortage of experienced and qualified personnel; nature of residence; poor funding inadequate office accommodation lack of development or landing or master plan poor monitoring delay in response to petitions; and delay in the processing of approval for development plans. The challenges were rated on a 3-point Likert scale: high, fairly high, and not high. Based on MIS analysis, the most important challenges of physical planning administration in Southwestern Nigeria and the ranking of the challenges across the sampled states were revealed.

There are challenges confronting physical planning administration in Southwestern Nigeria, and these include bribery and corruption; poor staff strength; inadequate tools and equipment; political interference; overlapping function; shortage of experienced and qualified personnel; nature of residence; poor funding inadequate office accommodation lack of development or landing or master plan poor monitoring delay in response to petitions; and delay in the processing of approval development plans.

However, governments at all levels should maximally leverage their powers to surmount the challenges confronting physical planning administration in Southwestern Nigeria, such as bribery and corruption, poor staff strength, inadequate tools and equipment, political interference, overlapping functions, shortage of experienced and qualified personnel, poor funding, and inadequate office accommodation.

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OCEAN ENERGY. CURRENT SITUATION, CHALLENGES AND DEVELOPMENT PROSPECTS

Abstract. Human society is facing numerous environmental problems, including climate change, mainly caused by the burning of fossil fuels in power plants to obtain electrical and thermal energy. On the other hand, electricity consumption is increasing due to population growth, urbanization or economic development. In order to reduce greenhouse gas emissions, one of the proposed solutions was the development of renewable energy sources, including oceanic ones. This research aimed to analyze ocean energy, its potential and ways of valorization, its contribution to the global energy system and the challenges to future development. The results show the concerns of many companies and states in identifying the most efficient technological solutions for valorizing ocean energy. It also highlights the growing contribution of the sector to the global energy system, but its share is still very low. Although the great energy potential of the waters of the seas and oceans is recognized, several challenges stand in the way of the large-scale development of these technologies, including environmental and economic challenges.

Keywords: ocean energy, tidal energy, wave energy, salinity gradient, OTEC

1. Introduction

Climate change is one of the greatest threats to the environment and human society and is already affecting many regions of the Earth. It is driven by increasing greenhouse gas emissions, including from the energy sector.

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In addition, global primary energy demand is expected to increase by more than 25% by 2040, reaching around 206,000 TWh/year, driven by the world's growing population, urbanization and economic growth (Taveira-Pinto et al., 2020). As a result, energy systems around the world must increasingly rely on renewable energy sources. The production capacity of renewable energy sources has grown rapidly in recent years, driven by political support and drastic cost reductions for certain sources, such as wind and photovoltaics, which have reached maturity. However, these sources have the disadvantage of being dependent on climatic conditions and the time of day (in the case of solar energy). In 2025, the share of renewable energy in global electricity production was 34.5%, a significant increase from 18.4% in 2000 (IEA, 2026).

Renewable sources also include energy that harnesses the energy potential of seas and oceans (here referred to as ocean energy). This energy resource is abundant, with over 70% of the Earth's surface covered by seas and oceans, and its benefits go beyond the energy sector, potentially driving a global blue economy for multiple end-use applications, including maritime transport (e.g. providing electricity for battery-powered ships, offshore charging stations or other port-based activities), space cooling (seawater air conditioning/SWAC can provide efficient cooling), aquaculture or water desalination. Ocean energy could also contribute to improving the lives of people living in coastal areas and small islands, especially in developing and least developed countries (IRENA, 2021, Herrera et al., 2021).

Ocean energy uses a wide range of technologies that harness the energy potential of tides, waves, currents, or differences in salinity and temperature in the seas and oceans. In a broader sense, marine biomass, offshore wind energy, and offshore solar energy are also included, but they do not use the energy potential of seawater. Many technologies are still under development and testing, some being floating devices, and others submerged or anchored to the seabed (Marinez et al., 2021).

Tides are driven by the gravitational forces of the Sun and Moon and are most significant at the mouths of rivers and in bays. There are two types of tidal energy, tidal barrage and tidal stream. Tidal barrage is the most mature of all ocean energy technologies and works on the same principle as hydropower, requiring a dam to hold back the water. A tidal basin is an inlet into an ocean bay or lagoon that fills with water

during high tide and empties during low tide. A bidirectional tidal energy system generates electricity from both incoming and outgoing tides. Because it is not affected by weather conditions, tidal energy is one of the most reliable sources of renewable energy.

The other form of tidal energy operates in deeper waters and generates energy using the currents that occur with the changing tides. Among the technologies that harness tidal streams, the following are distinguished: horizontal-axis turbines, tidal kites, enclosed tips, vertical-axis turbines, undulating membranes or oscillating hydrofoils (table 1). Tidal turbines can be fixed to the seabed or float closer to the surface with anchor points attached to the seabed. The most common type of technology is the horizontal-axis turbine, followed by the tidal kite and the vertical-axis turbine. These can also be used effectively in areas with slower tidal flows (EC, 2025; OEE, 2026).

Table 1

Different tidal energy technologies

Technology	Functional features	Technology readiness level
Barrage	Water that entered an enclosed tidal basin with high tide is released in low tide and generates electricity by passing through turbines.	9
Horizontal-axis turbine	The tidal currents flow past blades that are radially attached to a horizontal shaft and cause rotation, thus generating power, much like a wind turbine underwater. Either the hub or blades need to turn 180 degrees to accommodate a reverse flow direction.	9
Tidal kite	A kite connected to the sea bed or to a floating platform moves through the tidal stream in an eightshaped or linear trajectory. The relative velocity is increased and with it the electricity output.	9
Vertical-axis turbine	The tidal currents flow through a set of blades parallel to a rotating shaft, generating power irrespective of the direction of the flow.	7
Enclosed tips	The tidal stream's velocity is increased by concentrating it in a funnel or duct, in which a turbine is placed to generate energy.	7

Undulating membrane	A wave membrane in tidal energy operates by transforming the hydrodynamic pressure changes of ocean waves or tides into mechanical motion, which is then converted into electricity	7
Oscillating hydrofoil	The tidal flow lifts an oscillating hydrofoil attached to an arm. This up-and-down movement drives a shaft or pistons to generate energy.	6
Archimedes screw/ spiral	A tidal stream passes through the spiral of a helical-shaped impeller. The device starts to turn, and the rotation is converted into energy.	6

Source: IRENA, 2021; European Commission, 2025

Wave energy is mainly influenced by wave characteristics (height, speed, frequency), closely linked to surface winds, and these characteristics are strongest at latitudes between 30 and 60 degrees and in deep waters (over 40 m) (IRENE, 2021; Herrera et al., 2021). Although waves vary seasonally and in the short term, they are considered a reliable source of energy because they can be forecast into the future with a significant degree of accuracy.

There are several technologies for harnessing wave energy, including: oscillating water columns, point absorbers, oscillating wave surge converters, overtopping, attenuators, pressure differential devices, rotating masses or Archimedes screws (Table 2) (IRENA, 2021; EC, 2025).

Table 2

Prototypes of wave energy technologies

Technology	Functional features	Technology readiness level
Oscillating water columns	Passing waves raise the water level within a hollow, demi-submerged structure, causing the enclosed air to compress and flow to the atmosphere, driving a turbine.	9
Point absorbers	This floating or submerged buoy generates energy from the buoy's movement caused by waves in all directions relative to the base connection.	9
Oscillating wave surge converters	This structure uses the surge movement of the wave (back-and-forth motion) to capture energy in an oscillating arm.	8

Overtopping device	Water of passing waves is captured in a reservoir and released through a shaft. A turbine is located in the shaft that generates energy when water passes.	8
Attenuators	The attenuator consists of multiple connected segments or a single long and flexible part that extracts energy from waves by following the parallel motion of the waves.	8
Submerged pressure differential devices	The rise and fall of passing waves cause a pressure differential in the structure to trigger pressure pumps and generate electricity	7
Rotating masses	The heaving and swaying in the waves cause a weight to rotate within this device. This rotation drives an electric generator.	7
Archimedes screws	A wave passes through the spiral of a helical-shaped impeller. The device starts to turn, and the rotation is converted into energy.	6

Source: IRENA, 2021; European Commission, 2025

Salinity gradient is a renewable energy source that generates electricity through various technologies, such as pressure-retarded osmosis (PRO) or reverse electrodialysis (RED), which harness the difference in salinity in water. This typically occurs at the mouth of rivers, where fresh water meets seawater, or in stratified water, which does not mix. Pressure-retarded osmosis (PRO) harnesses the difference in chemical potential between fresh water and salt water (osmotic power). Osmotic pressure pushes water through a membrane and drives a turbine to create energy. Reverse electrodialysis is a membrane-based technology that uses electrochemical reaction instead of osmotic pressure. The device uses a series of membranes: half of them are permeable to sodium and the rest are permeable to chloride, with freshwater and seawater flowing interchangeably through each pair of membranes (IRENA, 2021; Azarpour et al., 2022; Watanabe et al., 2025).

Ocean thermal energy conversion (OTEC) plants rely on the difference in temperature (thermal gradients) of ocean waters between the surface and deeper layers (at 800-1000 m depth). This situation is found in tropical regions, such as the Pacific Ocean or the Caribbean Sea. The process involves either an open cycle, in which warm seawater is converted into steam to drive a

turbine, or a closed cycle, in which a working fluid is vaporized using the heat of the warm water (Weber, 2025). There are also hybrid-cycle OTEC plants, which combine both closed-cycle and open-cycle characteristics (Herrera et al., 2021). To power an electricity-generating turbine, ocean thermal energy conversion technologies use a temperature difference of at least 20°C between cold and warm water, which indicates that the surface water temperature must be around 25°C, as water temperature tends to stabilize at around 4°C at 1000 m depth (IRENA, 2021; EC, 2025). This temperature difference can be used to produce electricity and to desalinate seawater. Although the efficiency of OTEC systems is still low, they offer the advantage of producing fresh water, making them attractive for regions with limited water resources (Herrera et al., 2021; Weber, 2025).

2. Materials și methods

In the current climate context, the development of the global energy system is oriented towards low-carbon sources. From a spatial point of view, the research aimed to analyze the situation of ocean energy at a global level, and the temporal framework starts from the oldest concerns in the field, up to the present. The data used in this research come exclusively from the specialized literature. Sources belonging to international institutions with concerns in the field were consulted, such as the International Renewable Energy Agency (IRENA), the International Energy Agency, Ocean Energy Europe, the European Commission, as well as specialized scientific articles and other sources that have addressed the issue of ocean energy.

Quantitative and qualitative methods were used in the processing and interpretation of these data. Graphical methods were used to highlight the dynamics of some indicators, and the results were subsequently interpreted.

In the analysis of the current situation regarding the valorization of ocean energy, several aspects were pursued, including the identification of the potential for each type of renewable energy (tides, waves, salinity gradient, OTEC) and areas with high potential for the use of these resources. Also, in highlighting the constraints that influence the large-scale development of ocean energy, aspects such as: the reliability of technological devices,

economic efficiency (project costs, production cost) or the impact on the environment (biodiversity, habitats) were pursued. The research also targeted support policies (at national or international level) and the future evolution of ocean energy.

3. Results

Although many technologies are still in the early stages of development, ocean energy is believed to have a significant theoretical potential that could meet current and future global electricity demand. Many studies state that the potential of ocean energy is considerably higher than the annual global electricity demand (Melikoglu, 2018; Khan et al., 2022; Samsó et al., 2023). Although it varies greatly depending on the technology, the cumulative theoretical potential has been estimated to be between 45,000 and over 150,000 TWh/year (Taveira-Pinto et al., 2020; IRENA, 2021; IEA, 2025). However, a distinction must be made between theoretical and technical potential, as the exploitation of ocean energy depends on the efficiency of available technologies and certain restrictions related to the exploitation of resources, such as those of a legal, economic or environmental nature (Taveira-Pinto et al., 2020).

The cumulative operational capacity for all forms of ocean energy is over 513 MW, with 1.6 MW added in 2024 (REN21, 2025). Of this capacity, 494 MW (i.e. 96%) comes from two large tidal dam projects in South Korea and France (table 4). As for global electricity production from ocean sources, it was 928 GWh in 2023, down from previous years (Fig. 1). Within renewable energy, the share of ocean electricity production remains extremely low. In 2024, solar electricity alone provided over 2000 TWh (Ember, 2025).

According to the PRIMRE Projects Database (2026), 284 projects have been identified, defined as deployments of ocean energy devices in open waters, intended to generate electricity or provide an alternative benefit. This also includes decommissioned, cancelled or planned projects (Fig. 2). Most projects have been implemented by the United Kingdom (55 projects), the United States, China, Japan, Australia, Canada, Italy, France, the Netherlands and Denmark.

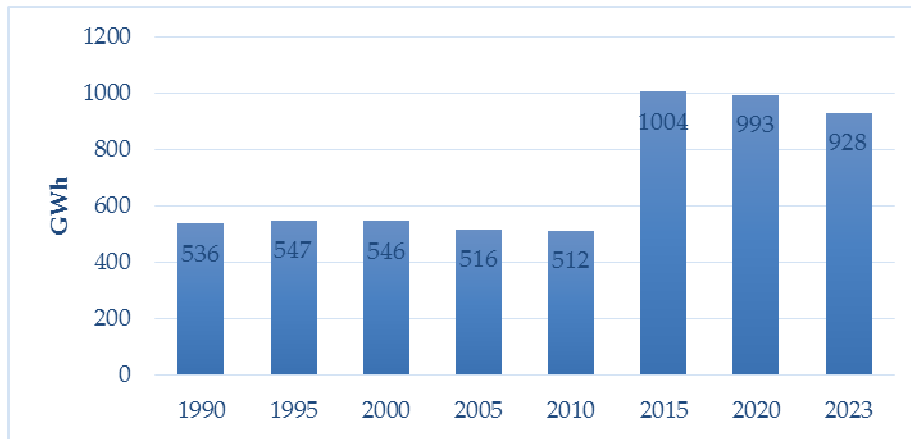


Figure 1. Global electricity generation from ocean sources 1990-2023
(Source: IEA, 2025)

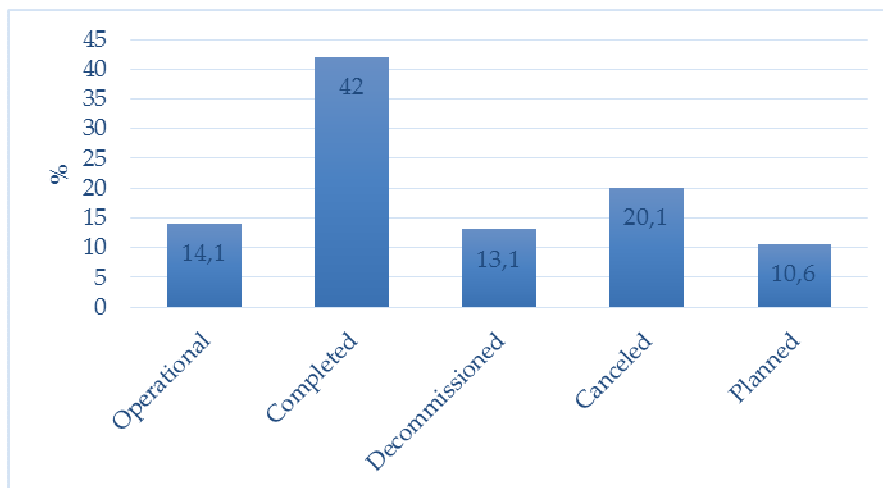


Figure 2. Projects by Life Cycle
(Source: OpenEI/PRIMRE, 2026)

The decommissioning of ocean energy projects has been driven either by the completion of demonstration phases or by financial and technical difficulties, as is the case with the Aguçadora Wave Farm project in Portugal. Many demonstration projects were designed with a limited lifespan, for example, 5 years for SeaGen. Between 2022 and 2024, 32 ocean energy projects were implemented globally (table 3).

Table 3

Ocean energy devices deployed worldwide in 2022, 2023 and 2024

Country	Location	Device developer	Type and year of implementation	Capacity device (kW)
France	Bordeaux	Hydrokinetic	Vertical Axis (2022)	25
France	Brest	EEL Energy	Undulating membrane (2022)	30
UK	Strangford Lough (Northern Ireland)	Gkinetic	Vertical Axis (2022)	12
Slovenia	Adriatic Sea	Sigma Energy	Point absorber (2022)	30
UK	Orkney (Scotland)	AWS	Point absorber (2022)	16
Belgium	Ostend	Exowave	Oscillating Wave Surge Converter (2022)	3.5
China	Xiushan Island, Zhejiang Province	Hangzhou LHD United Energy Corporation	Horizontal axis (2022)	1600
China	Shengsi island	Hann Ocean	Wave Rotor (2022)	15
US	Washington State	C Power	Rotating mass (2022)	1
Israel	Tel Aviv	Eco Wave Power	Attenuator (2022)	100
UK	Shetland (Scotland)	Nova Innovation	Horizontal Axis (2023)	100
UK	Shetland	Nova Innovation	Horizontal Axis (2023)	100
France	Etel Estuary	Nova Innovation	Horizontal Axis (2023)	50
France	Rhône river	EEL Energy	Undulating membrane (2023)	30
Portugal	Aguçadoura	CorPower Ocean	Point absorber (2023)	300
Italy	Mediterranean Sea	Eni	Oscillating WEC (2023)	260
Spain	Valencia	Rotary Wave	Point absorber (2023)	20
France	Nantes (SEM-REV)	GEPS Techno	Attenuator (2023)	10

US	Alaska	ORPC	Horizontal axis (2023)	40
US	Maine (3 devices)	ORPC	Horizontal axis (2023)	50 (cumulative)
China	Guangdong	GIEC, China Southern Power Grid	Point absorber (2023)	1000
US	Maine	Oscilla Power	Point absorber (2023)	-
US	New Jersey	OPT	Point absorber (2023)	-
Denmark	Faroe Islands	Minesto	Kite (2024)	1200
Netherlands	Ameland	SeaCurrent	Kite (2024)	200
UK	Strangford Lough (Northern Ireland)	ORPC Ireland	Horizontal Axis (2024)	18
Spain	Canary Islands	Wavepiston	Oscillating Wave Surge String Attenuator (2024)	30
UK	Aberdeen	ZOEX Power	Attenuator (2024)	100
US	Oahu (Hawaii)	OceanEnergy Group	Oscillating water column (2024)	500
US	Strait of Juan de Fuca (Washington)	Panthalassa	Other (2024)	40
Australia	King Georges Sound	University of Western Australia	Attenuator (2024)	1 to 10
Australia	North Fremantle	Carnegie Clean Energy	Point Absorber (2024)	5.7

Source: OEE, 2023-2025

3.1. Harnessing the energy potential of tidal waves

People have used tidal energy since ancient times to power stone mills. Tide mills, based on small basins or ponds, appeared on the Atlantic coasts of Europe around the 11th century and persisted until the 20th century (Smith, 2023). In 1920, the United Kingdom proposed using tidal energy to generate electricity, and China built small tidal power plants around 1956 (Li et al., 2025).

The theoretical potential of tidal power has been estimated to be between 450 and 1200 TWh/year (El Tawil et al., 2017; Sangiuliano, 2017; IRENA, 2021; Samsó et al., 2023), being the lowest of all ocean energy technologies. Europe has an estimated potential of 24 TWh/year, mainly in the United Kingdom (almost half), France and Ireland (El Tawil et al., 2017).

Of all ocean energy technologies, tidal power is the most mature and the first to be implemented on a large scale, with large plants in South Korea and France (EC, 2025). The La Rance tidal power plant in Brittany (France) was the first commercially operational plant of this type, inaugurated in 1966. This plant generates enough electricity to power a settlement of about 223,000 inhabitants. The Rance estuary has one of the largest tidal amplitudes in the world, 13.5 m (EDF, 2012).

Later, tidal power plants were installed in Russia, China, Canada and South Korea (table 4). The Kislaya Guba Experimental Tidal Power Plant, near Murmansk, is the second oldest. Although it has a limited capacity, the plant represented a pioneering effort in the development of tidal power in cold climates (Smith, 2023). Located in Yueqing Bay (near Wenling), the Jiangxia Experimental Tidal Power Station is the largest tidal power plant in China and generates about 7 million kWh annually. In 2022, this plant was integrated into a hybrid project, which includes 100 MW of floating solar panels (Garanovic, 2022).

The Sihwa Tidal Barrage Power Plant in the Sihwa Lake area (South Korea) is the largest of its kind in the world. The plant was installed in 2011 by the Korea Water Resources Corporation, has 10 submersible generators and provides power for a population of 500,000 (OpenEI, 2026). Since 2011, no new projects using tidal barrage technology have been developed globally (EC, 2025).

With some of the largest tidal energy resources in the world, several tidal barrage projects have been proposed in the UK, but none have been completed to date. It is estimated that these projects (Swansea Bay, Merseyside, the North Somerset Coast and the North Wales Coast), which are currently stalled, could deliver 10 GW of installed capacity by 2030 if they receive the appropriate permission and funding (Ferris, 2022).

Table 4

Tidal dam power plants

Name	Location	Inauguration	Installed capacity (MW)	Condition
La Rance	France (Rance Estuary, Brittany)	1966	240	In operation
Kislaya Guba	Russia (Kola Peninsula)	1968	0.8	In operation
Haishan	China (East China Sea)	1975	0.25	In operation
Jiangxia	China (East China Sea)	1980	4.1	In operation
Annapolis Royal	Canada (Bay of Fundy)	1984	20	Permanently closed in 2019
Sihwa	South Korea (Gyeonggi Bay)	2011	254	In operation

Source: EDF, 2012; Withers, 2021; Garanovic, 2022; Smith, 2023

Although tidal barrage projects have proven commercially viable, their implementation has been limited by the availability of suitable sites and the impact on the local environment (EC, 2025).

Compared to tidal barrages, tidal stream technologies are expanding. Orbital Marine Power, based in Orkney (Scotland), was the first company in the world to successfully connect a floating tidal turbine to the grid in 2011 (Ferris, 2022), and the first operational pre-commercial tidal farms appeared in Europe in 2016 (the MeyGen and Shetland projects). In 2016, Orbital Marine Power launched the world's most powerful tidal turbine (SR2000), which produced over 3 GWh of electricity in its 12-month continuous testing program (Orbital Marine Power, 2019).

In 2024, the cumulative electricity production from existing demonstration projects and tidal stream farms reached 106 GWh, up from 93 GWh in 2023 and 80 GWh in 2022, with an annual production of 13.4 GWh. The MeyGen and Nova Innovation pilot farms, as well as turbines from Orbital Marine Power, Magallanes Renovables and Inyanga Marine Energy Group, provided the bulk of the electricity. Europe remains the technological leader in tidal stream energy, with a cumulative capacity three times higher than all other countries combined (30.5 MW versus 10.9 MW) (OEE, 2024; OEE, 2025).

The world's largest tidal farm (the MeyGen project), owned by SAE Renewables, is located in northern Scotland, near Stroma Island, in a natural channel that harnesses the tidal flow between the North Sea and the Atlantic Ocean (Edmond, 2020). The tides here are particularly strong, with currents that can move up to five meters per second. The first four turbines of the project, with a cumulative capacity of 6 MW, are already operational, and an additional capacity of 59 MW is planned to be installed by 2029 (Cavcic, 2025). Ultimately, the region is expected to have a capacity of 398 MW, enough to power 175,000 homes (Bithenergy, 2026).

The Zhoushan LHD power plant, off Xiushan Island (Zhoushan Province, China), with a modular capacity of 3.3 MW, holds the world record for continuous operation for a tidal stream project, over 9 years (REN21, 2023).

The United States has no commercially operational tidal power plants, although several locations in the United States have potential, including Cook Inlet in Alaska, which has the second largest tidal range in North America, and several locations in the states of Maine and New York. A number of demonstration projects have been implemented or are in various stages of development, such as: Roosevelt Island in the East River in New York, Western Passage in Maine, and Cobscook Bay in Maine (EIA, 2026).

3.2. *Wave energy*

The first known concept for harnessing wave energy (a device that would power irrigation pumps) was proposed by Pierre-Simon Girard in 1799. Later, in 1910, Busso Belasek invented an early form of wave-powered power plant, capable of generating 1000 W of electricity. Yoshio Masuda is considered the father of modern wave energy because in the 1940s he developed wave-powered navigation buoys. In the 1980s and 1990s, various projects in this field were tested worldwide (Scotland, Japan, United Kingdom, Portugal). The world's first grid-connected, commercial-scale wave energy device, called LIMPET, was implemented in Scotland (on the island of Islay) in 2000. The 500 kW project was developed by Queen's University Belfast and operated by the Scottish company Wavegen until 2011 (Johanning, 2025).

The first wave farm (Aguçadoura Wave Farm), with a capacity of 2.25 MW, was put into operation near the Portuguese city of Porto in 2008, the result of a pioneering effort by the companies Pelamis (UK), Enersis (Portugal) and Babcock and Brown (Australia). However, after only a few months, due to technical and financial problems, the farm was decommissioned (Marine Insight, 2019).

The energy potential of waves is much higher than that of tides, estimated at around 29,000 TWh per year, which would mean meeting the current global electricity demand (Mørk et al., 2010; IRENA, 2021; OEE, 2026). There are estimates of this potential reaching over 87,000 TWh/year (Samsó et al., 2023). The west coasts of the United States and Europe, as well as the coasts of Japan and New Zealand, have potential sites for the exploitation of wave energy (EIA, 2026). In recent years, wave energy exploitation technologies have been implemented in Spain, Italy, Portugal and Sweden (EC, 2025).

Cumulatively, since 2010, about 27 MW of wave energy capacity has been installed globally, of which 13.5 MW is in Europe. Because many devices were test and prototype devices, only a fraction of the capacity remained continuously active in the water at any given time. For example, in Europe, of the cumulative capacity installed since 2010, 12.6 MW has been decommissioned following the completion of demonstration programs (REN21, 2024; OEE, 2025).

In Europe, 4 wave energy installations were deployed in 2023, with a capacity of 595 kW, and two full-scale devices were deployed in 2024, with a total capacity of 130 kW. All new devices in 2024 were deployed in the Atlantic, which has been the focus of wave energy activities in recent years. 2024 marks the third consecutive year in which the majority of deployed devices were full-scale, a clear indication that wave technologies have reached a higher stage of technological readiness (OEE, 2024; OEE, 2025).

The year 2023 marks the largest deployment volume outside Europe since 2019, with a total of 1 MW. In 2024, for the first time since 2015, cumulative deployments outside Europe exceeded those in Europe. This is the result of several deployments in the USA and Australia. However, European companies are still the global technology leaders. The Irish company OceanEnergy Group has deployed the only large-scale wave device (over 1 MW) in Hawaii (OEE, 2024; OEE, 2025).

3.3. *Salinity gradient*

The concept of salinity gradient energy (osmotic power or blue energy) was first introduced in 1954 by the British Richard Pattle, who discovered that electricity could be produced by mixing fresh and salt water. Later, technological innovations aimed at improving the efficiency of membranes, with various companies being involved in this process (Hsu et al., 2021).

The first pressure-retarded osmosis (PRO) plant was opened in Tofte (Norway) in 2009 by Statkraft, with a generating capacity of 4 kW. Although the process worked, the devices did not produce enough energy to offset the construction, operation and maintenance costs. The plant was therefore closed in 2013 (Ball, 2015).

The Mega-ton Water System Project was carried out in Japan between 2009 and 2013, and on 5 August 2025, Kyowakiden Industry put a PRO system into operation at a seawater desalination plant in Fukuoka City, the first of its kind in the country. The plant is expected to generate approximately 880,000 kWh of electricity annually, which will support the nearby water desalination plant (Asian Water, 2025). Also in Japan, Toyobo is the sole developer of commercial PRO membranes, and the Blue Energy Center for SGE Technology (BEST), a research center established at Yamaguchi University in 2018, has successfully developed a RED stack with the largest membrane area in the world (Watanabe et al., 2025). Denmark introduced a similar installation in 2023 at the Nouryon salt plant in Mariager, developed by the company SaltPower, together with Danfoss and DTU Chemical and Biochemical Engineering (Andersen, 2023). Although they do not use seawater directly, these projects confirm the viability of the technology.

Currently, the most advanced salinity gradient technology is reverse electrodialysis (RED), due to its higher energy efficiency and lower susceptibility to membrane fouling than pressure-delayed osmosis (Hsu et al., 2021). The RED technology was proposed by the Dutch company REDstack, spun off from the Wetsus Institute in Leeuwarden, a European center of excellence for sustainable water technology. In 2015, this company inaugurated the world's first RED power plant on the Afsluitdijk. Powered by the natural mixture of freshwater from the IJsselmeer and saltwater from the North Sea, this pilot plant started producing 50 kW of blue energy and demonstrated the real-world feasibility of continuous clean energy generation (REDstack, 2026).

Further developments to improve membrane performance and cost-effectiveness are ongoing (OEE, 2025). This technology has been tested mainly in the EU, and electricity production began in 2024 in a new demonstration plant built in France by Sweetech Energy (EC, 2025). Although estuaries are numerous globally and salinity can theoretically provide continuous baseload power, geographical requirements impose significant limitations on the potential, which is relatively small compared to other emerging ocean technologies, at around 1650 TWh annually (IRENA, 2021). Salinity gradient is the least mature ocean energy technology.

3.4. Ocean Thermal Energy Conversion (OTEC) plants

The concept of OTEC was proposed as early as 1882 by the French physicist Jacques Arsène d'Arsonval, and in 1926 it was tested by Georges Claude in Matanzas Bay, Cuba. However, significant progress in the field was only reported in the 1960s. In the 1970s, the US and Japanese governments supported research and development of the technology, followed by France, the Netherlands, the UK and Sweden (Weber, 2025).

The United States has been involved in OTEC research since 1974, with the establishment of the Natural Energy Laboratory of Hawaii Authority, which operated a 250 kW demonstration plant for six years in the 1990s. Another 105 kW demonstration plant, developed by the Makai company in Kailua-Kona, became operational in 2015 and supplies electricity to the local grid (EIA, 2026).

In 1994, the Ocean Energy Institute at Saga University in Japan, a leader in OTEC research, built a 4.5 kW plant. In 2013, a 100 kW OTEC plant was installed on Kume Island to verify the real-world functionality of this technology. Later, in 2015, the plant was also adapted for water desalination (Herrera et al., 2021).

There is currently no operational capacity in Europe for ocean thermal energy conversion technologies (EC, 2025). OTEC prototypes are often land-based, but floating prototypes are also being developed (OEE, 2026). Almost 100 nations have been identified with access to OTEC resources in their exclusive economic zone (Herrera et al., 2021).

A theoretical potential of approximately 44,000 TWh/year is estimated globally (IRENA, 2021; EC, 2025), which could meet current global electricity needs. Thus, OTEC could provide continuous and non-intermittent baseload electricity. However, this energy source is still in the research and development phase, with current deployment limited to 100 kW demonstration plants in Hawaii (USA) and Japan (IRENA, 2021).

4. Discussion

Ocean energy development faces a number of challenges related to hostile environmental conditions, capital costs and high electricity prices, and environmental impacts. Such challenges affect public and investor confidence in these technologies. Projects also involve obtaining permits from local agencies, negotiating power purchase agreements, communicating with local stakeholders, and coordinating with the supply chain for manufacturing and installation (Open EI/PRIMRE, 2026).

4.1. Environmental constraints

The economic exploitation of ocean energy faces challenges related to the exposure of technologies to the hostile maritime environment, marked by strong winds and waves, which make it difficult to install, operate and maintain the facilities. Also negatively impacting are the high humidity and high salt concentration in the atmosphere, which can trigger early corrosion of metal components. These conditions can have a significant impact on equipment, reducing their lifespan, maximum production power and efficiency. Thus, technologies must be designed to withstand extreme environmental conditions, but also to operate efficiently and with low maintenance requirements under frequent conditions. Regarding tidal dams, the development of this technology has been influenced by the small number of locations with high tides, and the favorable ones are located quite far from consuming centers. For example, in North America the only major locations for tidal dams are in Alaska and along the coast

of Maine (Ferris, 2022). Regarding tidal streams, the use of tidal energy is generally only feasible in locations where flow velocities are greater than 1 or 2 m/s, a limited number of locations meeting this condition (Taveiro-Pinto et al., 2020). Turbines cannot also be installed in shallow waters due to turbulence caused by waves, nor in very deep waters due to the decrease in tidal current speed with depth (El Tawil et al., 2017).

4.2. Environmental impact

Although ocean energy is seen as an alternative to fossil fuel sources, there are uncertainties about the potential environmental impact, as the technologies used are relatively new and poorly tested, and methods for assessing and monitoring environmental impacts are scarce. Coastal areas are generally fragile ecological balances, and changes to estuaries, coastal areas or currents can significantly affect the local environment. Negative impacts could occur through habitat loss, the risk of collision of animals with turbines (fish, marine mammals), noise or electromagnetic fields produced by submarine cables, which can have effects on aquatic species (IRENA, 2021; Martinez et al., 2021). Tidal dams can alter turbidity (the amount of suspended matter in the water) and affect navigation and recreation.

For example, the La Rance tidal dam (France) led to the siltation of the Rance River estuary, which significantly affected the fish population behind the dam. Similarly, the Annapolis Royal tidal dam (Nova Scotia, Canada) was permanently closed in 2019 due to a combination of technical issues (failure of a critical generator component) and environmental pressures. Studies conducted by Fisheries and Oceans Canada confirmed that the plant's turbines were causing significant fish kills: up to 23% of the American mackerel population passing through them. In addition, the dam caused increased erosion of the Annapolis River banks, affecting upstream farmland (DFO, 2019; Withers, 2021). Thus, environmental impact assessment studies and the implementation of best practices in the field are needed to avoid potential risks.

4.3. The cost issue

Despite investments in ocean energy, the commercial viability of this sector still remains uncertain, also due to the considerable initial costs. It has been found that the long operation of some installations can amortize the cost of the project. For example, the La Rance plant is operating well after almost 60 years, and has produced approximately 28,000 GWh of electricity, amortizing its cost many times over (Ferris, 2022).

In recent years, ocean renewables have seen reductions in the Levelized Cost of Electricity (LCOE), even though ocean energy technologies are still in a relatively early stage of development. LCOEs range from €110 to €480/MWh for tidal power and from €160 to €750/MWh for wave power. The UK government has granted reference prices for several tidal projects in 2023 and 2024. In 2024, the common price for all projects was €204/MWh, 33% lower than in 2023 (€303/MWh), which is a significant decrease (EC, 2025).

Due to high costs, some projects have not been implemented. For example, in the UK, a tidal power project failed. This was a £1.3 billion tidal lagoon proposed in Swansea Bay, off the south coast of Wales. Although the project received planning permission in June 2015, which the developers said could provide electricity for 155,000 homes, the plans collapsed in 2018 when the UK government refused to provide financial support to guarantee the price of electricity (Ferris, 2022).

And in the case of OTEC plants, almost all proposals have not made the leap from experimental prototype to commercial plants due to high infrastructure costs, especially for submarine cables and the hostile and corrosive environment of seawater (Herrera et al., 2021).

4.4. Technological development

Over the past two decades, ocean technologies have experienced varying levels of technological readiness, accompanied by an increase in innovation. Thus, tidal and wave energy holds the majority of patents filed internationally among ocean energy technologies. Since the early 2000s, over 24,000 patents have been filed. Other energy technologies, such as OTEC and salinity gradient, have also made progress (IRENA, 2021).

Ocean energy technologies are being developed and used in several countries, but only a few are more active: the United Kingdom, France, Finland, Ireland, Italy, Portugal, Spain, Sweden, Australia, Canada, China or the United States. These countries have the most tested, implemented and planned projects, as well as the most developers and manufacturers of devices. Although most ocean energy technologies are in the research and development phases, a growing number of companies, research institutes, universities and investors are showing interest in ocean energy technologies (IRENA, 2021).

Because these technologies are immature, they will face a number of challenges that could hinder commercialization. In the case of OTEC plants, there are still some technological difficulties, including the considerable amounts of dissolved gases in seawater (especially nitrogen and oxygen), which must be removed if flash evaporation is used (Weber, 2025).

4.5. Ocean energy support policies and growth projections

Ocean energy projects have benefited from significant investment, both from public and private sources. Government support schemes, such as the UK's Contracts for Difference (CfD), launched in 2021, and the French feed-in-tariff, are also important. Power purchase agreements (PPAs) can complement or provide an alternative to financing farms. For example, the Minesto farm in the Faroe Islands is being developed under a PPA with utility company SEV. However, PPAs can only provide a sufficiently high return for innovative projects in areas where competing alternatives are costly (OEE, 2025).

In Europe, dozens of ocean energy projects have been funded with over EUR 180 million. The EU supports the most advanced projects in particular through the EU Innovation Fund (EUR 31.3 million for Normandies Hydroliennes) and the European Innovation Council Accelerator (EUR 17.5 million for CorPower) (EC, 2025). Also in 2024, the ONDEP wave energy project received EUR 19 million in funding through the Horizon Europe programme (OEE, 2025). The EU Offshore Renewable Energy Strategy, initially published in 2020, sets a target of at least 1 GW of installed capacity for ocean energy by 2030 and 40 GW by 2050 (EC, 2026).

US funding reached \$141 million in 2024 and a cumulative total of \$591 million over five years, focused primarily on wave energy. California and Oregon have passed dedicated ocean energy legislation. China is also an active player in ocean energy, with major deployments and ambitious plans. Several energy bills were published in 2024 that support the continued exploitation of ocean energy. China's public support is channeled through a combination of generous grants and revenue support (OEE, 2024, OEE, 2025).

In the UK, in November 2021, the fourth round of allocations for the UK's contracts for difference scheme announced that £20 million per year would be set aside for tidal stream projects, a signal that this is a viable technology. However, some large projects, including the £7 billion Tidal Lagoon in North Wales, have yet to be implemented (Ferris, 2022).

Future developments are encouraged by technological advances in recent years. An increase in installed capacity is expected, with the implementation of publicly funded projects. As a result of market expansion, IRENA estimated in 2021 that ocean energy technologies could reach an installed capacity of around 70 GW by 2030 and 350 GW by 2050 globally (Fig. 3). Also, according to the International Energy Agency's Ocean Energy Systems (IEA-OES), ocean energy has the potential to contribute 300 GW of renewable energy generation capacity to the global transition to Net Zero emissions by 2050 (OES, 2023).

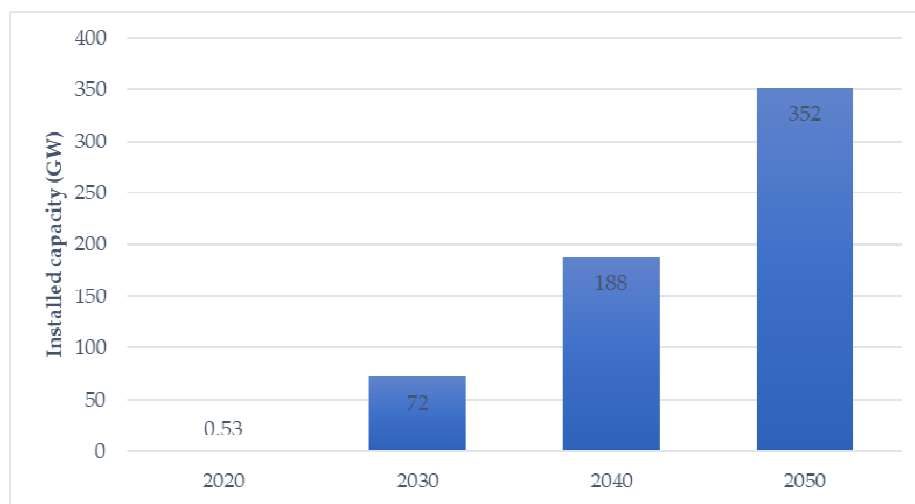


Figure 3. Projected ocean energy capacity by 2050 (IRENA, 2021)

Conclusions

It is widely accepted that the burning of fossil fuels is the major cause of climate change, and the development of renewable energy sources is necessary to reduce greenhouse gas emissions. Renewable sources also include ocean energy.

It is estimated that the potential of ocean energy sources is significant and could cover the global demand for electricity. However, most ocean energy technologies are still under development and face various problems, including high implementation costs, durability of equipment in the marine environment and some forms of environmental impact.

Although increases in installed capacities have been reported in recent years, electricity production is still very low. An increase in installed capacity is expected, with the implementation of pre-commercial parks financed from public funds.

Despite investments, the commercial viability of this sector still remains uncertain, also due to the high implementation costs. Under these conditions, public institutions and the private sector should support research and development in the field more consistently to identify the best solutions and technologies to capitalize on these renewable energy sources and to satisfy global energy demand.

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Florina GRECU¹

VILLE CONSTANTINE – AFRIQUE DU NORD. IL ÉTAIT UNE VILLE... IL ÉTAIT CONSTANTINE

Nous présentons deux ouvrages traitant du même sujet, mais dont la forme d'expression écrite diffère. Ces livres exposent la géographie, l'histoire, l'habitat, l'ethnographie et le mode de vie de la ville de Constantine à la fin du XIX^{ème} siècle (1879). À partir de la description utilisée comme méthode, le texte est restitué par la méthode photographique dans un album paru en 2012. Ces deux volumes font revivre un passé que l'on croyait « révolu ». Ils sont publiés sous l'égide de l'Université Mentouri de Constantine, sous la direction d'une équipe d'éditeurs inspirés, admiratifs de la beauté et de la portée scientifique de ces travaux.

- Constantine & sa région. Voyage et séjour. 1879, Louis Régis, préface de Kamel Filali, publication du LERSHMM, Université Mentouri-Constantine, 2005, 182 p., ISBN 9947-0-0696.
- Il était une ville... C'était Constantine. Regards croisés à travers : « Constantine, voyage et séjours 1879 » de Louis Régis. Illustrations et témoignages, ARAJA Éditions, Constantine, Algérie, 2012, 160 p., ISBN : 978-9961-9781-4-6.

La présente exposition, bien que consacrée à deux livres distincts (Fig. 1), met en lumière une seule région et ville enchantées, à travers son histoire,

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son habitat, sa géographie et son ethnographie, tous issus de la relation séculaire entre l'homme et son milieu de vie. Cette « ville... appelée Constantine » a attiré et attire toujours l'attention non seulement de ceux qui explorent sa nature et son habitat et s'intègrent à la vie urbaine, mais aussi de ceux qui s'y promènent temporairement dans ses rues à la fois archaïques et modernes. Depuis plus de vingt ans, animée par une curiosité exacerbée nourrie d'imagination et de soif de connaissance, je parcours cette ville unique à l'existence millénaire (Fig. 2). Le titre de cet ouvrage, qualifié de « touristique », se révèle en réalité comme une lecture scientifique et informative couvrant divers domaines complexes géographie, ethnographie et histoire urbaine. L'actualité des informations et la précision de la description, à la fois scientifique et littéraire, ne manquent pas de surprendre lorsque l'on prend conscience de l'ancienneté de la rédaction, attestée par l'année inscrite dans le titre : 1879, soit il y a près de cent cinquante ans. La préface de l'ouvrage, signée par Kamel Filali (16 novembre 2004), fournit des informations sur l'auteur et le contexte historique dans lequel il écrivit son texte, renforçant ainsi l'intérêt du lecteur pour la lecture et l'imaginaire des lieux décrits. Comme pour tout « lieu », le nom et la position géographique constituent ici des attributs identitaires fondamentaux.

L'ancienne ville numidienne de Cirta reçoit le nom de Constantine au IV^{ème} siècle. « Après la révolte d'Alexandre et sa répression, l'Afrique se rallia à Constantin dès sa victoire sur Maxence au pont Milvius, en octobre 312. Cirta fut restaurée, grâce aux financements et à la générosité impériale, et prit le nom de Constantina » (Albeche Youcef, 2009, p. 24), devenant ainsi capitale de la nouvelle Numidia Imperialis, sous le nom de Numidia Constantina.

La chaîne des Maghrébides (au Nord-Est de Constantine, en Algérie) présente des sommets alpins et des bassins sédimentaires du Miocène-Pliocène-Quaternaire, ainsi que des dépressions au relief vallonné situées entre 800 et 1 200 m d'altitude. Sur le plan géologique, la série néritique constantinoise (Crétacé moyen), constituée de calcaires massifs, est d'une importance majeure et forme la partie connue sous le nom de « le Rocher », au centre de la ville. Le flysch massylien et les formations faiblement érodées sont propices aux glissements de terrain (Chabour N., 2007).

La vieille ville se dresse sur un promontoire calcaire où les eaux du Rhumel ont creusé des gorges étroites et profondes (Fig. 3). Toute la région alpine du Nord-Est de l'Algérie, marquée par une sismicité notable,

conserve les traces de sa longue évolution géologique. Venant de la Méditerranée, l'auteur dresse un tableau de toute la zone traversée en train jusqu'à la gare de Constantine : « Le paysage, changeant d'aspect et s'embellissant à chaque instant... jusqu'aux splendeurs pittoresques du rocher sur lequel est posée la ville de Constantine » (p. 6).

Constantine et son Rhumel constituent un paysage diversifié de premier ordre, façonné par la topographie des lieux et la typologie de l'habitat. La dynamique des cours d'eau (le Rhumel et ses affluents) a engendré des paysages de second et de troisième ordre, aux multiples facettes au sein même de la ville : berges douces, verdoyantes et sablonneuses, berges occupées par des vergers, des quartiers spontanés, une zone industrielle, ainsi que des gorges profondes et étroites s'élargissant par endroits, ponctuées de cascades. Par ses activités, la population a occupé, transformé et anthropisé ces paysages naturels, développant ainsi un paysage urbain complexe. Les paysages naturels se trouvent dès lors subordonnés au paysage urbain (Grecu et al., 2023).

La ville et ses régions avoisinantes, regroupant une population dépassant le million d'habitants, s'inscrivent dans le bassin versant de l'oued Rhumel (superficie : 5 336,79 km², longueur : environ 150 km). Les rivières affluentes qui traversent la ville sont torrentielles, caractérisées par un fort déséquilibre morphologique, et exposées aux aléas hydrogéomorphologiques (Benoudina et al., 2026 ; Yakhlefoune et al., 2023).

Un critère essentiel dans la dynamique de la ville a été son développement continu sans altération du paysage existant. Dans cette optique, la ville s'est étendue soit vers des zones naturelles propices à la construction, soit vers des zones anthropisées (Fig. 4) par des aménagements sur les versants et/ou les lits des cours d'eau ; les paysages intra-urbains inadaptés ont progressivement cédé la place à des espaces de loisirs, de détente et de culture. Toutes les modifications survenues au fil du temps s'intègrent dans un paysage actuel profondément ancré dans le passé (Fig. 5).

Ainsi, les descriptions et les présentations contenues dans ces deux volumes peuvent aisément être reconstituées dans le paysage contemporain. Dans ce contexte, la description s'affirme comme une véritable méthode de recherche, couramment employée par les pionniers des sciences de

la Terre, y compris en géographie roumaine (exemple : George Vâlsan, Descriptions géographiques).

Le second volume-album restitue en images photographiques le texte du premier volume, accompagné des commentaires des éditeurs qui reconstituent, à partir de la description, la position géographique, le relief, les conditions de vie, les coutumes et le costume traditionnel. La préface de l'album, signée par Zineb Labidi (professeure de lettres à l'Université Paris VIII et écrivaine), met en évidence l'importance actuelle de l'ouvrage, en particulier pour les jeunes générations. Ancien élève de l'École Normale de Constantine, elle dresse un portrait succinct mais éloquent de l'ouvrage en tant que témoin authentique.

Les chapitres sont organisés selon le même plan que dans le premier volume, leurs titres reflétant fidèlement le contenu : Et Constantine paraît... (chap. I) ; Et la ville, c'est... (chap. II) ; Constantine, c'est aussi un art de vivre (chap. III) ; Et Constantine s'anime (chap. IV) ; Conclusion ; Annexes (plans de la ville A, B, C et D ; diplômes n° 1, 2 et 3 ; bibliographie). Les chapitres V et VI ne figurent pas dans l'album, car ils concernent non pas Constantine, mais « sa région ». L'album s'inscrit dans la collection L'Algérie d'hier à demain.

L'ensemble de cette œuvre éditoriale, présentée ici succinctement, est recommandé non seulement aux spécialistes des domaines complexes liés à la nature et à l'homme, mais à tout lecteur désireux de se former et de s'informer par la littérature. À notre sens, la perception de la valeur d'un livre dépend avant tout du lecteur : il n'existe ni livre ancien ni livre nouveau si l'on s'en tient à la seule année de parution et non au contenu. Cet ouvrage met en évidence, outre la maîtrise de l'écriture de Louis Régis, le talent de tous ceux qui ont contribué à son élaboration : M. Redjel Tahar, Mme Benkhelil Leila, Mme Dib Meziane Habiba, Mme Benseddik-Bdeir Sakina ; conception graphique : M. Redjel Mohamed Lamine ; collection de photographies personnelles et familiales.

« *Constantine. Voyage et séjour* fait partie du patrimoine mondial de la civilisation. » (Florin Grecu)

« *Constantine. Voyage et séjour* est un tableau merveilleusement dessiné. » (Kamel Filali)

« ... comme un texte mémoire, relu aujourd'hui. » (Zineb Labidi).

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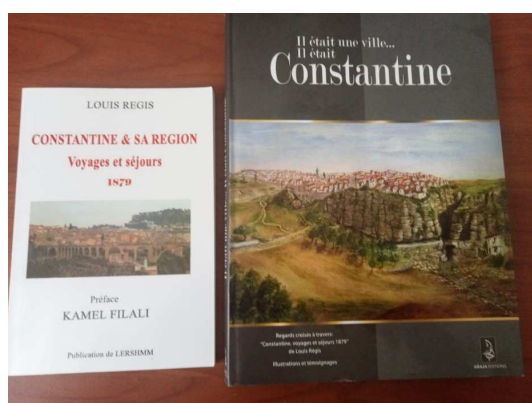


Figure 1. Couverture des livres



Figure 2. Esplanade central
(Grecu, 2026)

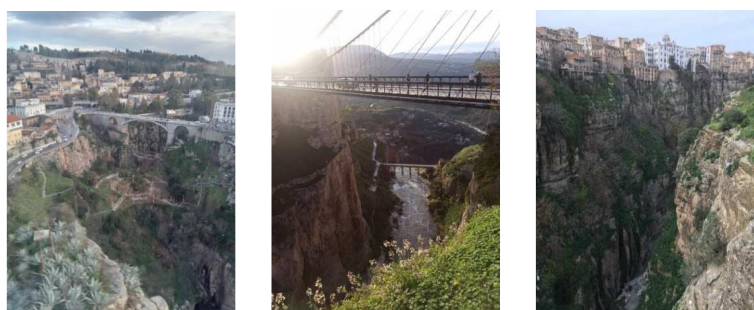


Figure 3. Le Rhumel : vue aérienne (télécabine) ; ponts suspendus ; des gorges, versants droit
(Grecu, 2026)



Figure 4. Aménagement des versants
(Grecu, 2023 et 2026)



Figure 5. Développement de la ville.
Paysage urbain de plateau avec les monts de l'Atlas en arrière-plan
(Grecu, 2026)

All links were verified by the author and found to be functioning before the publication of this text in 2026.

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Gabriel CAMARĂ¹

David A. FENNELL (2026). *Ecotourism (Sixth Edition)*, Routledge, Abingdon and New York, 412 p., ISBN 9781003565635 (EBK)

As tourism growth raises issues regarding its effects on natural and cultural environments, ideas on tourism ethics and tourism activities friendly with the destinations become worth studying. Professor David A. Fennell is one of the authors which had long-date interests in tourism ethics and nature-based tourism; this book on ecotourism being at its 6th edition. This edition distinguishes itself from the previous ones by the integration of recent research and new case studies from underrepresented world regions, and also a deeper analysis of contemporary challenges such as climate change, policy reform, and the UN Sustainable Development Goals. Each chapter also includes learning objectives, which makes this book valuable for students and academics in the field of social sciences, for policymakers, and for professionals involved in sustainable tourism practices.

As expected from a book with such a topic, this volume is cross-disciplinary, the core idea of tourism sustainability being supported by perspectives from different disciplines, such as geography, economics, ethics, and environmental studies.

The book is organized into three parts, which include 12 chapters. The first two parts define ecotourism, while the third part discusses the impacts of ecotourism and issues related to development, governance, policy, and programme planning.

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Within the first part, *The essence of ecotourism* (chapters 1-2), Chapter 1 draws an overview of the tourism industry, by presenting mass tourism and alternative tourism (including ecotourism), with the scope to highlight their different features. The entire book is of interest for anyone and for any destination, but the chapter contains a case study particularly relevant for Romania, on the interactions between tourists and wildlife, specifically the bears: *Up close and personal with grizzly bears in Denali National Park, Alaska*. Chapter 2 focuses on ecotourists, after an overview of general tourist typologies. It demonstrates that ecotourists are not a homogeneous group based on several segmentation and typology studies. The author already introduces ethics, arguing that ethics has to be a core element of ecotourism.

The second part, *Core criteria used to define ecotourism* (chapters 3-7), deepens the definition of ecotourism by presenting the nature-based component of ecotourism (Chapter 3), and comparing ecotourism with other nature-based tourism types (such as hunting and fishing tourism) and emphasizing their relations with the natural environment. Chapter 4 introduces the concept of sustainability and discusses the necessity of local involvement and the local benefits, seen as key components of ecotourism. Chapter 5 continues the discussion on sustainability in relation to conservation and the management of natural areas and biodiversity, and this discussion continues in Chapter 6 with the presentation of some actors (operators and guides) who facilitate the knowledge on ecotourism through the learning experience. In a logical sequence, Chapter 7 refers to the ethical implications of ecotourism, its title being suggestive as it contains the word “imperative”, and highlights the responsibilities of both tourists and practitioners.

Within the third part, *Topics and issues important to ecotourism* (Chapters 8-12), Chapter 8 examines what may seem surprising, related to ecotourism, specifically the disturbances created in destinations. It also examines the concept of carrying capacity in tourism and its related weaknesses. Chapter 9 focuses on economic impacts and marketing of ecotourism, on issues related to the value of land, gaining revenues for parks and protected areas, marketing challenges in ecotourism, etc.

Chapter 10 contains discussions on development theory with links to the tourism industry, island environments, pro-poor tourism, Glasbergen’s five models of environmental governance, the use of ecotourism, and

newer forms of management such as collaborative management and adaptive co-management, governance, and equity.

The practical components needed for the development of ecotourism programmes are presented in Chapter 11. This approach is necessary, since the author considers that it has received scant attention in ecotourism and tourism more broadly, both in theory and practice.

The final chapter, *Conclusion*, contains personal reflections of the author concerning the future of ecotourism, in phrases wrote at the first person which denote his attachment to the field of ecotourism and to the idea exposed: "While some argue, as I do, for a stricter definition of ecotourism, some of my colleagues go so far as to suggest that ecotourism cannot survive devoid of a relationship with sustainable mass tourism. We will have to see. If ecotourism does partner mass tourism, has it not undergone a significant transformation? Is it not then mass sustainable tourism with a sprinkling of nature? I still believe there is a distinct market of ecotourists, contrary to what some scholars argue" (p. 330).

As already mentioned, this volume is of interest for academics and professionals in various fields, but it is also a good book for the general public, since it presents the general field of tourism, an activity which involves almost everyone, from mass tourism to niche tourism (ecotourism), with relevant examples and case study, and wrote in an accessible language perfected over previous editions and through dedicated work for several decades.

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Constantin-Răzvan OPREA¹

**THE 3rd INTERNATIONAL CONFERENCE:
GEOGRAPHICAL SCIENCE AND FUTURE OF EARTH**



The Faculty of Geography of the University of Bucharest hosted, on November 7, 2025, the 3rd edition of the Geographical Sciences and Future of Earth Conference (GeoEarth 2025), organized by the Department of Geomorphology–Pedology–Geomatics as part of the Annual Conference program of the Faculty of Geography. Continuing the tradition of the 2017 and 2021 editions, the event brought together university professors, researchers, PhD students, and specialists from Romania, Switzerland, Germany, the Republic of Moldova, France, and Algeria to discuss contemporary geographical research, environmental dynamics, socio-economic processes, climate change, and sustainable development.

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The official opening in the Mehedinți Amphitheatre was attended by the leadership of the University of Bucharest and international guests. The inaugural ceremony featured Prof. Dr. Marian Preda, Rector of the University of Bucharest; Prof. Dr. Laura Comănescu, Vice-Rector for Academic Programs and Student Internships; Prof. Dr. Alexandru Nedelea, Dean of the Faculty of Geography; and Assoc. Prof. Dr. Constantin-Răzvan Oprea, Director of the Department of Geomorphology–Pedology–Geomatics. Diplomas and medals were awarded to pre-university teachers for their contribution to promoting the Faculty of Geography.

The scientific program opened with plenary lectures delivered by Prof. Dr. Emmanuel Reynard (University of Lausanne, Professor Honoris Causa of the University of Bucharest) and Prof. Dr. Olaf Kühne (University of Tübingen), who also received diplomas and medals for their contribution to strengthening academic relations with the Faculty of Geography of the University of Bucharest.

GeoEarth 2025 gathered 279 participants and included 130 scientific presentations (oral communications and posters) organized in two working sessions and several thematic panels, including Applied Geomorphology from Landscapes to Land Use, Water – Society – Environment, Monitoring Weather and Climate to Reduce Their Impacts and Effects, Recent Dynamics and Challenges of Territorial, Economic and Social Processes, Challenges of Environment and Human Dimension, and Teaching Geography.

The conference concluded with a closing ceremony highlighting the importance of international academic cooperation and the continuity of geographical research. Detailed information can be found on the following page: GeoEarth 2025. From this page, the volume of abstracts, with ISBN, can also be downloaded.



Official opening of the conference



Prof. Dr. Marian Preda,
Rector of the University of Bucharest



Prof. Dr. Laura Comănescu,
Vice-Rector for Academic Programs
and Student Internships



Prof. Dr. Alexandru Nedelea,
Dean of the Faculty of Geography



Diploma of participation offered to Prof. Dr. Olaf Kühne
(University of Tübingen) by Assoc. Prof. Dr. Constantin-Răzvan Oprea,
Director of the Department of Geomorphology-Pedology-Geomatics,
Faculty of Geography

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Gabriel CAMARĂ¹

**IGU CDES CONFERENCE INTERNATIONAL GEOGRAPHICAL
UNION – COMMISSION OF “THE DYNAMICS OF ECONOMIC
SPACES” FACULTY OF HUMAN GEOGRAPHY AND PLANNING,
ADAM MICKIEWICZ UNIVERSITY, POZNAŃ (POLAND),
SEPTEMBER 16–18, 2025**

The annual Conference of the International Geographical Union (IGU) – Commission of “The Dynamics of Economic Spaces” (CDES) took place in September 2025 in Poznań, Poland, under the theme “Geopolitical Turbulences, Environmental Challenges and the Reconfiguration of Economic Spaces”.

The first day of the Conference took place at the University’s main building (Collegium Minus), in the city center, and the next two days of the Conference were hosted at the Faculty of Human Geography and Planning, Morasko Campus, in the north of the city.

The Conference opened with introductory remarks of Prof. Zbyszko Melosik, Vice-rector of the Adam Mickiewicz University, Prof. Paweł Churski, dean of the Faculty of Human Geography and Planning, Prof. Eva Kiss, Chair of the IGU Commission on the Dynamics of Economic Spaces, and Prof. Robert Kudłak, Head of the Local Organising Committee.

Then, a keynote speech was held by Prof. Gavin Bridge (Durham University), the subject being very welcome within the conference theme and providing interesting facts about an area almost unknown but decisive for the contemporary civilization: “Geo-economics and the critical minerals moment”.

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The Conference had 24 presentations grouped within eight sessions: The natural environment and sustainability transition I and II, (Geo)Political Impacts, Evolutionary Economic Geography, MNEs' Behaviour and (Geo)Politics, Sustainable Economy and Urban Places, Industry and Regional Development, Economic Resilience and Innovation.

All the presentations were of very high quality, reflecting the innovative approaches in a complex field such as economic geography. Among chairs and presenters were well-known specialists: Prof. Robert Hassink, Prof. Tadeusz Strykiewicz, Prof. Neil Reid, Prof. Nuri Yavan, Prof. Lech Suwala, Prof. Rolf Schlunze, Prof. Piotr Pachura, Prof. Michał Męczyński, Prof. Edilson Pereira Júnior, to name only a few.

Another interesting moment was the keynote speech of Mr. Marcin Rzepczyński (VW Group Poland), titled "Spatial reconfiguration of the production and logistic processes in the automotive industry: A historical and contemporary perspective", where the presenter discussed the challenges that Volkswagen Group must deal with in an era of changes.

The Conference ended with a field trip to the VW Plant Września in Białeżyce (approx. 60 km from Poznań), one of the most modern automotive factories in Europe. The program included a tour of the welding shop and the assembly hall, showcasing automation and robotic processes.

The next Conference of this Commission will be held in Turku, Finland, May 27-29, 2026. IGU Regional Conference, which will be held in Istanbul, Turkey, between 17 and 21 August 2026, will also include sessions of this Commission.

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Oana PUIA¹

**DOCTORAL THESES
DEFENDED DURING THE PERIOD
October 1, 2023 – September 30, 2025**

No. Crt.	Doctoral Student's First and Last Name	Professor Coordinator	Title of the Doctoral Thesis	Date of Public Defense
1	POPA (CIMBRU) Daniela Gabriela	Prof. univ. dr. Liliana DUMITRACHE	Vulnerabilități socio- teritoriale în bazinul Tazlău	06.10.2023
2	CHELU Maria Alexandra	Prof. univ. dr. Liliana ZAHARIA	Hydroclimatic drought and it's impacts on vegetation in south-eastern Romania	19.12.2023
3	POPA Mihnea Cristian	Prof. univ. dr. Daniel PEPTENATU	Amenajarea luncii inferioare a Dunării pe sectorul Giurgiu–Călărași în scopul atenuării undelor de viitură și regenerării ecologice	12.01.2024
4	PETRE (RĂȘINEANU) Corina Mihaela	Prof. univ. dr. Silviu NEGUȚ	Potențialul României pentru patrimoniul mondial natural și cultural UNESCO	15.01.2024
5	PUTICI (PASCAL) Maria Daniela	Prof. univ. dr. Alfred VESPREMEANU STROE	Istoria glacierei și deglacierii masivului Făgăraș	21.02.2024
6	TRUȚESCU Marius Nicolae	Prof. univ. dr. Elena MATEI	Dezvoltarea turismului durabil în Subcarpații Olteniei	19.07.2024

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7	ILIE Gabriel Cosmin	Prof. univ. dr. Florina GRECU	Geosituri de pe valea Buzăului în sectorul carpatic și subcarpatic	13.09.2024
8	GIUREA Alexandru Andrei	Prof. univ. dr. Laura COMĂNESCU	Analiza dinamicii albiei râului Gilort. Prognoza evoluției și impactul asupra infrastructurii de transport. Studiu de caz: Situl Natura 2000 râul Gilort în perioada 1965-2019	23.09.2024
9	ȚIȚINEANU Iris Elena	Prof. univ. dr. Georgeta BANDOC	Contribuții la cunoașterea caracteristicilor fizice ale atmosferei libere și ale stratului limită atmosferic.	24.09.2024
10	PETRE Florin Bogdan	Prof. univ. dr. Cristian BRAGHINĂ	Evoluția socio-economică a primului inel de așezări umane din jurul Municipiului București după anul 1990	27.09.2024
11	ȘERBAN Ioan Daniel	Prof. univ. dr. Alexandru NEDELEA	Analiza transparenței apelor din Nord-Vestul Mării Negre pe baza datelor de observare a Pământului	27.09.2024
12	IORDACHE Gabriel	Prof. univ. dr. Georgeta BANDOC	Analiza interdisciplinara a dinamicii albiei Dunării în difluențele Ceatal Izmail și Ceatal Sfântu Gheorghe	30.09.2024
13	BAZAC Dumitru Titus Felix	Prof. univ. dr. Daniel PEPTENATU	Parcul Carol I – management teritorial specific prin prisma accesibilității utilizatorilor	30.09.2024
14	COVĂTARU Cristina Ioana	Prof. univ. dr. Alfred VESPREMEANU STROE	Analiza distribuției spațiale a așezărilor din perioada Neo-Eneolitică din Muntenia și Dobrogea și a favorabilității mediului geografic. Integrarea aplicațiilor GIS și a analizelor de paleomediu în arheologie	18.12.2024
15	TUFĂNOIU Ionuț	Conf. univ. dr. Cristian DRĂGHICI	Geoturismul în zona carpatică și subcarpatică a județului Vrancea	31.07.2025
16	DOBRE Roxana Ioana	Prof. univ. dr. Laura COMĂNESCU	Relația relief-activități turistice, în masivul Făgăraș, sectorul dintre vârfurile Negoiu și Moldoveanu la altitudini peste 1800 metri	29.09.2025



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