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Thank you.

Dedications

To you reading now.

Résumé

Cette recherche aborde les défis urbains et culturels critiques auxquels Tlemcen, en Algérie, est confrontée, en proposant un cadre innovant qui intègre le patrimoine architectural traditionnel aux pratiques durables contemporaines. En se concentrant sur l'entrée nord-ouest de la ville, El-Koudia, une porte d'entrée historiquement importante mais dégradée, l'étude élabore un plan directeur et une intervention architecturale pour revitaliser la zone tout en préservant son identité culturelle et en améliorant la résilience écologique.

Le mémoire identifie des problèmes systémiques, notamment la détérioration des structures historiques, l'étalement urbain incontrôlé, les vulnérabilités sismiques et la perte de continuité culturelle. Il émet l'hypothèse que la combinaison de techniques de construction vernaculaires avec des stratégies de durabilité modernes, telles que la réutilisation adaptative, la conception bioclimatique et la planification centrée sur la communauté, peut atténuer ces défis. Sur le plan méthodologique, l'œuvre utilise des outils informatiques (Revit BIM, Flex 4.0) ainsi que des principes architecturaux islamiques traditionnels, notamment la thermorégulation des cours, les proportions géométriques et les réseaux spatiaux inspirés des souks.

Les principales innovations comprennent : (i) Un centre communautaire multifonctionnel qui réactive l'espace public grâce à des programmes à usage mixte, atteignant les normes LEED Or en matière d'efficacité énergétique et de qualité de l'environnement intérieur. ii)Technologies durables (barrières rayonnantes, panneaux photovoltaïques, récupération des eaux de pluie) associées à des stratégies passives (ventilation naturelle, orientation solaire) pour réduire de 40 % les émissions de carbone opérationnelles. iii)Analyse du cycle de vie (ACV) validant la réutilisation adaptative par rapport à la démolition, avec des stratégies de récupération des matériaux minimisant le carbone intrinsèque. iv)Des réseaux de circulation hiérarchisés pour résoudre les embouteillages tout en renforçant la connectivité des piétons.

Les résultats démontrent : (i) Renforcement de l'identité culturelle grâce à l'engagement communautaire et à la réinterprétation du patrimoine. ii)Amélioration de la résilience urbaine en s'attaquant aux risques sismiques et aux vulnérabilités climatiques. (iii) Un modèle évolutif pour les villes méditerranéennes aux prises avec la modernisation et le patrimoine.

L'étude se termine par des recommandations politiques en architecture visant à encourager la réutilisation adaptative, à intégrer le BIM dans la conservation et à mettre à jour les programmes d'études pour faire le lien entre l'artisanat traditionnel et les outils numériques. En positionnant le patrimoine culturel comme un moteur de durabilité, ce cadre offre un modèle reproductible pour concilier croissance urbaine et préservation historique.

Mots-clés : Flex 4.0 de la réutilisation adaptative , Durabilité, Patrimoine culturel de tlemcen, Revit-BIM, Revitalisation urbaine, Pôle communautaire à l'entrée nord-ouest d'Elkoudia

ملخص

يتناول هذا البحث التحديات الحضرية والثقافية الحرجة التي تواجه تلمسان بالجزائر من خلال اقتراح إطار مبتكر يدمج التراث المعماري التقليدي مع الممارسات المستدامة المعاصرة. مع التركيز على المدخل الشمالي الغربي للمدينة، الكودية - وهي بوابة ذات أهمية تاريخية ولكنها متدهورة - تطور الدراسة مخططا رئيسيا وتدخلا معماريا لتنشيط المنطقة مع الحفاظ على هويتها الثقافية وتعزيز المرونة البيئية.

تحدد الأطروحة القضايا المنهجية، بما في ذلك تدهور الهياكل التاريخية، والزحف الحضري غير المنضبط، ونقاط الضعف الزلزالية، وفقدان الاستمرارية الثقافية. تفترض أن الجمع بين تقنيات البناء العامية واستراتيجيات الاستدامة الحديثة - مثل إعادة الاستخدام التكيفي والتصميم المناخي الحيوي والتخطيط المتمحور حول المجتمع - يمكن أن يخفف من هذه التحديات. من الناحية المنهجية، يستخدم العمل أدوات حسابية (Revit BIM وFlex 4.0) جنبا إلى جنب مع المبادئ المعمارية الإسلامية التقليدية، بما في ذلك التنظيم الحراري للفناء، والتناسب الهندسي، والشبكات المكانية المستوحاة من السوق.

تشمل الابتكارات الرئيسية ما يلي: (i) مركز مجتمعي متعدد الوظائف يعيد تنشيط الأماكن العامة من خلال البرمجة متعددة الاستخدامات، وتحقيق معايير LEED الذهبية في كفاءة الطاقة وجودة البيئة الداخلية. (2) التقنيات المستدامة (الحواجز المشعة، والمصفوفات الكهروضوئية، وحصاد مياه الأمطار) مقترنة بالاستراتيجيات السلبية (التهوية الطبيعية، التوجيه الشمسي) لتقليل الكربون التشغيلي بنسبة 40٪. (iii) تقييم دورة الحياة (LCA) التحقق من إعادة الاستخدام التكيفي على الهدم، مع استراتيجيات استعادة المواد التي تقلل من الكربون المتجسد. (4) شبكات الدوران الهرمية لحل الازدحام المروري مع تعزيز اتصال المشاة.

وتبين النتائج ما يلي: (ط) تعزيز الهوية الثقافية من خلال المشاركة المجتمعية وإعادة تفسير التراث. (2) تحسين القدرة على الصمود في المناطق الحضرية من خلال معالجة المخاطر الزلزالية ومواطن الضعف المناخية. نموذج قابل للتطوير لمدن البحر الأبيض المتوسط التي تتصارع مع التحديث والتراث.

وتختتم الدراسة بتوصيات سياسية لتحفيز إعادة الاستخدام التكيفي، ودمج نمذجة معلومات البناء في الحفظ، وتحديث المناهج الدراسية لربط الحرفية التقليدية بالأدوات الرقمية. من خلال وضع التراث الثقافي كمحرك للاستدامة، يقدم هذا الإطار مخططا قابلا للتكرار للتوفيق بين النمو الحضري والحفاظ على التاريخ.

الكلمات المفتاحية: إعادة الاستخدام التكيفي Flex 4.0, الاستدامة, التراث الثقافي لتلمسان, Revit-BIM, التنشيط الحضري, المركز المجتمعي عند المدخل الشمالي الغربي للكودية

Abstract

This research addresses the critical urban and cultural challenges facing Tlemcen, Algeria, by proposing an innovative framework that integrates traditional architectural heritage with contemporary sustainable practices. Focusing on the northwestern entrance of the city, El-Koudia—a historically significant yet degraded gateway—the study develops a masterplan and architectural intervention to revitalize the area while preserving its cultural identity and enhancing ecological resilience.

The dissertation identifies systemic issues, including the deterioration of historic structures, uncontrolled urban sprawl, seismic vulnerabilities, and loss of cultural continuity. It hypothesizes that combining vernacular building techniques with modern sustainability strategies—such as adaptive reuse, bioclimatic design, and community-centric planning—can mitigate these challenges. Methodologically, the work employs computational tools (Revit BIM, Flex 4.0) alongside traditional Islamic architectural principles, including courtyard thermoregulation, geometric proportioning, and souk-inspired spatial networks.

Key innovations include: (i)A multifunctional community hub that reactivates public space through mixed-use programming, achieving LEED Gold benchmarks in energy efficiency and indoor environmental quality. (ii)Sustainable technologies (radiant barriers, photovoltaic arrays, rainwater harvesting) paired with passive strategies (natural ventilation, solar orientation) to reduce operational carbon by 40%. (iii)Life-cycle assessment (LCA) validating adaptive reuse over demolition, with material recovery strategies minimizing embodied carbon. (iv)Hierarchical circulation networks to resolve traffic congestion while reinforcing pedestrian connectivity.

The outcomes demonstrate: (i)Enhanced cultural identity through community engagement and heritage reinterpretation. (ii)Improved urban resilience by addressing seismic risks and climate vulnerabilities. (iii)A scalable model for Mediterranean cities grappling with modernization and patrimony.

The study concludes with architectural policy recommendations to incentivize adaptive reuse, integrate BIM in conservation, and update curricula to bridge traditional craftsmanship with digital tools. By positioning cultural heritage as a driver of sustainability, this framework offers a replicable blueprint for reconciling urban growth with historical preservation.

Keywords: Flex 4.0 of Adaptive reuse, Sustainability, Cultural heritage of tlemcen, Revit-BIM, Urban revitalization, Community hub in North-west entrance-Elkoudia

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Abbreviations

2D : Deux Dimension
3D : Trois Dimension
AEC:Architecture, Engineering & Construction Collection
AEK : Emir Abdelkader or Abd al-Qadir al-Hassani al-Jaza'iri
AGI : Artificial general intelligence
AI : Artificial intelligence
AIA : The American Institute of Architects
BC : Before Christ
BIM : Building Information Modelling
BREEAM : Building Research Establishment Environmental Assessment Method
CC : Chemin communal
CES : Corps D'état Secondaires
CFD : Computational fluid dynamics
CGI : Computer Generative images
CW: Chemin de wilaya
GIS : Geographic Information System
H/F : Homme / Femme
HQE : Haute Qualité Environnementale
HVAC : Heating, Ventilation, and Air Conditioning
ICOMOS: International Council on Monuments and Sites
IEQ: Indoor Environmental Quality
LCA : Life Cycle Assessment
LEED : Leadership in Energy and Environmental Design
OPJI : Office de Promotion et de Gestion Immobilière
PAW : Plan d'aménagement de wilaya
PC : Personal Computer
PDAU : Le plan directeur d'aménagement et d'urbanisme
POS : Le plan d'occupation des sols
PSN: PlayStation Network
RIBA : The Royal Institute of British Architects
RN : Route Nationale
RPA : Règles Parasismiques Algériennes
UFAD : Underfloor Air Distribution
UFM : Union for the Mediterranean
VFX : Visual effects
VOC: Volatile Organic Compounds
VRD : Voiries et Réseaux Divers

GENERAL INTRODUCTION

1.Introduction

Contemporary architecture stands at a pivotal crossroads, necessitating a profound rethinking of construction practices in response to pressing environmental and social challenges. As the world grapples with the ramifications of climate change and resource depletion, the construction industry one of the largest contributors to global carbon emissions faces increasing scrutiny. In Algeria, this urgence is particularly pronounced; the prevalent lack of sustainability in current construction practices has led to rapid obsolescence of new buildings, often requiring maintenance shortly after completion.

This scenario underscores the need for innovative approaches that not only enhance the resilience of new structures but also draw upon the rich tapestry of built heritage, which embodies traditional knowledge and sustainable practices that have stood the test of time. The current construction practices in Algeria often result in buildings that require extensive maintenance shortly after completion, reflecting a systemic failure to integrate sustainable methodologies. (Harouache et al., 2024).

In addition, this situation stands in stark contrast to building heritage, which embodies centuries of accumulated knowledge and demonstrates remarkable durability. Research (Kardampiki, 2020) indicates that heritage buildings often utilize materials and methods that are inherently sustainable, offering valuable lessons for modern architectural practices by examining these structures, we can identify key attributes that contribute to their resilience we can uncover materials, techniques and more of their functionality so we can relate how they have stood with the test of time. Such an exploration not only preserves cultural identity but also promotes environmentally responsible construction methods that mitigate the impacts of climate change.

The challenge remains in creative adaptation to ancient knowledge to meet contemporary needs without resorting to mere imitation. This inquiry is crucial as it encourages a dialogue about the role of architecture in fostering sustainable communities. To add on, innovative practices in cultural heritage management can enhance community engagement and promote social cohesion. Initiatives that leverage cultural resources can create economic opportunities while fostering a sense of identity and belonging among local populations. (Labadi et al., 2021)As such, integrating innovation into heritage conservation not only preserves cultural assets but also contributes to broader societal goals.

The literature on sustainable architecture highlights a growing recognition of the need for innovative solutions that integrate traditional practices with modern sustainability principles. For instance, studies have documented the benefits of adaptive reuse of a practice that repurposes old buildings for new uses while minimizing waste and preserving cultural significance(Kardampiki, 2020). Furthermore, the circular economic concept has gained traction, emphasizing the importance of rethinking resource use in construction. (Giliberto & Labadi, 2022). However, despite these advancements, significant questions remain regarding the practical implementation of these concepts in diverse contexts.

Research also indicates that integrating heritage techniques into modern design can yield structures that are not only culturally relevant but also environmentally responsible. For instance, the UfM (Union for the Mediterranean) Workshop on Urban Heritage and Traditional Building Skills convened experts to explore innovative solutions using local materials and vernacular techniques(UfM Secretariat, 2024). This initiative aims to bolster local heritage resilience while discussing sustainable approaches to rebuilding adapted to climate challenges. Such workshops highlight the importance of preserving cultural identity while fostering community resilience through sustainable practices.

However, despite the clear benefits of utilizing heritage techniques, conflicts arise regarding the best methodologies for achieving this integration. Some scholars argue for a more radical departure from traditional methods, advocating for entirely new materials and technologies. Others emphasize the value of maintaining historical integrity through careful adaptation(Li & Zhang, 2022)This divergence points to a broader debate within the field: how do we balance innovation with preservation? Additionally, while many studies highlight successful case studies of sustainable service innovation in various sectors(Akinboyewa et al., 2020) there is a lack of comprehensive frameworks for evaluating these practices specifically within architectural heritage.

The role of supply chain management is crucial in enhancing sustainable construction practices within the Algerian context. A recent study by (Harouache et al., 2024) investigates how effective supply chain management can improve sustainability outcomes in construction projects. It emphasizes collaboration among stakeholders, including designers, manufacturers, contractors, and suppliers—to foster innovative ideas that contribute to sustainable development. By establishing a conducive environment for collaboration, stakeholders can align their efforts toward creating value through sustainable construction practices.

Historic centres, time capsules of our past, are tangible links to our cultural heritage, shaping our identity. Yet, many of these urban treasures struggle to keep pace with modern demands. Algeria's old cities, like Tlemcen, bear the scars of colonial interventions, fragmenting their once harmonious urban fabric. (RAIS & ELYEBDRI (2019)

To breathe new life into these historic gems, adaptive reuse emerges as a powerful tool. By marrying history with modernity, it transforms these spaces into vibrant, sustainable hubs. This approach, balancing heritage preservation and innovation, safeguards our cultural legacy for future generations. Tlemcen's designation as the Islamic Culture Capital provided an ideal opportunity to repurpose its historic monuments into living museums, ensuring their enduring relevance. (Djebbour & Biara (2019)

By drawing inspiration from Tlemcen's historic buildings and monuments for example "*…The Great Mosque of Tlemcen is a unique case, as it is one of the few mosques dating back to the Almoravid period that is almost intact. It has evolved in a constantly changing space and now has a conjoined public square, following an occidental configuration, which is quite rare. The size of this square suggests that it could be put to use as an additional vector for the valorisation of the mosque, but the current situation is different. This added space, introduced by occidental culture, creates a dual architectural language with several other buildings that mark all the layers of evolution in the urban fabric. Apart from its religious function, this mosque used to play the role of a covered public square, a role that has eroded over time..."* (M. C. Selka & Oussadit (2023) , from this, we aspire to contribute to the sustainability of contemporary architecture while fostering an appreciation for our architectural legacy.

This approach not only revitalizes neglected structures but also integrates them into the evolving urban landscape of Tlemcen, ensuring that our architectural practices remain relevant and respectful of the past.

2.Case study

Unveiling the secrets of time, this research explores the enduring legacy of Tlemcen historic buildings. By delving into the wisdom of ancient builders, we aim to bridge the gap between past and present. By reinterpreting traditional techniques and materials, we can develop innovative solutions that respect our heritage while addressing today's challenges on site El Koudia north west the entrance of Tlemcen city. Therefore, this research aspires to create a future where Tlemcen's rich history and sustainable urban development coexist harmoniously.

3.Interest of the research

Tlemcen, often called the "African Granada," is the focus of this study due to its unique architectural heritage, blending Moorish influences with vernacular building traditions, particularly evident in districts like Tlemcen. As one of the first urban expansions of the colonial era. (SELKA, 2021)

Despite this rich historical backdrop, the city's entrance from El Koudia currently presents a stark contrast. While recent efforts, such as the "Welcome to Tlemcen" signs erected in late 2024, aim to improve the city's image, this entry point projects a negative impression. The area suffers from visible degradation due to informal settlements, obsolete buildings, poor connectivity, traffic congestion, and unexploited land resulting from inadequate planning that fails to meet the needs of the population. This disconnects between the city's historical richness and its uninviting entrance motivates this research to explore solutions through a sustainable masterplan focused on revitalizing this gateway. The aim is to create an entrance that truly reflects Tlemcen's historical nature, preserving its culture and identity while providing a welcoming and functional space for residents and visitors.

4.Research problem:

Tlemcen, renowned for its wealth of architectural heritage, confronts serious difficulties in safeguarding its historical landmarks and ensuring the upkeep of modern buildings. Among the most affected sites are the Great Mosque of Tlemcen, the Sidi Boumediene Mosque, and the National Museum of Islamic Monuments, all which grapple with issues like structural deterioration, moisture infiltration, pollution-related harm, and other vulnerabilities explored further in this analysis. Additionally, the historic Medina of Tlemcen struggles with neglect, misguided restoration efforts, and the encroachment of contemporary infrastructure, alongside a host of other concerns. The subsequent sections delve into a systematic classification and detailed exploration of these multifaceted challenges:

4.1 Deterioration of Historic Buildings: The deterioration of these structures can be attributed to several key factors: *(i)Neglect and Lack of Maintenance*: Many historic buildings in Tlemcen have suffered from prolonged neglect, leading to severe structural decay and aesthetic decline. The abandonment of properties by their owners has exacerbated this issue, resulting in the proliferation of dilapidation and even homelessness in the area.

Despite various intervention strategies implemented by local authorities, these efforts have often failed to produce the desired outcomes, leaving many historic structures vulnerable to further deterioration.

(ii)Inappropriate Restoration: Restoration projects in Tlemcen have frequently been poorly executed, damaging the original fabric of historic buildings. Past interventions have sometimes led to the demolition of significant structures or alterations that do not respect the historical context, contributing to a loss of cultural identity. For example, various projects have resulted in the transformation or destruction of important architectural sites, undermining their historical value and integrity.

(iii)Natural Disasters and Climate Change: Tlemcen is also susceptible to natural disasters such as earthquakes and floods, which can significantly exacerbate the deterioration of its heritage sites. Climate change poses additional risks, as shifting weather patterns may lead to increased rainfall and flooding, further threatening the structural integrity of these historic buildings. The Great Mosque of Tlemcen, for instance, has faced challenges due to environmental factors that contribute to its decline despite its historical significance.

4.2 Urban Sprawl and Loss of Historical Character: There are significant challenges due to rapid and uncontrolled urban sprawl. This unchecked development threatens to erode the city's unique character and historical identity, disrupting its traditional urban fabric and leading to infrastructure deficiencies. All these can be deepened with a detailed explanation below:

(i)Uncontrolled Urban Expansion: The rapid urbanization of Tlemcen has led to uncontrolled expansion that encroaches on historic areas « le médina de Tlemcen ». As the population grows and economic activities increase, new developments often extend into regions that are rich in cultural significance. This expansion not only alters the landscape but also diminishes the historical context of the city, making it difficult for residents and visitors to appreciate Tlemcen's unique heritage.

(ii)Loss of Traditional Urban Fabric: New developments in Tlemcen frequently disrupt the traditional urban fabric, leading to a loss of historical continuity. Insensitive architectural designs and construction practices can overshadow or replace historic buildings, erasing the visual and cultural links to the past. For instance, modern commercial structures may be built in proximity to ancient mosques or traditional houses, creating a jarring contrast that undermines the city's historical narrative.

(iii)Traffic Congestion and Pollution: The increase in urban population and development has resulted in heightened traffic congestion and pollution, which further impact the historic environment of Tlemcen. The influx of vehicles not only contributes to air and noise pollution but also affects pedestrian accessibility to historic sites. This degradation of the urban environment detracts from the experience of both locals and tourists, making it less appealing to engage with Tlemcen's rich cultural heritage.

4.3 Inadequate Heritage Management and Conservation: The effectiveness of preservation efforts is undermined by several critical issues:

(i)Lack of Financial Resources: One of the most pressing challenges in Tlemcen is the lack of financial resources allocated for heritage conservation. Insufficient funding limits the ability of local authorities and heritage organizations to undertake necessary restoration projects, conduct maintenance, and implement effective preservation strategies. This financial shortfall often results in the deterioration of historic sites, as essential repairs and conservation work are postponed or neglected altogether.

(ii)Limited Expertise: The shortage of skilled professionals in the field of heritage conservation further complicates preservation efforts in Tlemcen. Trained conservators, architects, and restoration specialists are vital for ensuring that conservation practices adhere to established standards and respect the integrity of historic structures. Without access to this expertise, restoration projects may be poorly executed, leading to irreversible damage to Tlemcen's architectural heritage.

(iii)Weak Legal Frameworks: The legal frameworks governing heritage protection in Tlemcen are often weak and inadequately enforced. Existing laws may lack the necessary rigor to safeguard historic sites effectively, leaving them vulnerable to neglect, inappropriate development, or even demolition. The absence of stringent regulations makes it challenging to hold property owners accountable for the maintenance of their historic buildings, further exacerbating the risk of deterioration.

4.4 Deterioration of Materials*:* Historic buildings such as *"Musee public national des monuments islamiques de Tlemcen"* are affected by erosion, salt damage, and biological attacks that compromise their structural integrity. Material deterioration can be classified into (i) *Erosion*: Natural erosion processes contribute to the gradual wear and tear of building materials, compromising their structural integrity. (ii) *Salt Damage*: The presence of salts in the environment can lead to efflorescence and crystallization within building materials, causing further degradation and loss of decorative elements. (iii) *Biological Attack*: Biological factors, such as mold and vegetation growth, can infiltrate structures, leading to material decay and weakening of the overall construction.

4.5 Structural Issues: Factors such as seismic vulnerability and uneven settlement threaten the stability of historic structures. Material deterioration can be classified into (i)*Seismic Vulnerability*: Tlemcen is in a seismically active region, making its historical structures susceptible to earthquake damage. Many buildings may not have been designed to withstand seismic forces, increasing the risk of collapse during tremors. (ii)*Settlement:* Uneven settlement of foundations can lead to cracks and structural instability in older buildings. This issue is particularly prevalent in areas with poor soil conditions or inadequate drainage systems. (iii) *Load-Bearing Issues*: Some historic structures may face challenges related to load-bearing capacity due to alterations made over time or the natural degradation of materials.

4.6 Fire Hazards*:* Historic buildings such as Tlemcen great mosque contain combustible materials and lack modern fire safety systems, increasing fire risk. In addition, *Illegal Alterations:* Unauthorized modifications to buildings can introduce fire hazards by compromising structural integrity or adding flammable materials without proper safety measures.

4.7 Aesthetic Degradation: Inappropriate restorations and unregulated alterations impact the aesthetic value of historic buildings especially in the *"Musee public national des monuments islamiques de Tlemcen"*. Problem elaboration in details: (i)*Inappropriate Restoration:* Restoration efforts that do not adhere to established conservation principles can result in visual discordance and loss of authenticity. Poorly executed restorations often fail to respect the original design and materials. (ii)*Unregulated Alterations*: Unauthorized changes made by property owners can disrupt the historical character of buildings, leading to a fragmented urban landscape. (iii)*Visual Pollution*: The introduction of modern signage, unsightly utilities, and other visual clutter can detract from the historical ambiance of Tlemcen's streetscapes.

4.8 Lack of Skilled Craftsmanship: The decline in traditional building skills hinders effective restoration efforts. That is to say: (i)*Decline of Traditional Building Techniques:* The loss of skilled craftsmen who are knowledgeable about traditional construction techniques hinders the ability to carry out authentic restorations. This gap in expertise means that many restoration projects may rely on modern methods that do not align with historical practices. (ii)*Difficulty in Sourcing Authentic Materials:* Without access to skilled artisans who understand the nuances of traditional materials and techniques, restoration efforts may not achieve the desired outcomes, leading to further deterioration over time.

4.9 Lack of Planning: There is no proper planning by authorities with increase in population that is to Say: (i)*Uncontrolled Development*: Rapid urbanization is occurring without adequate planning, resulting in a chaotic urban environment that disrupts the historical continuity of Tlemcen's neighbourhoods. This lack of foresight leads to the encroachment of new developments into historically significant areas, diluting the city's unique character. (ii)*Infrastructure Deficiencies*: The rapid growth has outpaced the development of necessary infrastructure, leading to inadequate public services and amenities. This deficiency further complicates efforts to maintain a sustainable urban environment. (iii)*Housing Shortages*: The increasing population has resulted in a shortage of affordable housing, pushing many residents into informal settlements for Example the case of El-Koudia that often lack basic services and infrastructure.

4.10 Energy Inefficiency and Environmental Impact: Outdated building codes contribute to environmental problems due to poor insulation and reliance on fossil fuels. *Outdated Building Codes*: Many historic buildings do not meet modern energy efficiency standards due to outdated building codes. This lack of compliance results in higher energy consumption and increased operational costs for residents. That is to Say (i)*Poor Insulation*: Insufficient insulation in older structures contributes to energy inefficiency, making buildings less comfortable and more expensive to heat or cool. (ii)*Reliance on Fossil Fuels*: The continued dependence on fossil fuels for heating and energy exacerbates environmental problems, including air pollution and greenhouse gas emissions, further threatening the sustainability of Tlemcen's urban environment.

4.11Accessibility and Inclusivity: Accessibility remains a critical concern within Tlemcen's urban framework. that is to Say (i) *Lack of Accessibility*: Many historic sites such as the medina of Tlemcen and public spaces « la place » are not designed to accommodate individuals with disabilities, limiting access to cultural heritage for all community members. (ii)*Equitable Urban Development*: The lack of inclusive planning practices can marginalize certain populations and « la conception spatiale qui cause la ségrégation fonctionnel urbaine », creating disparities in access to resources and opportunities within the city.

4.12 Modern Architectural Trends and Cultural Sensitivity: The clash between modern architectural trends and traditional styles presents significant challenges: (i)*Clashing Architectural Styles*: New developments often incorporate modern designs that do not harmonize with Tlemcen's historical architecture. This visual discord can detract from the city's aesthetic appeal and cultural identity. (ii)*Loss of Cultural Identity*: The prevalence of insensitive architectural practices threatens to erode Tlemcen's unique cultural identity, as traditional building techniques and styles are overshadowed by contemporary designs.

4.13 Economic Constraints and Lack of Investment: Economic factors play a crucial role in shaping Tlemcen's architectural landscape. That is to Say; (i)*Limited Resources:* Financial constraints hinder the ability of local authorities to implement effective urban planning and heritage conservation initiatives. This limitation affects both the preservation of historic sites and the development of new infrastructure. (ii)*Bureaucratic Inefficiency and Corruption:* Governmental corruption and inefficiencies can impede urban development by delaying project timelines, increasing costs, and reducing the quality of infrastructure and housing.

Summing it up : *The signification question remains that: how can Tlemcen, a city with a rich architectural heritage and its uninviting entrance in El-Koudia zone restructure a new master plan that can effectively address the complex challenges, ensure the long-term viability of its historic urban fabric and promote a sustainable future that can create an entrance that truly reflects Tlemcen's historical nature, preserving its culture and identity while providing a welcoming and functional space for residents and visitors?*

5.Hypothesis

The integration of traditional building techniques and sustainable practices from Tlemcen's architectural heritage into contemporary construction methods will lead to improved preservation outcomes for historic structures, enhance the resilience of new buildings, and foster community engagement.

5(i)Traditional Knowledge Utilization: By examining and applying the sustainable materials and construction techniques used in historic buildings, modern architecture can reduce resource consumption and maintenance needs. This approach aligns with findings that heritage buildings often demonstrate remarkable durability due to their time-tested construction methods.

5(ii)Community Engagement: Engaging local communities in the preservation process can foster a sense of ownership and identity, encouraging maintenance and care for historic sites. This is supported by literature emphasizing the social benefits of cultural heritage management.

5(iii)Adaptive Reuse Strategies: Implementing adaptive reuse of historic structures and contemporary buildings can mitigate urban sprawl by revitalizing existing buildings rather than constructing new ones. This method not only preserves cultural significance but also addresses modern urban challenges.

5(iv)Environmental Resilience: Incorporating sustainable practices into both new constructions and restorations can enhance resilience against climate change impacts, such as flooding or structural degradation due to environmental factors.

6.Research objectives

In light of the identified hypotheses and the challenges, the research objectives for the study on the preservation and sustainability of Tlemcen's architectural heritage are as follows: 6*(i)Assess the Current State of Heritage Structures and Building Techniques:* Examine the state of historic buildings in Tlemcen, pinpointing critical factors that lead to their deterioration, such as neglect, unsuitable restoration efforts, and environmental influences. Additionally, explore traditional construction methods and materials utilized in Tlemcen's historic architecture to uncover sustainable practices that can be incorporated into modern construction.

6(*ii)Evaluate Urban Development Impacts:* Examine the effects of urban sprawl on Tlemcen's architectural heritage, focusing on how modern developments disrupt historical contexts and contribute to the loss of cultural identity.

6(iii)Develop Sustainable Preservation Strategies: Formulate innovative strategies for the preservation and adaptive reuse of historic structures that respect cultural heritage while addressing modern environmental challenges.

7.Methodology.

This starts with a preliminary question: Why should we be building with rapid deterioration of contemporary structures that are also obsolete hence abandoned for new construction that are not sustainable and long-lasting?

Thus, the research employs a mixed**-methods approach**, integrating qualitative and quantitative analyses to develop a sustainable and adaptive urban intervention for Tlemcen's El-Koudia district. The methodology is structured into **five key phases**:

7(i)**Contextual Analysis & Problem Identification**: (i)Historical & Urban Morphology Study: Examines Tlemcen's evolution from the 8th-century Medina to post-colonial expansions through archival research, cartographic analysis (PDAU urban plans), and typo-morphological mapping. (ii)Site-Specific Diagnostics: Assesses El-Koudia's challenges (degradation, traffic congestion, seismic risks) via GIS mapping, climate data (temperature, wind patterns), and field surveys. (iii)Stakeholder Engagement: Conducts interviews with local authorities, heritage experts, and residents to identify community needs and preservation priorities.

7(ii)**Theoretical Framework & Design Principles:** (i)Adaptive Reuse & Flex 4.0: Evaluates building adaptability using Geraedts' Flex 4.0 matrix to assess spatial, functional, and technical flexibility. (ii)Bioclimatic Design: Integrates passive strategies (courtyard ventilation, solar chimneys, shading systems) inspired by Tlemcen's Great Mosque and vernacular architecture. (iii)Sustainability Benchmarks: Aligns with LEED Gold and BREEAM criteria for energy efficiency, water conservation, and material reuse.

7(iii)**Computational Modelling & Simulation:** (i)BIM (Revit): Develops a 3D digital twin of the proposed community hub for structural analysis, and lifecycle assessment (LCA). (ii)CFD & Energy Modelling: Simulates airflow (natural ventilation), solar gain, and thermal performance using Autodesk CFD and Revit Energy model: (iii)Parametric Design: Optimizes geometric patterns (e.g., Islamic latticework) for daylighting and solar control via Revit Modelling

7(iv)**Masterplan & Architectural Proposal:** (i)Urban Strategy: Proposes a hierarchical traffic network and mixed-use zoning to reactivate public spaces while preserving heritage corridors. (ii)Modular Design: Implements Flex 4.0 principles for future adaptability (e.g., convertible partitions, raised floors for HVAC flexibility). (iii)Material Innovation: Combines traditional materials (earth bricks, lime plaster) with recycled aggregates and low-carbon concrete.

7(v)**Validation & Policy Integration:** (i)Life-Cycle Assessment (LCA): Quantifies carbon savings (40% reduction vs. new construction) using. (ii)Community Feedback Workshops: Refines design through participatory sessions with local stakeholders. (iii)Policy

Recommendations: Advocates for updated heritage laws, BIM adoption in conservation, and incentives for adaptive reuse projects.

8. Structure of the dissertation:

In order to achieve the objectives outlined and in order to provide satisfactory answers to the questions raised in the problem and to validate our hypothesis, we have structured the research as follows and summed up in figure 1:

(i) General Introduction

(ii) The first chapter: Theoretical approach (Genese and semantic definitions)

(iii) The second chapter: Analytical approach (Study and analysis of the city of tlemcen)

(iv) The third chapter: Program, site analysis and Genese

(v) Chapter Four: Schematic Design

(vi) Conclusion :

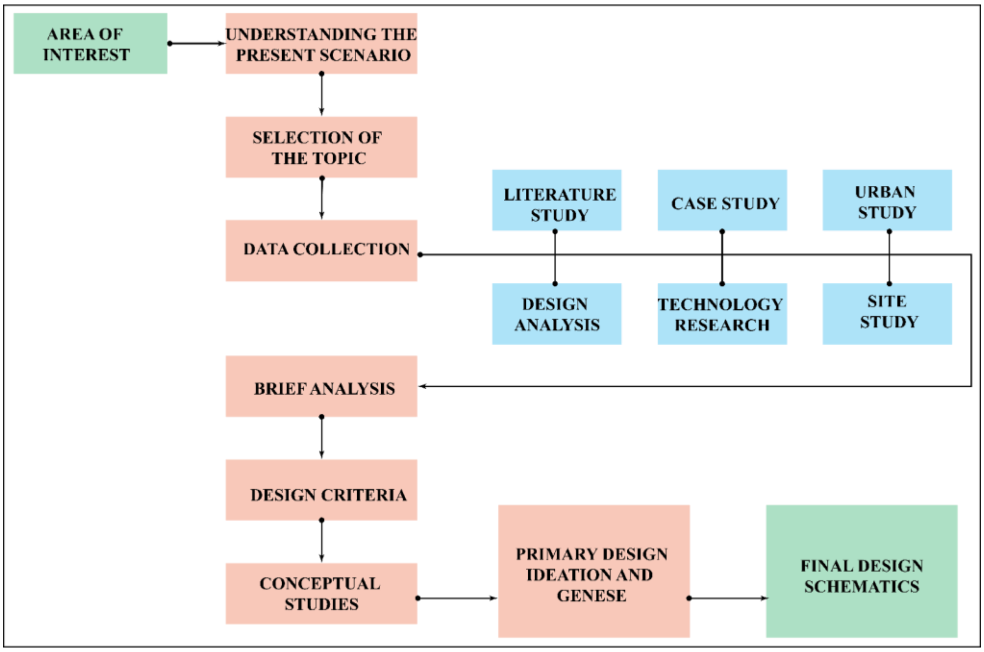


Figure 1: Methodology summery sketch

Source: author

Summery:

This methodology bridges **historical preservation** and **technological innovation**, offering a replicable model for sustainable urban regeneration in Mediterranean cities. By leveraging computational tools, bioclimatic principles, and community engagement, the framework ensures resilience, cultural continuity, and environmental performance.

CHAPITRE I:

GENERAL DEFINITIONS

1.Introduction

Innovation has emerged as a vital necessity in harmonizing cultural heritage preservation with sustainable development goals. This interdisciplinary approach examines how cutting-edge technologies, adaptive reuse strategies, and participatory community initiatives can revitalize heritage management in modern contexts or projects. Central to this evolving concept is the seamless incorporation of cultural heritage into sustainable development frameworks, recognizing heritage's dual function as both a repository of cultural value and a driver of progressive, ecologically conscious transformation.

1.1. Innovation in heritage and sustainability

The notion of innovation inheritance and sustainability emerged from the understanding that cultural heritage transcends its role as a static artifact of history, instead serving as a dynamic resource capable of addressing modern societal needs. This perspective gained global traction following the United Nations' 2030 Agenda for Sustainable Development, which formally recognized culture as a pillar in advancing sustainability objectives. By highlighting heritage's potential to foster social cohesion, economic vitality, and environmental stewardship, the agenda reframed it as an indispensable element within global sustainability frameworks, acknowledging heritage's capacity to generate multidimensional benefits while shaping progressive development paradigms.(Heritage Centre, 2015)

1.2. Historical Context

Early approaches to heritage preservation were frequently siloed from wider socioeconomic progress, treated as distinct priorities. This outlook shifted fundamentally through a paradigm shift toward acknowledging the interdependence between cultural legacy and sustainable development. The 1972 World Heritage Convention marked a turning point by establishing foundational principles that linked preservation with ecological and social sustainability. Modern policy frameworks have increasingly prioritized the incorporation of sustainable practices into conservation methodologies, reflecting a holistic understanding of heritage as both a cultural anchor and a dynamic contributor to balanced, forward-looking development agendas. (Heritage Centre, 2015)

2.Definitions of innovation in service of heritage and sustainability.

Innovation in service of sustainability: This refers to creating positive change that addresses environmental, social, and economic factors(Innovation, 2025). In the context of cultural heritage, it means implementing environmentally friendly and sustainable practices in conservation, restoration, and management to ensure the longevity and responsible use of heritage sites

In addition, innovation in the service of heritage and sustainability can as well be defined through several lenses detailed as following:

2.1.Technological Innovation:

Technological innovation refers to the implementation of new technologies or the improvement of existing technologies to enhance processes, products, or services. In the context of heritage preservation and sustainability, technological innovation encompasses a range of tools and methods that facilitate the conservation, documentation, and promotion of cultural heritage while addressing contemporary environmental challenges.

2.1.1. Criteria for Technological Innovation

When evaluating technological innovations in heritage preservation and sustainability, several key criteria can be considered:

(i) Effectiveness: Technology must effectively address specific challenges related to heritage conservation. This includes improving the accuracy of restoration work, enhancing the durability of materials used in preservation, and providing reliable data for decision-making.

(ii) Sustainability: Innovations should promote sustainable practices by minimizing resource consumption, reducing waste, and utilizing eco-friendly materials. Technologies that support energy efficiency or reduce carbon footprints are particularly valuable (Technological Innovations, n.d.)

(iii). Accessibility: Technologies should be accessible to a wide range of stakeholders, including conservationists, architects, local communities, and policymakers. This accessibility ensures that innovations can be widely adopted and integrated into various preservation practices.

(iv). Integration with Traditional Practices: Successful technological innovations should complement rather than replace traditional knowledge and practices. This integration fosters a holistic approach to heritage preservation that respects cultural contexts while embracing modern advancements(Innovation vs. Preservation, n.d.).

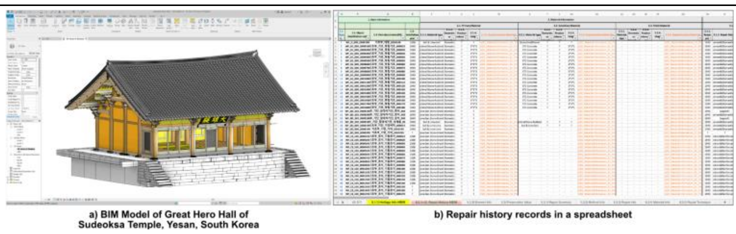
(v). Scalability: The ability to scale innovations for diverse types of heritage sites—from small local structures to large historical landmarks—is essential. Technologies that can be adapted to various contexts enhance their utility and impact.

(vi) User-Friendliness: The technology should be user-friendly and require minimal training for effective implementation. This criterion is crucial for ensuring that stakeholders can easily adopt and utilize the innovations (Balancing Heritage n.d.).

2.1.2. Examples of Technological Innovations:

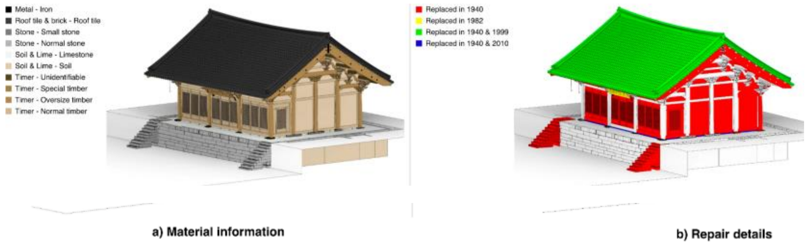
There are more examples of technological innovations, but the following can give an insight into what modernized technology is in capacities:

(i) Building Information Modelling (BIM): BIM is revolutionizing architectural conservation by creating detailed digital models that facilitate collaboration among architects, engineers, and conservationists (**table** 1). It allows for simulation of restoration scenarios and ensures that projects meet both modern safety standards and historical integrity(Technological Innovations , n.d.) .



(**a**) BIM and (**b**) repair history records of the target heritage building.

. Graphic visualizations based on (**a**) the damage types and (**b**) repair details.



Graphic visualizations based on (**a**) the material information and (**b**) corresponding repair details.

Table 1 shows BIM workflow application using Revit software

Source (Park et al., 2024)

(ii) Drones: Drones equipped with high-resolution cameras are invaluable for surveying hard-to-reach areas of historical buildings. They provide detailed aerial footage that helps assess the condition of structures without invasive inspections (Technological Innovations , n.d.).

(iii). Augmented Reality (AR) and Virtual Reality (VR): These technologies create immersive experiences that allow users to explore historical sites digitally. AR can enhance visitor engagement at museums by providing contextual information (**Figure 1**)without altering physical artifacts (Innovation vs. Preservation , n.d.). VR offers virtual tours that educate users about cultural heritage while preserving the integrity of physical sites (Heritage Preservation, n.d.).

(iv). Artificial Intelligence (AI): AI-driven predictive modelling enhances risk assessment for heritage sites by analysing vast datasets to identify deterioration patterns and optimize conservation strategies. This proactive approach helps prevent irreversible damage to vulnerable sites(Emerging Technological , n.d.).

(v) Nanotechnology: Advances in material science through nanotechnology offer innovative solutions for protecting artifacts from environmental degradation. Nanomaterials can create protective coatings that shield artifacts from moisture and pollutants without altering their appearance (Emerging Technological , n.d.).

(vi) Digital Twin Technology: This technology creates a digital representation of a physical structure that allows real-time monitoring and management of building performance. By integrating various components such as sensors into a digital twin model **Figure 2 and 3**, stakeholders can optimize maintenance and conservation efforts based on real-time data(Balancing Heritage n.d.).

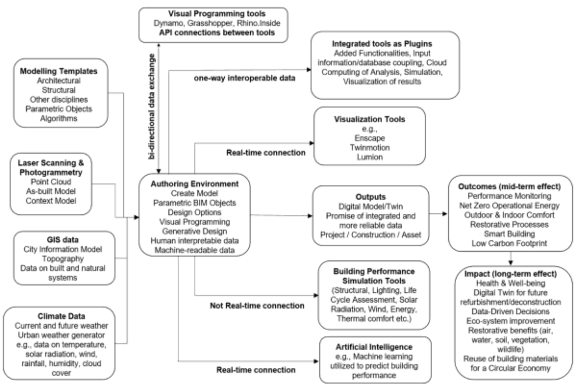


Figure 2 Conceptual diagram of available BIM workflows for regenerative design

Source (Dervishaj, 2023)

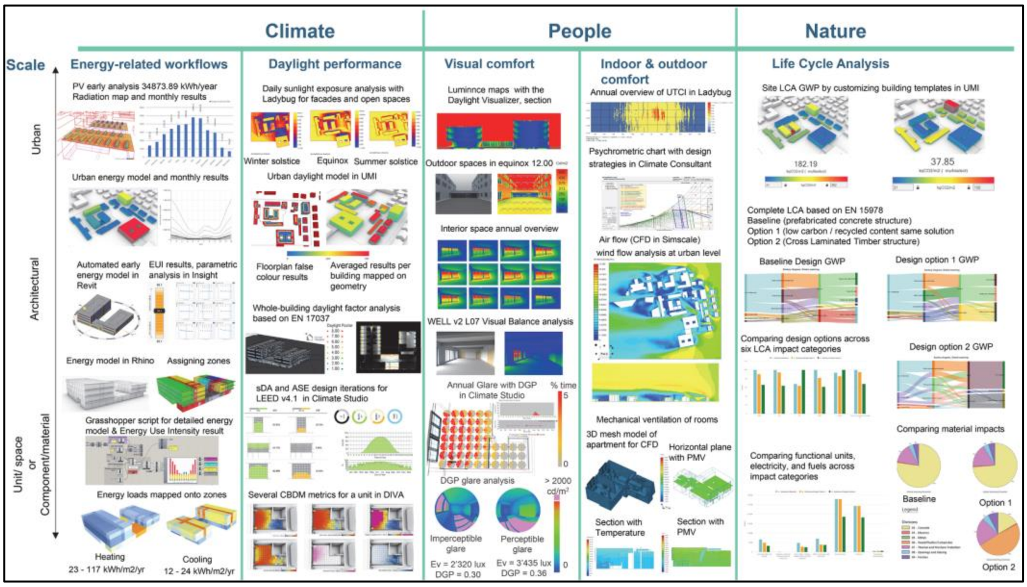


Figure 3 Results in the case study and grouping of workflows within the three pillars of regeneration for a multiscale design approach, as well as across various design phases

Source (Dervishaj, 2023)

2.2. Adaptive Reuse

Adaptive reuse is a crucial architectural strategy that balances the preservation of cultural heritage with contemporary needs, promoting sustainability and contributing to economic development. This process involves repurposing old or historic buildings for new uses while preserving their cultural, architectural, and historical significance (ICOMOS 2013). This approach extends the lifespan of existing structures, minimises waste, and reduces the environmental impact associated with new construction (figure 4). Integrating adaptive reuse into architectural practices is essential for addressing modern challenges while protecting cultural assets for future generations.(Autodesk Revit, 2025)

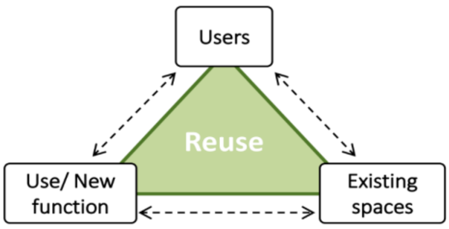


Figure 4 Best design condition in reuse

Source; (Beccari et al., 2020.)

Research indicates that successful adaptive reuse projects can revitalize urban areas and enhance community engagement(Djebbour & Biara, 2019). For instance, Tlemcen's initiative to convert historical monuments into museums exemplifies how adaptive reuse can contribute to both cultural preservation and urban revitalization (Djebbour et al., n.d.)

The “shearing layers” of a building **(Figure 5).** The life expectancy of the layers varies somewhat among the different analyses; this illustration uses a combination of their estimates.

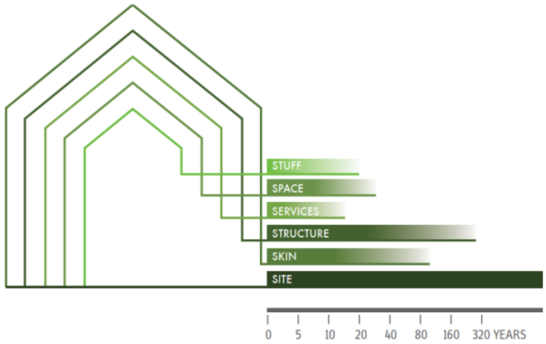


Figure 5 shows Building functional layers

Source; (Beccari et al., 2020.)

2.2.1. Importance of Adaptive Re-use

Its significance spans environmental, cultural, economic, social, and urban realms, offering multifaceted benefits that address contemporary challenges, see (**Table 2**). Below is a detailed exploration of its importance:

(i) Cultural Heritage Preservation: Adaptive reuse helps maintain the historical and architectural integrity of buildings, allowing communities to retain their cultural identity (Arfa et al., 2022).

(ii) Sustainability: By reusing existing structures, adaptive reuse reduces the need for new materials and minimizes waste, contributing to environmental sustainability (Adaptive Reuse Guidelines, n.d.)

(iii) Economic Development: Revitalizing old buildings can stimulate local economies by attracting tourism and creating new business opportunities (Arfa et al., 2022).

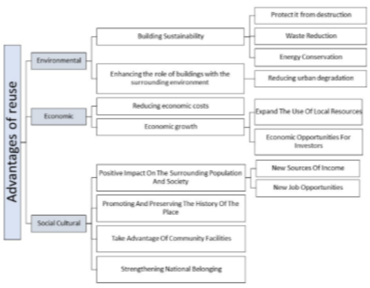


Figure 6 Advantages of adaptive reuse

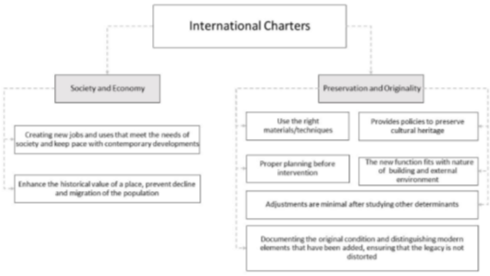


Figure 7 Summary of international charters.

Table 2 Advantages of adaptive re use.

source: (Alhojaly et al., 2022)

2.2.2. Criteria for Adaptive Reuse During Project Conception

When planning for adaptive reuse projects, several criteria should be considered to ensure effectiveness and sustainability:

(i) Cultural Significance: Assess the historical and cultural value of the building to determine appropriate new uses that honour its heritage (Arfa et al., 2022) .

(ii). Legal Protection and Compliance: Evaluate existing legal frameworks and heritage protection regulations that may affect the reuse process (Adaptive Reuse Guidelines, n.d.) .

(iii)Structural Integrity: Conduct a thorough analysis of the building's structural condition to determine its suitability for adaptation (Technology In Cultural n.d.).

(iv)Economic Viability: Analyse the financial implications of adaptive reuse compared to new construction(Arfa et al., 2022).

(iv)Environmental Sustainability: Consider environmental factors such as energy efficiency and resource conservation(Innovation vs. Preservation, 2023.).

(v)Community Engagement: Involve local stakeholders in the decision-making process to ensure that the new use aligns with community needs (Bounoua et al., 2023a).

(vi)Flexibility of Design: Design solutions should accommodate potential future changes in use or function including Flex 4.0 instrument (Geraedts, 2016) (fastercapital, 2011) .

(vii)Innovation in Design: Encourage innovative approaches that blend modern design elements with historical features (Arfa et al., 2022).

2.3. Community Engagement:

Community engagement in the context of heritage preservation refers to the active involvement of local communities in the decision-making processes related to the management, protection, and promotion of cultural heritage. This engagement is essential for fostering a sense of ownership, enhancing cultural continuity, and ensuring that preservation efforts align with the needs and values of the community.

2.3.1. Importance of Community Engagement:

These include the following:

(i)Cultural Continuity: Involving communities in heritage preservation helps maintain cultural practices and traditions, reinforcing local identity and pride.

(ii)Social Sustainability: Active participation fosters social cohesion and resilience, as community members collaborate towards common goals(Usmaedi et al., 2024).

(iii)Effective Preservation: Engaging local stakeholders often leads to more effective preservation outcomes, as community members possess valuable knowledge about their heritage(Timhadjelt et al., 2023) .

2.4. Sustainability in architecture

Sustainability in architecture, often referred to as **sustainable architecture** or **green architecture**, is an approach to building design and construction that aims to minimize negative environmental impacts while promoting the health and well-being of occupants. This concept encompasses a holistic view of the built environment, integrating ecological, social, and economic considerations (**Figure 8**)throughout the lifecycle of a building—from planning and design to construction, operation, and eventual demolition or repurposing

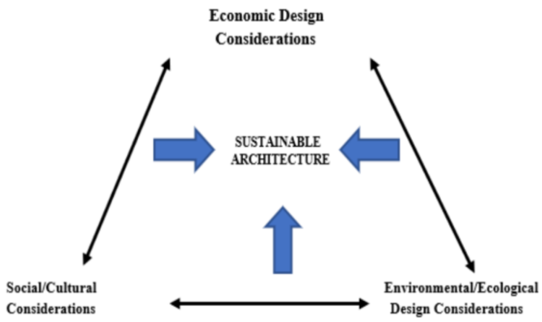


Figure 8 Sustainable design concept**.**

Source (Emmanuel, 2020)

2.4.1 Principles of sustainable design:

These include (i)Use of environmentally friendly products, (ii)Optimize building site potential, (iii)Enhancement of indoor environmental quality, (iv)Protection and conservation of resources, such as water, (v)Optimize renewable energy, (vi)Enhance operational and maintenance procedures **figure 9:**

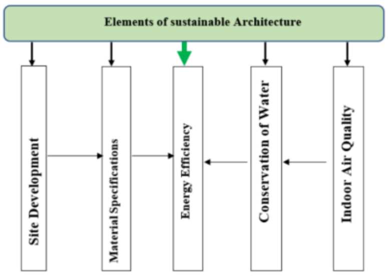


Figure 9 Basic Elements of sustainable Architectural Design

Source: (Emmanuel, 2020)

Sustainable architecture reduces energy consumption and improves your standard of living. Green rating systems such as BREEAM and LEED extensively specify the necessity for assessments of sustainability metrics. These rating systems provide a framework for sustainable development.(*Alpin Limited*, 2025)

2.4.2. Other related architectural concepts:

Sustainability serves as a foundational framework encompassing various architectural approaches aimed at harmonizing environmental stewardship, social responsibility, and resource efficiency. This article explores key concepts under this umbrella, each contributing uniquely to sustainable design practices. It's all summed up in **Table 3**

(i)Climate-Responsive Design: This approach tailors' buildings to local climatic conditions by analysing sun, wind, precipitation, and humidity patterns. Architects leverage passive strategies—such as natural ventilation, shading, and thermal mass—to optimize comfort and energy use. By aligning structures with their environment, climate-responsive design reduces reliance on mechanical systems while enhancing resilience.(*Alpin Limited*, 2025)

(ii)Biomimetic Architecture: Inspired by nature's ingenuity, biomimicry emulates biological systems to solve design challenges. This approach operates at three levels: Organism: Mimicking natural forms (e.g., structures modelled after plant morphology). Behaviour: Replicating natural processes (e.g., ventilation systems inspired by termite mounds). Ecosystem: Creating self-sustaining environments that mirror ecological cycles. By learning from nature's efficiency, biomimetic design fosters innovation in sustainability .(*Alpin Limited*, 2025)

(iii)Vernacular Architecture : Rooted in local traditions, vernacular architecture responds to regional climates, materials, and cultural practices. It emphasizes passive techniques—such as natural ventilation, thermal mass, and regionally sourced materials—to achieve comfort without excessive energy use. These time-tested strategies, from adobe construction in arid regions to raised dwellings in flood-prone areas, offer lessons in resilience and resource efficiency, bridging heritage with modern sustainability goals (*Alpin Limited*, 2025).

Each concept underscores the synergy between cultural heritage, ecological responsibility, and innovation, illustrating how architecture can evolve as a catalyst for sustainable progress.

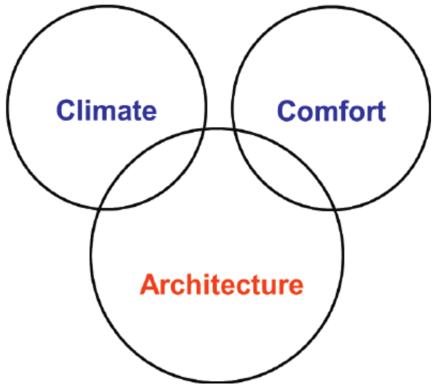


Figure 10 Vitruvian model of environment in architecture
Source (Vitruvian Model of Environment , 2024)

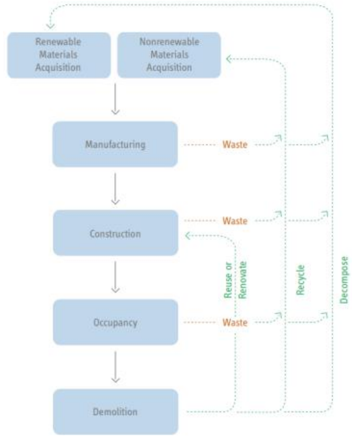


Figure 11 All waste materials, including those resulting at the end of life, return to either biological
Source (Bergman, 2012)

Table 3 showing architectural concepts

2.4.3. Key Components of Sustainability in Architecture

The key principles of sustainable architecture encompass a range of strategies aimed at creating buildings that are not only functional but also environmentally responsible and resource efficient. Below are the detailed key principles:

(i)**Energy Efficiency**

Energy efficiency is a cornerstone of sustainable architecture, focusing on reducing energy consumption throughout a building's lifecycle. This principle aims to optimize energy use through various design strategies and technologies. Key considerations include:

(i) (a) **Passive Design Strategies:**

Incorporating passive design features is crucial for minimizing energy needs **Table 4**. These strategies leverage natural elements to regulate indoor environments: **(i)Natural Ventilation:** Utilizing natural airflow to cool and ventilate buildings reduces reliance on mechanical systems. **(ii)Daylighting:** Strategically placing windows and other openings to maximize natural light reduces the need for artificial lighting (The Spruce, 2024). This not only saves energy but also improves occupant's well-being. **(iii)Thermal Mass:** Incorporating materials with high thermal mass helps regulate indoor temperatures by absorbing and releasing heat, reducing temperature fluctuations and the need for mechanical heating and cooling.

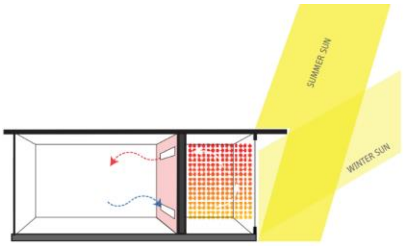
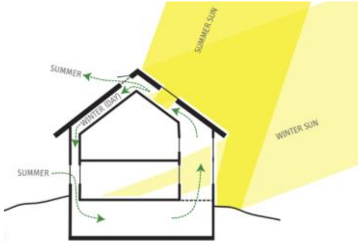
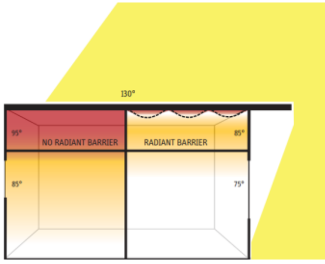
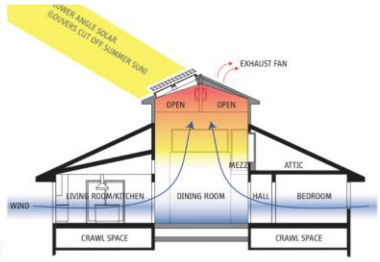
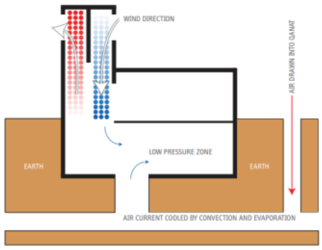
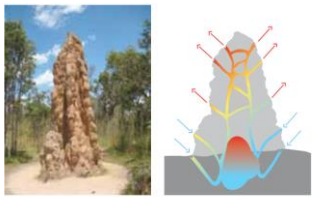
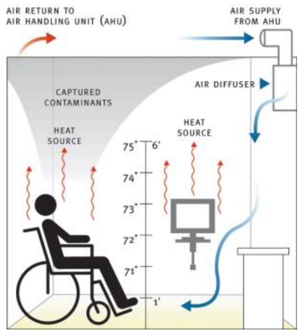
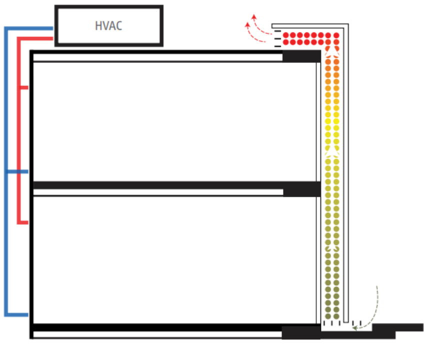
 **Figure 12** operable vents and space for a sunroom**.** Source: (Bergman, 2012)	 **Figure 13** daytime airflows in winter and summer**.** Source**:** (Bergman, 2012)	 **Figure 14** Cooling effect of a radiant barrier**.** Source**:** (Bergman, 2012)
 **Figure 15** solar atrium Source**:** (Bergman, 2012)	 **Figure 16** Persian wind catcher Source (Bergman, 2012)	 **Figure 17** Termite mound, passageways and vents control of the temperature Source: (Bergman, 2012)
 **Figure 18** **-**Depleting Chemicals in HVAC&R Systems Source**:** (Charles J. Kibert, 2016)	 **Figure 19** heating system Source**:**(Bergman, 2012)	

Table 4 shows different passive strategies

(i) (b) **Active Systems (Renewable Energy Sources):**

Integrating active systems that utilize renewable energy sources is essential for achieving net-zero energy buildings, which produce as much energy as they consume **Table 5**. These systems include: **(i)Solar Panels (Photovoltaics):** Converting sunlight directly into electricity. **(ii)Wind Turbines:** Harnessing wind energy to generate electricity. **(iii)Geothermal Systems:** Utilizing the Earth's stable underground temperature for heating and cooling. **(iv)High-Performance Insulation:** Minimizing heat transfer through building envelopes to reduce heating and cooling loads. **(v)Energy-Efficient Appliances:** Selecting appliances with high energy efficiency ratings to further reduce energy consumption (Cemex Ventures, 2025)

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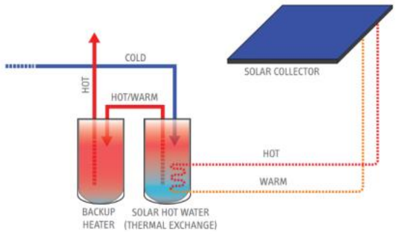
<td>

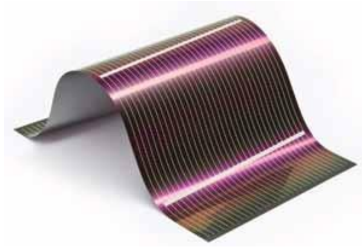
Figure 20 Illustrations of open and closed-loop solar thermal hot-water systems
Source (Bergman, 2012)</td>
<td>
Figure 21 Thin-film PV is next-generation technology
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Figure 22 Vertical & Horizontal axis turbines
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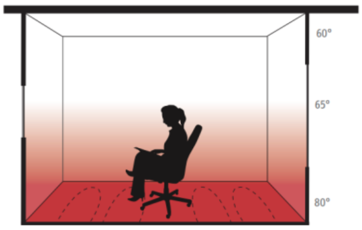
<td>

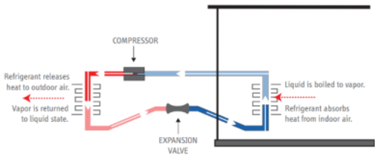
Figure 23 Radiant floor heating evenly distributes heat
Source (Bergman, 2012)</td>
<td>

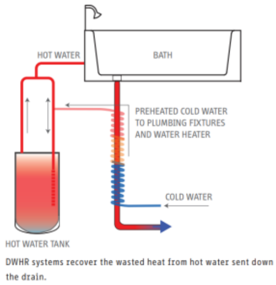
Figure 24 Diagram of the cooling cycle of an air-source heat pump. The heating cycle works in reverse
Source (Bergman, 2012)</td>
<td>

Figure 25 Recovery of wasted water
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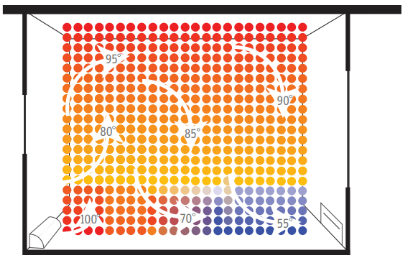
<td>

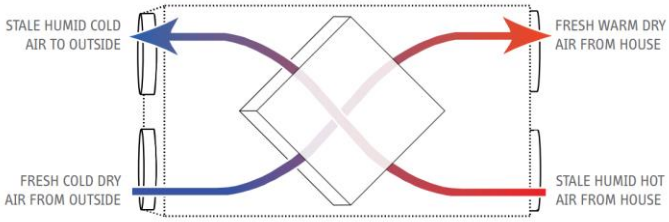
Figure 26 Conventional heating systems usually result in stratified, uneven heating and drafts
Source (Bergman, 2012)</td>
<td colspan="2">

Figure 27 Diagram of an HRV in heating mode. The circulation reverses for cooling
Source (Bergman, 2012)</td>
</tr>
</table>

Table 5 illustrating active Systems

(i) (c)**. Energy Management Systems:**

Implementing smart technologies to monitor and optimize energy use can further enhance efficiency and reduce operational costs (Emmanuel, 2020). These systems can track energy consumption patterns, automate building systems, and optimize performance based on real-time data.

By combining passive design strategies with active renewable energy systems and intelligent energy management, buildings can significantly reduce their environmental footprint and contribute to a more sustainable future.

(ii) **Resource Conservation (Including Water Protection and Conservation)**

This principle emphasizes the responsible use of resources throughout a building's lifecycle, encompassing water, materials, and land (**Table 6**). A crucial aspect of resource conservation is the protection and efficient use of water resources.

(ii) (a)**. Water Protection and Conservation :**

Sustainable architecture prioritizes minimizing water consumption and protecting water resources through various strategies:**(i) Water-Efficient Fixtures:** Installing low-flow faucets, toilets, and showerheads can significantly reduce indoor water usage. **(ii)Efficient Irrigation:** Implementing efficient irrigation systems, such as drip irrigation or smart controllers, and utilizing sustainable landscape design with native, drought-tolerant plants can minimize outdoor water usage for irrigation **(iii)Rainwater Harvesting:** Collecting rainwater for irrigation, toilet flushing, or other non-potable uses helps conserve freshwater resources **(iv)Greywater Recycling:** Treating and reusing greywater (wastewater from showers, sinks, and laundry) for non-potable purposes like irrigation or toilet flushing further reduces freshwater demand **(v)Stormwater Management:** Designing landscapes that effectively manage stormwater runoff can prevent flooding, erosion, and pollution of local waterways. This includes using permeable surfaces, bioswales, and other green infrastructure techniques (Emmanuel, 2020)

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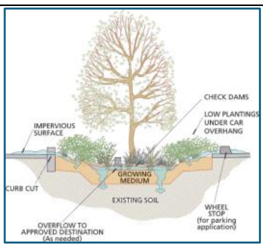
<td>
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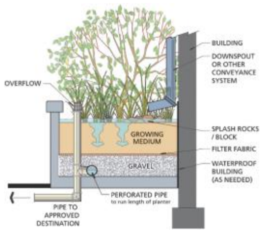
<td>
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<td>Figure 28 Vegetated swales,
Source: (Charles J. Kibert, 2016)</td>
<td>Figure 29 Flow-through planters
Source: (Charles J. Kibert, 2016)</td>
<td>Figure 30 Pervious for rainwater runoff.
Source (John Wiley & Sons, 2014)
(Charles J. Kibert, 2016)</td>
</tr>
</table>

Table 6 showing: Resource Conservation (Including Water Protection and Conservation)

(iii) **Material Efficiency and Maintenance Optimization**

Responsible material selection is crucial for resource conservation and directly impacts long-term building performance and maintenance needs. Sustainable architecture prioritizes minimizing environmental impact throughout a material's lifecycle, from extraction and processing to use and eventual disposal.

(iii) (a) **Key Considerations:**

These are divided into three:

(iii) (a1) Material Selection: Choosing appropriate materials is paramount.

This includes: (i)Locally Sourced Materials: Reduces transportation emissions and supports local economies. (ii)Renewable Materials: Utilizes resources that can be replenished naturally, minimizing depletion of finite resources. (iii)Recycled or Reclaimed Materials: Reduces the demand for virgin materials and diverts waste from landfills.

(iii) (a2) Durability and Longevity: Selecting durable materials that require minimal maintenance is essential for both resource conservation and maintenance optimization. These materials: (i)Reduce the need for replacements and repairs, minimizing resource consumption over time. (ii)Contribute to better Indoor Environmental Quality (IEQ) by ensuring that interior finishes are long-lasting and do not contribute to poor indoor air quality through degradation or off-gassing.

(iii) (a3) Monitoring Systems: Implementing systems to track energy use, water consumption, and waste generation allows for proactive management of building performance (Criteria for a Sustainable, 2024). This proactive approach: (i)Reduces the likelihood of major repairs or replacements, further minimizing resource consumption. (ii)Can indirectly benefit IEQ by identifying potential issues with building systems (such as ventilation or HVAC) that could negatively impact indoor air quality.

(iv) **. Indoor Environmental Quality (IEQ)**

Ensuring the health and well-being of occupants is a primary goal of sustainable architecture **Table 7**. This principle focuses on creating comfortable and healthy indoor environments. Key considerations for Indoor Environmental Quality (IEQ) include:

(iv) (a) **Air Quality:**

Maintaining good indoor air quality is crucial for occupant health **Table 7**. This can be achieved through: (i)Natural Ventilation: Incorporating natural ventilation systems allows for fresh air circulation and reduces the buildup of indoor pollutants (Moser Associates, 2025) (ii)Low-VOC Materials: Using building materials with low volatile organic compound (VOC) emissions minimizes the release of harmful chemicals into the indoor air (Moser Associates, 2025)

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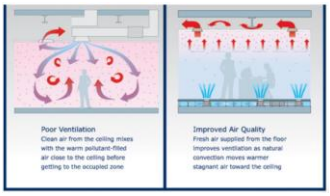
<td>

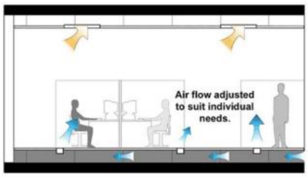
Figure 31 Maintaining the minimum outdoor air intake
Source (USGBC LEED Green Associate Study Guide, 2009)</td>
<td>

Figure 32 control of the amount of air supplied
Source (John Wiley & Sons, n.d.)</td>
<td>
Figure 33 Raised access floors
Source (John Wiley & Sons, n.d.)</td>
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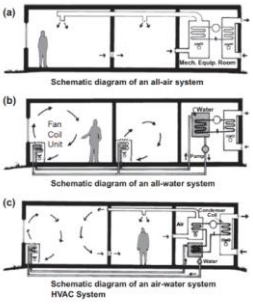
<td>

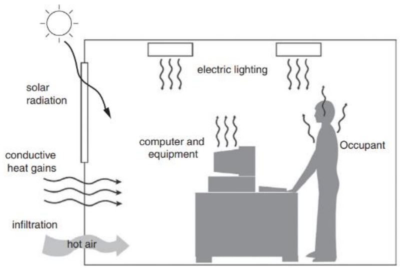
Figure 34 three basic HVAC systems. (a) All-air system (b) all-water system (c) air–water system
Source (Kubba, 2017)</td>
<td>

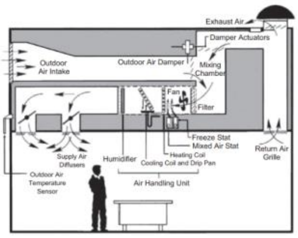
Figure 35 transparent glazing causes thermal discomfort
Source (Kubba, 2017)</td>
<td>

Figure 36 typical HVAC deliver conditioned air to a building or space to maintain thermal comfort and IAQ.
Source (Kubba, 2017)</td>
</tr>
</table>

Table 7 showing Indoor Environmental Quality potential

(iv) (b)**. Natural Light and Acoustics:**

Designing spaces that prioritize natural light, and acoustic comfort enhances occupant's well-being: (i)**Daylight Maximization:** Maximizing natural light through strategic window placement reduces dependence on artificial lighting and improves occupant comfort (ii)**Acoustic Comfort:** Designing spaces to minimize noise pollution creates a more pleasant and productive environment (*Alpin Limited*, 2025)

(iv) (c)**. Thermal Comfort :**

Maintaining comfortable indoor temperatures throughout the year is essential for occupant well-being **Table 8**. This can be achieved through: (i)**Effective Insulation:** Proper insulation minimizes heat transfer through the building envelope, reducing the need for excessive heating and cooling. (ii)**Temperature Control Systems:** Implementing efficient heating and cooling systems ensures comfortable indoor temperatures regardless of external conditions

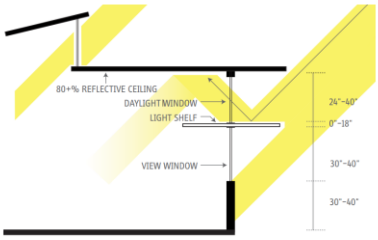


Figure 37 Light shelves may be indoors, outdoors, or both and may double as shading solutions. Clerestories can also bring light deeper into spaces.

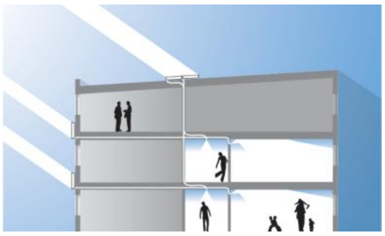


Figure 38 Collectors on the roof or facade focus light into fibre-optic tubes that are then run to light points where needed**.**

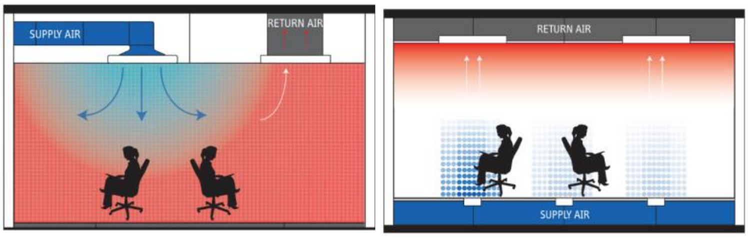


Figure 39 These two diagrams compare a conventional HVAC distribution system (left) with an UFAD system.

Table 8 shows natural light and acoustics and thermal comfort

Source: (*USGBC LEED Green Associate Study Guide*, 2009)

These key aspects of IEQ, sustainable buildings can promote occupant health, productivity, and overall well-being.

(v) **Sustainable Site Design**

Sustainable site design focuses on planning and developing buildings in harmony with their natural surroundings to minimize environmental impact. This involves careful consideration of site selection, optimization, and ecosystem preservation.

(v) (a) **Site Selection :**

Choosing appropriate locations is crucial for sustainable development. This involves reducing urban sprawl and preserving green spaces by prioritizing brownfield redevelopment over new construction on undeveloped land, thereby protecting existing ecosystems (Basic principles, 2024). Buildings should be strategically sited to take advantage of natural resources such as sunlight, prevailing winds, and existing landscape features. Proper orientation can significantly enhance energy efficiency by reducing heating and cooling loads (Criteria for a Sustainable, 2024)

(v) (b)**. Site Optimization:**

The location and design of a building should minimize its environmental impact while maximizing its integration with the surrounding ecosystem **Figure**.**40** Key considerations for site optimization include:

(v) (b1). **Location and Orientation:** Buildings should be sited to optimize the use of natural resources. This includes leveraging natural light, prevailing winds, and landscape features to enhance energy efficiency. Proper orientation can significantly reduce heating and cooling loads (Criteria for a Sustainable, 2024)

(v) (b2). **Ecosystem Preservation:** Sustainable site design prioritizes the protection of existing ecosystems, including vegetation and wildlife habitats. Utilizing native plant species in landscaping is crucial for supporting local biodiversity (Green building, 2024).

(v) (b3).. Transportation Accessibility: Sustainable sites should be easily accessible via public transportation and promote alternative transportation methods such as walking and cycling to reduce reliance on fossil fuels (Emmanuel, 2020)

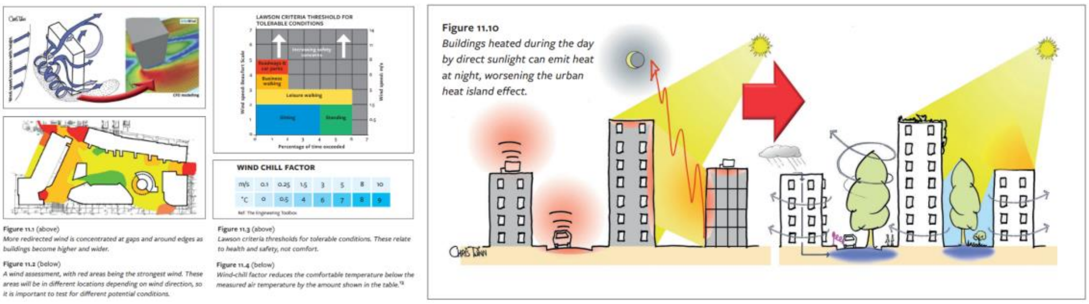


Figure 40 showing site optimization and sustainability**.**

Source (RIBA Publishing, 2017)

(vi)**. Ecosystem Preservation:**

Sustainable site design should prioritize ecosystem preservation. This can be achieved through various strategies, including:

(vi) (a). **Green Infrastructure:** Incorporating green elements like green roofs and living walls can improve insulation, enhance biodiversity, and effectively manage stormwater runoff. The use of permeable paving materials further contributes by reducing erosion and water runoff (Sustainable Architecture, 2025).

(vi) (b).. Native Landscaping: Protecting existing ecosystems, including vegetation and wildlife habitats, is essential. This includes using native plant species in landscaping to support local biodiversity (Green building, 2024).

By integrating these principles, sustainable site design can minimize environmental impact, enhance ecological health, and create more resilient and harmonious built environments.

(vii) Flexibility and Adaptability

Buildings should be designed with flexibility in mind to accommodate changing needs over time. **Future-Proofing**: Designing spaces that can easily adapt to different functions or configurations allows buildings to remain relevant as community needs evolve. This principle also includes designing for deconstruction so that materials can be reused or recycled at the end of a building's lifecycle (Cultural Heritage Tourism, 2022).

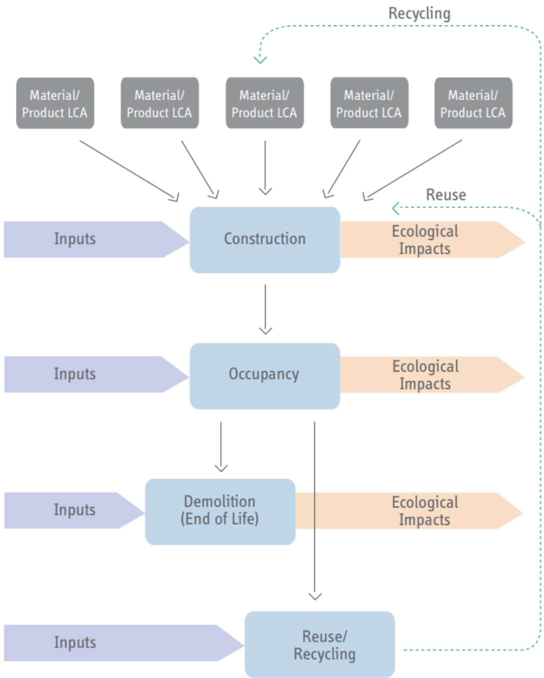


Figure 41 In a building LCA, buildings also have the added end-of-life possibility of renovation.

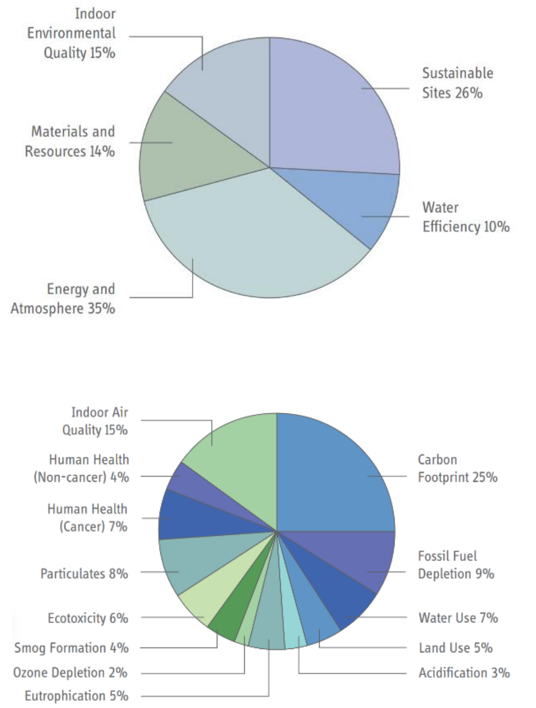


Figure 42 Categories and allocation of points in LEED 2009

Table 9 LEED 2009 redistributed the points to place greater importance on climate change and carbon emissions (adapted from Green Source).

Source: (*USGBC LEED Green Associate Study Guide*, 2009)

To sum up: Sustainable architecture embodies a holistic approach that integrates environmental responsibility with social equity and economic viability. By adhering to these key principles—energy efficiency, resource conservation, indoor environmental quality, sustainable site design, biophilic design, flexibility/adaptability, and community engagement—architects can create buildings that contribute positively to the environment while enhancing the quality of life for occupants.

3.Conclusion

The concepts outlined earlier establish the groundwork for the project’s first stage. Moving forward, the design will prioritize sustainability and integrate cutting-edge methods to develop an architectural paradigm that challenges and transcends conventional practices. In the following section, we delve into Tlemcen—a historic city showcasing both preserved and climate-impacted examples of sustainable architecture. This analysis will deepen as the project unfolds, offering insights into balancing heritage conservation with adaptive innovation in response to environmental and cultural pressures.

CHAPITRE 2:

URBAN STUDY APPROACH

1. Introduction

This chapter presents a multidimensional examination of Tlemcen, synthesizing its architectural legacy and developmental opportunities to contextualize the insights introduced earlier. The analysis integrates cartographic resources, archival records, and urban planning frameworks—such as the *Plan Directeur d'Aménagement Urbain (PDAU)*—to map the city's historical, cultural, and spatial dynamics. Building on this foundation, the chapter culminates in a strategic intervention framework (comprehensive master plan) and a core architectural blueprint, designed to harmonize preservation with sustainable urban advancement.

1.1. Presentation of the Tlemcen city.

Tlemcen, a major urban centre in northwestern Algeria and the administrative capital of Tlemcen Province, remains a strategic and cultural crossroads in the Maghreb. With an estimated population of 173,531(*Algeria Population - Worldometer*, 2025)(*Algeria Cities Database*, 2025), it ranks among Algeria's most significant cities, blending Arab, Berber, Andalusian, Ottoman, and Western influences. From this mosaic of influences, the city derives the titles of capital of Andalusian art in Algeria and various titles are attributed to the city including "the Pearl of the Maghreb" and "the Medina of the West".

Economically, Tlemcen has developed leather, carpet, and textile industries, which it exports through the port of Rachgoun. Culturally, the city remains a guardian of Andalusian traditions.(*Tlemcen - Wikipedia*, 2025)

1.1.1. Delimitation:

It is delimited by: The wilaya of Naâma in the South, Morocco to the West, The wilaya of Sidi-Bel-Abbès in the EastThe Mediterranean Sea in the North(**table 10**)

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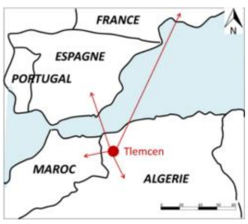
<td>

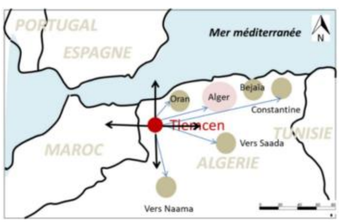
Figure 43 Location of Tlemcen city internation scale
Source :(SelmaDJR, 2020)</td>
<td>

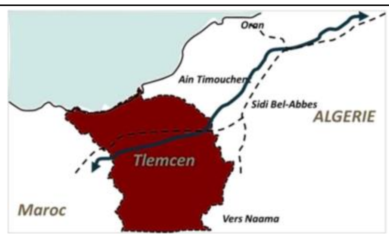
Figure 44 Location of Tlemcen city National scale
Soruce :(SelmaDJR, 2020)</td>
<td>

Figure 45Location of Tlemcen city Wilaya scale
Soruce :(SelmaDJR, 2020)</td>
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</table>

Table 10: Case study location

1.2. Location of the study area:

The commune of Tlemcen, capital of the Tlemcen wilaya, sits on a plateau 800 meters above sea level, overlooking the Hannaya plains (Sidi el Haloui, Sidi Othmane, and Sidi Said) and situated below the Lalla Setti plateau (**figure 46**). Its transportation infrastructure includes the East-West motorway, a network of national roads, a railway, an international airport, and a cable car.

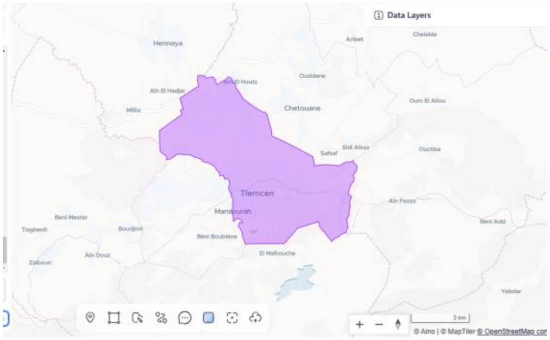


Figure 46 Case study zone

Source : (Aino AI, 2025)

1.3. Climate of Tlemcen city.

Tlemcen, located in northwestern Algeria, experiences a **Mediterranean climate** characterized by hot, dry summers and mild, wet winters **Table 11**. This climate classification is often denoted as **Csa** under the Köppen climate system, indicating a hot-summer Mediterranean climate with some continental characteristics.

1.3.1. Key Climate Characteristics:

These following table summarises the four seasonal mediterranean climate of Tlemcen.

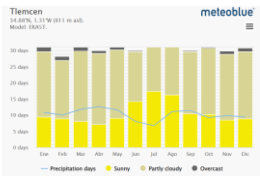
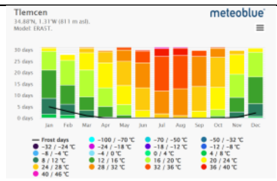
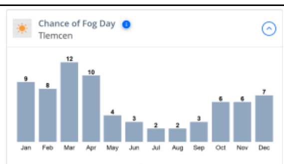
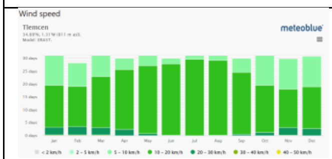
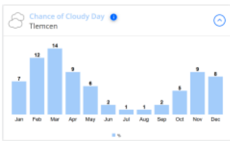
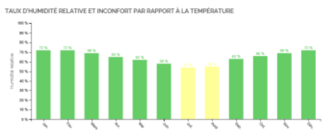
 **Figure 47** precipitation days **Source**: (meteoblue, 2025)	 **Figure 48** Maximum temperatures **Source**:(meteoblue, 2025)	 **Figure 49** Foggy days **Source**:(Tlemcen weather, 2025)
 **Figure 50 Wind speed** **Source**:(meteoblue, 2025)	 **Figure 51 Cloudy days** **Source**:(Tlemcen weather, 2025)	 **Figure 52 Humidity** **Source** :(Météo et climat, 2025)

Table 11: Tlemcen climate

1.4. Seismic

While national classifications place the Tlemcen Wilaya within a zone of low seismic risk (zone 1), suggesting stability, a closer look at neotectonics reveals a different picture. The region is part of the Tellian zone, situated on the northern margin of the African plate. This positioning suggests that seismic activity, though perhaps currently low, should not be disregarded **Table 13**. The region's apparent stability could potentially indicate a seismic gap, where accumulated stress may eventually be released.

1.4.1. Classification of seismic zones

The national territory is divided into seven (07) **Table 12** zones of increasing seismicity, defined on the map of seismicity zones, cf. which specifies this distribution by wilaya and by municipality, namely: (RPA, 2024)

Seismicity	Zone	Seismicity	Zone	Seismicity	Zone	Seismicity	Zone	Seismicity	Zone	Seismicity	Zone
Very weak Zone	0	Weak	I	Low to medium	II	Average	III	Medium to high	IV	High	V & VI

Table 12 Seismic zones

Source: (RPA, 2024)

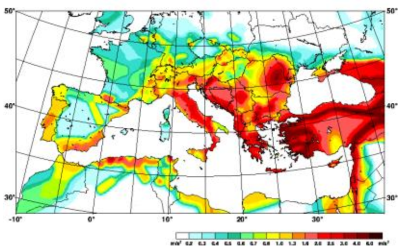


Figure 53 Mediterranean area
Source:(Rafik TALEB, 2010)

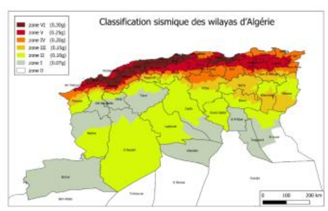


Figure 54 Zonage sismique de l'Algérie
Source : (RPA, 2024)

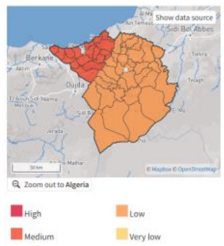


Figure 55 Earthquake
Source: (Tlemcen - Earthquake, 2025)

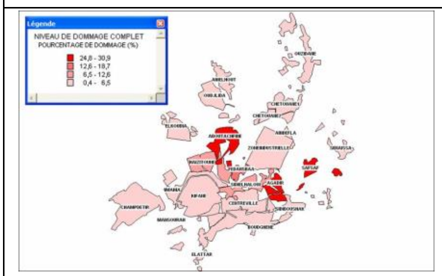


Figure 56 Distributions of Complete Damage
Source: (Rachedi & Zendagui, 2015)

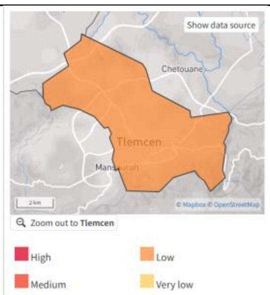


Figure 57 Earthquake
Source: (Tlemcen - Earthquake, 2025

Figure 58 Fault considered for the introduction of the seismic event
Source: (Rachedi & Zendagui, 2015)

Table 13 showing Earthquake

1.4.2. Landslides and support structures :

All the cases of slope landslides observed (eastern ring road, ITE and the housing estate of 500 dwellings **Figure 59** are caused: (i) Either by applying additional loads (loading by backfill or other (ii) Either by removing the abutment at the foot of the embankment, (iii) and finally, by a modification of the geometry of the embankment (increase in the angle of the embankment)

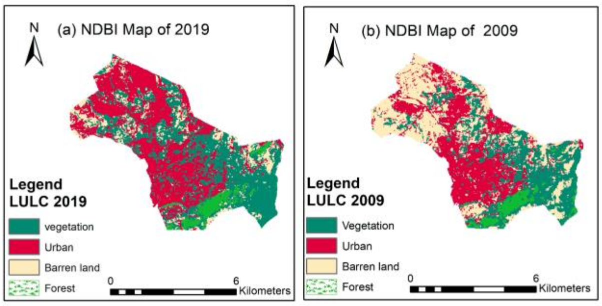


Figure 59 urban growth resulted in a reduction in bare soil in the north and a decrease in vegetation, primarily consisting of agricultural land, in the east

Source (I. Selka et al., 2024)

All these shifts are caused by human intervention and without prior studies. The extent of these landslides has been mitigated because of the drawdown of surface water tables **Figure 60** following the drought that the region has experienced in recent years. Much greater damage should be expected if measures are not taken (drainage and/or stabilization), when rainfall becomes normal

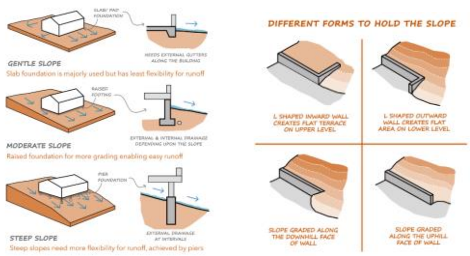


Figure 60 Drawdown of surface water tables

Source: (Kaarwan, 2025)

1.5. Historical context | the creation of Tlemcen city:

This study examines the historical evolution of Tlemcen, tracing its development from prehistoric settlements to a major urban centre. We will focus on its urban development and socio-economic transformations from the earliest evidence of human presence through the post-independence period. The analysis integrates historical events with typo-morphological (urban form) and functional (economic, social, political) readings of the city, particularly from the Zianide period onwards, based on PDAU final report of 2008. **Table 14.**

1.5.1. A brief historical overview:

• Evidence from the prehistoric (Neolithic) period has been discovered in the region (caves of Boudghene – Bab El Karmadine – Ouzidane). The region was then inhabited by certain Berbers. Roman settlement (to 17 BC). Vandals land in the Maghreb on the shores of the Mediterranean and the Atlantic Ocean in particular. In 710, the Arabs arrived at Tlemcen, and converted the population into almost 80 years old. In 790, Sultan Idriss 1st obtained possession of the medina and created his enclosure until the year 930 and the foundation of the city of Agadir (790 -1078).

In 1080, the Almoravids arrived and used the name "Tilimsan" and foundation of "Tagrart" now Tlemcen by Abou Tachefine (1080 -1147). In 1235, Tlemsan became the capital of the kingdom of the Ziandes, the seat of the government of Provence. In 1370, Ibn Khaaldun took refuge with the Sultan of the Zianids. In 1553, the region of "Tilimsan" fell under the rule of Otthomane.

In 1836, Tlemcen was conquered by French colonization that came with a spatial segregation in their urban planning and mode of life that they imposed on the Arabs. In 1942, Tlemcen became the capital of the 5th military division of Oran. In 1834 – 1836, Tlemcen submitted to the Sultan of Morocco, who was recognized by the AEK Emir. In 1837 – 1942, Treaty of Tafna between Emir AEK and the French occupier. 1858, Tlemcen becomes sub-prefecture of the department of Oran. 1872, the destruction of the cultural and economic bases of the Medina – 1872

Destruction of the Tachfinia madrasa and construction of French squares and administrations. 1904, destruction of the Kaissaria, and construction of the covered market in its place. 1920, urbanization began outside the city walls, with the creation of housing estates Faubourgs- Beauséjour and Bellair. Creation and development of the colonial core. Creation of the railway line (Oran-Mecheria – Béchar) which diverted the former trade flourished and Tlemcen lost its rank to the benefit of Oran. Redefinition of the role of Tlemcen, as a local centre that would be filmed only green agriculture and its ancillary services

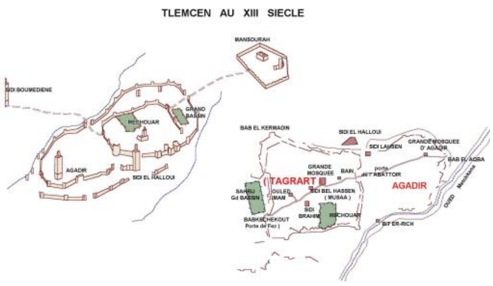


Figure 61 8th Century
Source (KAOUADJI AMINA, 2015)

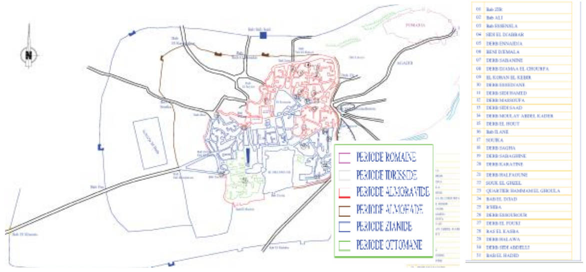


Figure 62 Settlements of pre-colonial periods : Romans, Iddrisid,Almoravide, Almohade, Zianide, Ottomane

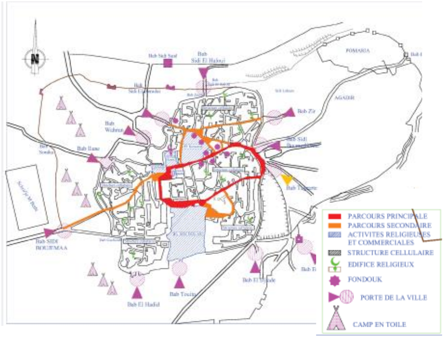


Figure 63 Morphological structure of the medina

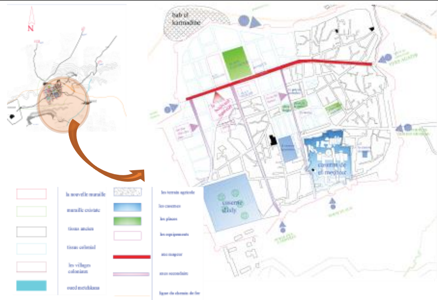


Figure 64 Colonial ; french : "1860-1900" military intervention ; « le but de cette intervention était de renforcer la défense de la ville »

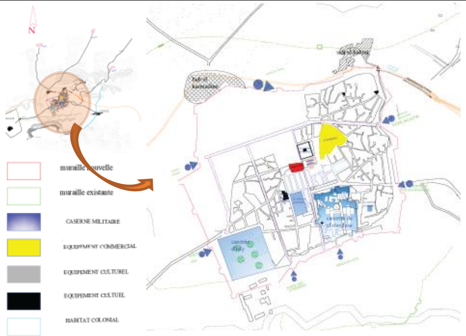


Figure 65"1860-1900" administrative intervention : « le but des colons dans cette période était de ne pas créer une nouvelle ville mais de créer une ville européenne sur la ville ancienne »

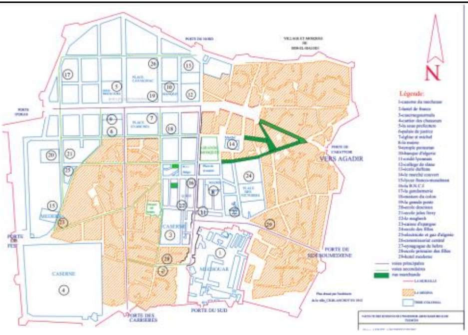


Figure 66 After intervention : New urban structural fabric

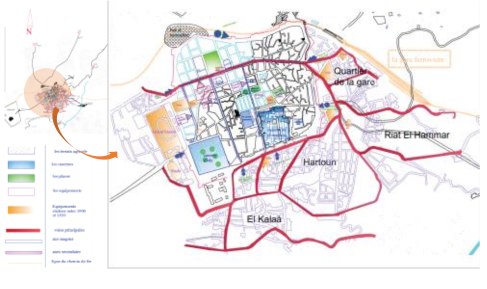


Figure 67 "1900-1939" : « L'extension s'est faite vers l'est pour des raisons de : - Proximité des remparts, Insécurité à l'intérieur de la ville, Présence de ressources naturelles (la fouara principale source alimentant la ville), Proximité de la gare, Les premiers exodes des colons vers la ville. »

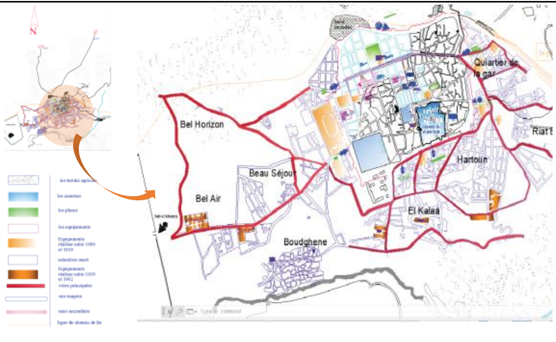


Figure 68 "1900-1939" « extension ouest : Premiers quartiers extra-muros : Habitat individuel de type colonial »

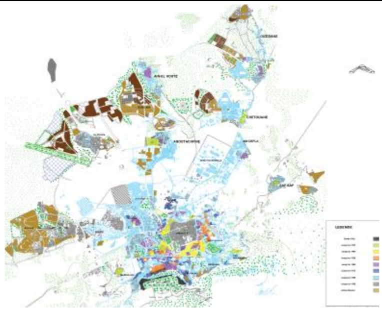


Figure 69 post-coloniale (1962-1977) « L'état était le principal agent de développement à travers les différentes politiques urbaines »

Figure 70 « A nos jours : Institution de nouveaux instruments d'aménagement du territoire et d'urbanisme (P.A.W, P.D.A.U, P.O.S) : »

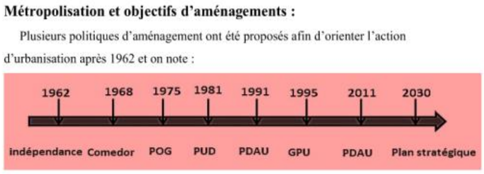


Figure 71 Timeline for past(from independence), present and future politique of Urban planning :

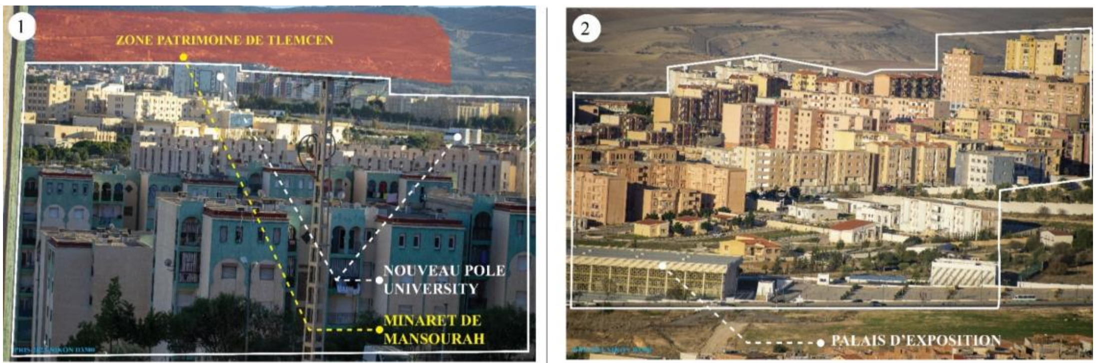
Source:(Quartier La Marine, 2020)

Table 14 Tlemcen History

Source PDAU et (Author, 2025k)

1.5.2. Colonial impact today:

These are models of Fernand Pouillon and le Corbusier with a concept of 'le climat francais en Algerie" repeating everywhere you go including in Tlemcen city as Copy and paste architecture both in plans, scale and functionality (**figure 72**).The Algerian state calls these models "OPJI, Promotionelle" (new social housing typology in Algeria) but they have no local identity in the Arab world. "Les bâtiments modern sont confus dans le monde Arab en compétition avec le dieu (des minarets de la patrimoine). Ces modèles sont composés des bureaux des salon. Aux étages et dans le patrimoine la ville est en Harmonie avec la nature et des minarets plus haut qui se dit "Dieux et là plus Haut" (Fathy- YouTube, 1978).



Extention urbain Tlemcen (La rocade-nouveau pole universite comme repere) | Extention urbain Tlemcen (El-Koudia- Palais d'exposition comme repere)

Figure 72 Colonial impact of Urban planning

Source (Author, 2025al)

1.5.3. Obsolete with time.

These models become obsolete with time since they have no identity, less economic with high energy consumption, with inflexibility index and monofunctionally. At times its due to poor planning methods and outdated policies on the contextual models and as well as corruption in the offices. **Figure 73**

Figure 73 Obsolete building typology in Tlemcen city a specified location

Source: (Author, 2025q)

1.5.4 Investigation interview—explanation by Tlemcen people

« Ceux bâtiment sont comme notre vêtement ou nos téléphones, ils ont la tendance aujourd'hui et demain on a plus besoin. Parce qu'il y'as les nouvelles tendances d'avancement et la batterie de ces téléphones se dégrade avec le temps qu'il n'est plus utilisé ou même utile et c'est mieux d'acheté une nouvelle téléphone que la batterie. Et ben ces besoins plus la tendance qui rendre ceux bâtiment obsolète. Par exemple c'est bâtiment des imports en face le muse « The National Public Museum of Islamic Culture »«dès qu'il y a eu le nouvelle siège(emplacement), c'est plus utile. comme les maison francais, c'est l'obsolescence dans notre ville tlemcen. Pour la durabilité de grande mosquée, ce n'est pas le temps qui comte ici. C'est l'originalité qui reflète notre religion et notre culture de nos maisons qu'on a vecu, Donc c'est nécessaire de notre histoire et l'utilité » **Figure 74**

Figure 74 « un colloque des citoyennes » Obsolescent de bâtiments Tlemcen

Source (Author, 2025r)

2.Urban study:

This analysis will draw on cartographic data, written documents, and urban planning instruments (PDAU)

2.1. Heritage study of Tlemcen city:

This study explores the architectural heritage of Tlemcen, analysing its historical legacy, the transformative effects of colonialism, and modern-day initiatives to safeguard and revitalize its cultural identity. The city's heritage is anchored in two primary elements: (i) the **medina** and its iconic monuments, including the Grand Mosque of Tlemcen and the Sidi Boumediene Mosque, and (ii) archaeological remnants such as the ancient sites of **Agadir** and **Mansourah** (**Figure 75**)

Alongside these historical treasures, Tlemcen's urban landscape has expanded to accommodate population growth, resulting in sprawling contemporary neighbourhoods like **Imama, Chetouane, and El Koudia**. However, rapid urbanization has led to haphazard development, with illegal constructions encroaching on sensitive areas—notably at the city's entrance—and modern buildings that are often obsolete, frequently lack compliance with functional, aesthetic, or safety standards. This juxtaposition highlights the tension between preserving Tlemcen's storied past and addressing the demands of its evolving present.

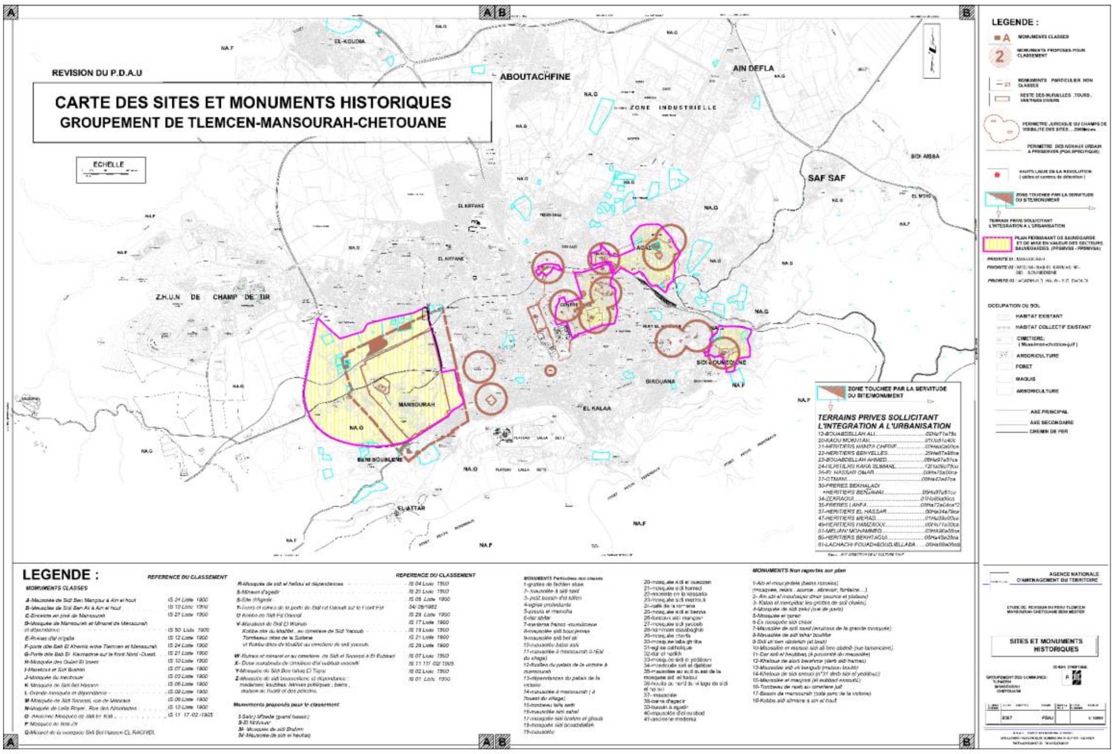


Figure 75 Tlemcen's historical heritage sites and monuments**:**

Source: PDAU et (Author, 2025c)

2.1.1. Typo-Morphological and Functional Elements of the Medina and its iconic monuments

This part focuses on the sustainability of monuments like the grand mosque in specified due to its frequent usage as compared to the other monuments and the medina which is organized around a main east-west axis, with commercial activities and residential areas branching off.

2.1.2. The medina of Tlemcen city:

Here, we shall detail structure such as the commercial space, residential space, political and Cultural Space

(i) **Commercial Space:**

The commercial area is spatially structured, distinguishing itself from the residential space. It concentrates around the grand mosque and is organized based on the prestige of the merchandise sold. Key elements include: **Kissaria:** An assemblage of covered galleries with shops. It played a significant role in Tlemcen's economic life. **Fondouk:** Equivalent to a caravansérail, providing lodging, storage, and trading space for merchants **Figure 76**. This arrangement induces a central space (a central courtyard) that becomes the centre of daily exchange of these closed communities. There is only one communication passage with the outside closed by a door opening onto a passageway or a souk

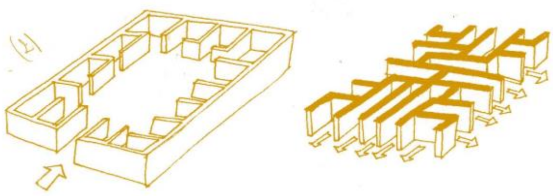


Figure 76 Diagram of the perimeter wall of the foundouk

Source: (Batita, 2023)

Souk: The market, a fundamental element of the médina's social and economic life. (**Figure 77** The path, as a linear component, allows the souk to organize a network of connections. Indeed, the networking of different components allows him to design a structure *of exclusion by confinement* that extends over the entire urban space**.**

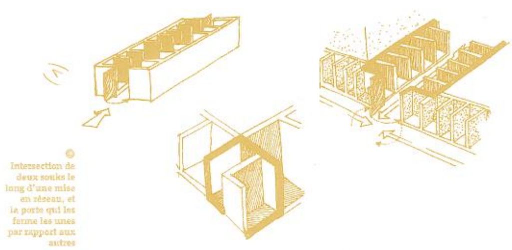


Figure 77 Diagram of a souk networking

Source: (Batita, 2023)

(ii) Residential Space (El Houma):

Constitutes the third belt of the urban fabric, as it occupies the largest surface area. It goes from the interior square (Tahtaha which separates the productive part and the residential district until the walls **Figure 78**. **Derb:** The basic spatial unit within a "houma," consisting of houses aligned along a street. **E'skiffa:** A passage over a street, marking a transition. **Impasse:** A dead-end street providing a semi-private space. **Tahtaha:** A small square within a neighbourhood containing a four, bath, moçala, and zawiya. **Moçala:** small mosque for daily prayers. **Four (El Ferrane):** A traditional oven for baking bread. **Bath (Hammam):** Public bathhouses, important social spaces for women. **House (Edder):** Typically, with a ground floor and one upper floor, composed of a *Bab eddar*, *El derbouze*, *Wast eddar*, *El bieut*.

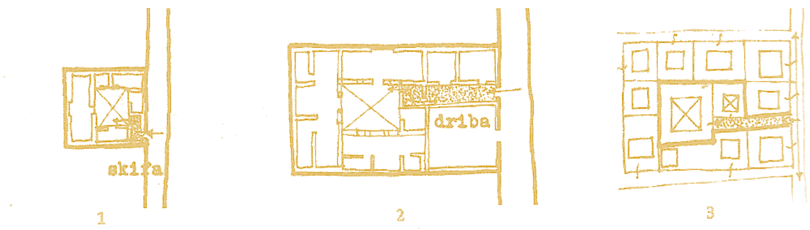


Figure 78 Transition diagrams for street space/private space

Source: (Batita, 2023)

The courtyard, like the cell and the chicane, is the result of an orthogonal network of four walls. It has a dual centripetal character **Table 15** (thanks to the convergence towards inhabited rooms) and centrifugal (due to its character as a perforated enclosure). Its central position denotes the value of a protected and reserved place. It is a device that contains and indicates exclusion (outwards and inwards) from a semantic point of view.

The path represents a linear vector element. It embodies the operating instrument and allows you to travel, cross the city, but also go within a certain spatial configuration.

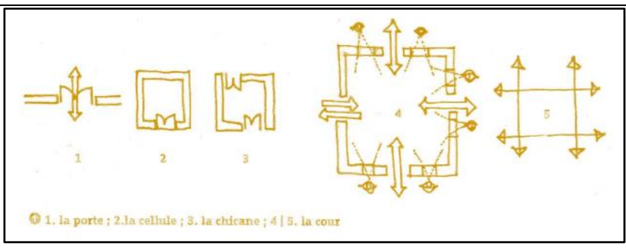
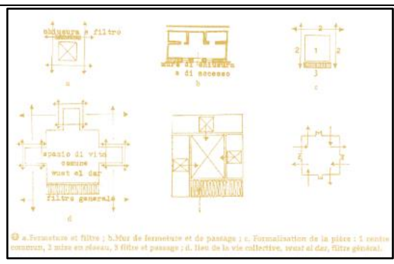
 **Figure 79 Diagrams of the door, cell, baffle and courtyard**	 **Figure 80 Spatial distribution diagram**

Table 15 Court yard

Source: (Batita, 2023)

(iii). Political and Cultural Space:

Located at the "summit of the conical form of space," this zone includes: **Mosques:** Serving not only religious but also social, political, and economic functions (**Table 16) Medersas:** Schools for religious sciences and student housing, organized around a central courtyard. **Palaces.**

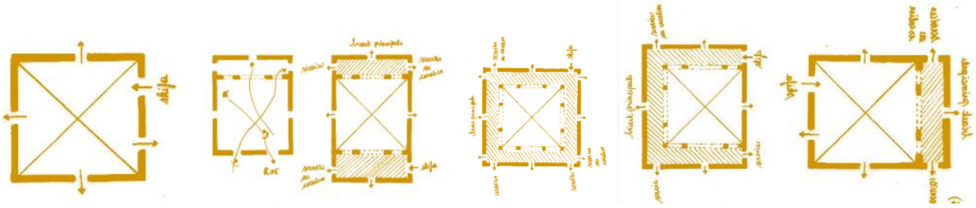


Figure 81 Outline of the different types of courses found in these cultural spaces

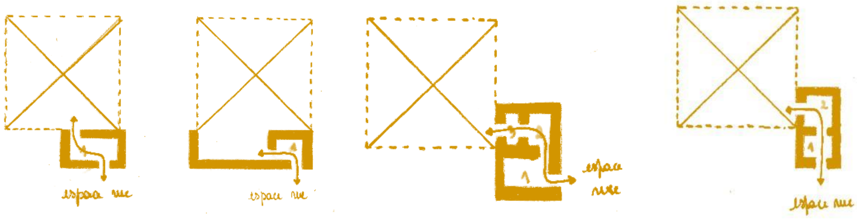


Figure 82 Diagrams of the different types of entrances

Table 16: Cultural space

Source (Batita, 2023)

2.1.3. Sustainability study of Tlemcen great mosque:

The Great Mosque of Tlemcen, a historic architectural masterpiece founded in 1082 and one of Algeria's oldest and best-preserved examples of Almoravid architecture, exemplifies sustainability through its enduring structural integrity, cultural significance, and centuries of adaptability. Serving as both a religious site and a testament to sustainable principles relevant to contemporary architectural practices, the mosque's sustainability will be examined within the context of heritage preservation and the urban development challenges faced by Tlemcen. This analysis draws upon principles established by historical figures such as Euclid, Vitruvius, Palladio, and Al-Khwarizmi, as well as recent research on adaptive reuse and sustainability in heritage buildings. The key elements include the following

(i). Structural Integrity and Material Sustainability

The Great Mosque is constructed using locally sourced materials such as stone and brick, which contribute to its durability and resilience over time. The architectural design incorporates advanced techniques for its era, including the use of horseshoe arches and a ribbed dome that exemplifies structural innovation. These features not only enhance the aesthetic appeal but also provide significant structural support, allowing the mosque to withstand environmental stresses (Muslim Heritage, 2024). The enduring nature of these materials aligns with sustainable architectural practices that prioritize longevity and minimal environmental impact.

(ii). Cultural Significance and Community Role

As a central place of worship and community gathering, the Great Mosque plays a vital role in maintaining Tlemcen's cultural identity. It embodies the synthesis of Islamic art and architecture, showcasing intricate arabesques and Kufic calligraphy that enhance its spiritual ambiance (Britannica., 2024). The mosque facilitates social cohesion among residents by serving as a hub for cultural events and religious activities. This ongoing relevance underscores the importance of preserving such heritage sites as they contribute to the social fabric of the community.

(iii) Adaptability Over Centuries

The Great Mosque has demonstrated remarkable adaptability throughout its history. Its layout includes spacious courtyards that can accommodate various community activities, enhancing its relevance in contemporary society. The mosque's design promotes natural ventilation and light, reducing reliance on artificial systems and promoting energy efficiency (Algeria.com, 2024). This adaptability reflects sustainable design principles by ensuring that heritage structures remain functional in a changing urban environment.

(iv). Historical Principles in Contemporary Context

The principles established by historical figures such as Euclid and Vitruvius emphasize harmony between form and function in architecture **Figure 83**. These principles are evident in the design of the Great Mosque, which combines aesthetic beauty with practical functionality. (Madandola & Boussaa, 2023)

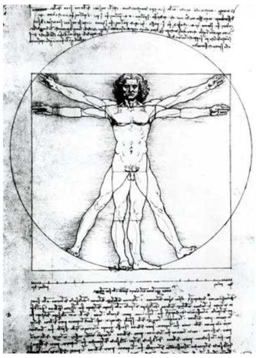


Figure 83 Vitruvian man, a figure study by Leonardo da Vinci (*c.* 1509) illustrating the proportional canon laid down by the…

Source: (Golden ratio, 2025)

(v). Geometry study of Tlemcen great mosque;

The influence of historical mathematical and architectural figures on design, particularly concerning the use of geometry and proportion, and suggests practical applications for the city of Tlemcen.

Geometric principles, particularly proportion and symmetry (including the Golden Ratio), have been fundamental to architectural design throughout history and can be applied to contemporary challenges like heritage preservation and sustainable development.

(vi). **Historical Influences:** These are **Euclid (Geometry):** Established geometric principles like the Golden Ratio and proportional relationships, providing a mathematical foundation for harmonious design. **Vitruvius (Architectural Theory):** Emphasized *Firmitas*, *Utilitas*, and *Venustas* (firmness, utility, and beauty), linking beauty to proportion and natural order. **Palladio (Classical Architecture):** Exemplified the practical application of classical proportions and geometric harmony in building design, using elements like columns and pediments to enhance aesthetics. **Al-Khwarizmi (Mathematics):** Provided mathematical tools for calculating areas and volumes, crucial for precise construction and efficient material use, influencing geometric patterns in architecture. (**Table 17**)

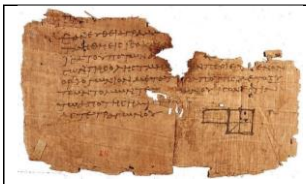
 **Figure 84** 100 CE fragment from papyri found at Oxyrhynchus, Egypt, shows a diagram from Book II, Proposition 5 of Euclid’s Elements. Source (Meisner, n.d.)	 **Figure 85** Arabic translation of Euclid’s Elements was created by Persian polymath Nasir al-Din al-Tusi (1201– 1294.) Source (Meisner, n.d.)	 **Figure 86** These pages from a 1342 edition of al-Khwarizmi’s Book of Algebra Source (Meisner, n.d.)	 **Figure** 87 Beauty, proportion and natural order; La Maison Pompéienne ("Pompeian house") Source: (*(1) Three Principles of Good Architecture* | *LinkedIn*, n.d.)

Table 17 Geometrical references

(vi). Practical applications in the great mosque of Tlemcen:

Incorporating these geometric concepts into Tlemcen's architectural practices can address challenges related to heritage preservation and urban development: **Facade Design:** Using the Golden Ratio for visually appealing facades that respect historical aesthetics (**Table 18**.) **Room Dimensions:** Applying geometric principles for functional and comfortable spaces while maintaining historical integrity. **Sustainable Practices:** Integrating modern technologies with traditional geometric principles for energy-efficient buildings that preserve architectural heritage.

Figure 88 View of the Great Mosque of Tlemcen Courtyard

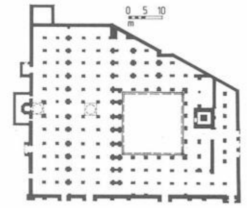


Figure 89 General plan of the great mosque

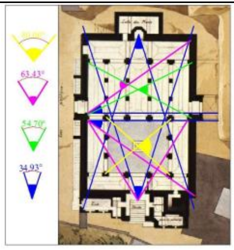


Figure 90 Plan geometry principle

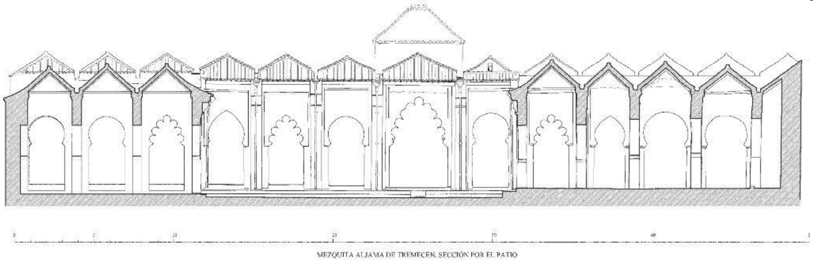


Figure 91 Cross-section through the courtyard of the Great Mosque of Tlemcen

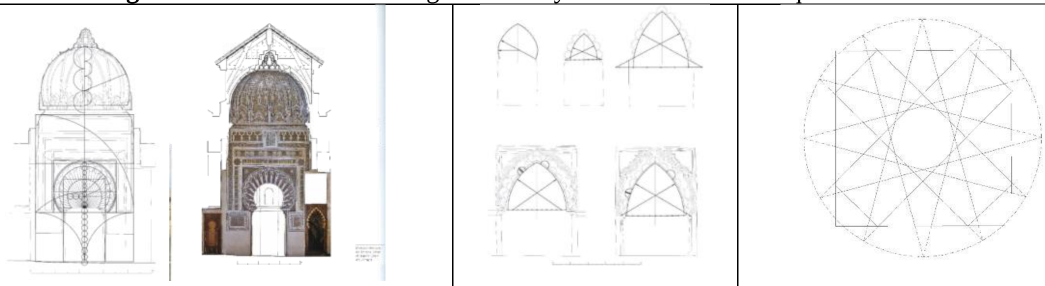


Figure 92 Geometric lay out of the ribbed domes arches vaults of the interlaced arches of Al-Andalus and the Maghreb

Table 18 Geometry rhythms of Tlemcen mosque

Source (Almagro, 2015)(MosquéeTlemcenR, 2017)

In essence, the text argues that by understanding and applying historical geometric principles, architects can create beautiful, functional, and sustainable buildings that respect both tradition and the environment.

(vii). Sustainability remarks by Hassan Fathy in the medina of Arabs

« Le vide s'exprime, ce n'est pas un simple espace qui est vide ou de laissée à faire **Figure 93** en plus à cette espace, Le vide correspond aux désirs de l'homme. La maison Arabe est une maison introvertie, en rentrant en coude qui nous coupe entièrement de la ville. En Europe La fonction de la fenêtre combine l'air, l'eau, et la lumière qui n'est pas maison arabe. C'est 3 fonctions sont séparé lune de l'autre, la ventilation avec le malquaf (taille dépend de la région) et moucharabieh. »

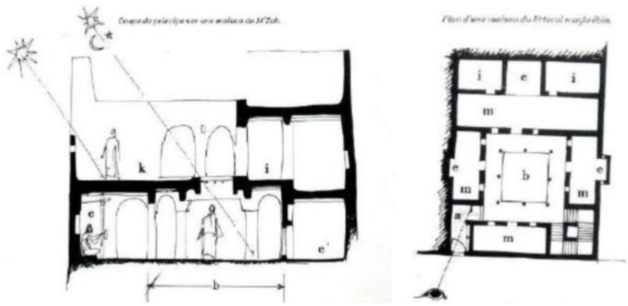


Figure 93 Main section on a house of the m'zab

Source : (André Raverau, Hassan Fathy, 1985)

« Le confort thermique dépend du mouvement de l'air, le plus courant de l'air que vous avec dedans, Le mieux c'est **Figure 94-95**. Mais quand vous ouvrir les grand ouverture, vous faire introduire l'aire chaux et vous auriez aussi la réverbération—le reflet des autre maison qui vous faire entre de la chaleur—alors que avec le moucharabieh qui varie dans une région, vous avez d'espace airée avec le bois d'une valeur hygrométrique d'absorption d'humidité, l'aire qui passe serait de-humidifie et l'absorption d'humidité réévapore avec le mouvement de l'aire et ça fait tamise de lumière, ça distribue la luminosité d'une façon le contraste entre le sombre et le claire n'est pas grande. »

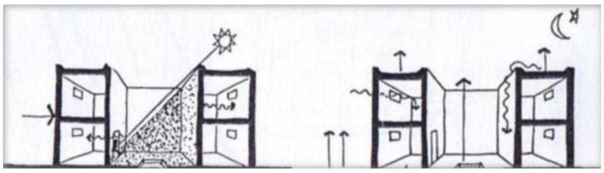


Figure 94 Climatic sketch functioning of a courtyard (the Patio Medina of Algiers, Algerian context)

Source (Mouloud & Tizi-Ouzou, 2018)

Figure 95 (i)Thermal performance of the courtyard in a traditional house (ii)Extrovert looking openings

Source (i) (Sabah & Al-Zubaidi, 2007) (ii) (Sabah & Al-Zubaidi, 2007)

« Aujourd'hui vous avez l'aire conditionne, qui demande des chambres très étroit, des plafonds très bas et quand cas ne marche pas, on soufre dedans. Les bâtiment modernes comme les route asphaltes sont mal académise. Ça fait partie de l'industrie de la voiture, ça veut dire, on fait express de chambre étroit avec de plafond très bas parce que l'architecture et rentre dans l'industrie de l'air conditionné. Nous dévons tout payée même l'aire et l ; eau. Mais pas tout le monde a l'argent de tout payée **Figure 97**. La valeur de l'esthétique et les valeurs fonctionnelle sont Aujourd'hui perdues, il nous faut remplace ça par discrimination et le savoir qui peut être su avec l'héritage de l'occident. »

« Economiquement, Les Architect et les ingénieurs doivent sujet il la technologie et la science moderne au service de ce pauvre gens dans tout façons **Figure 96**. Ils sont pas du tout des clients des produit industrie. »

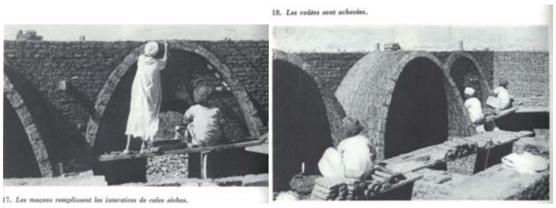


Figure 96 Building with the people "Construire avec le people.."

Source: (Hassan Fathy, 1969)

Figure 97 Contemporary Architecture in Tlemcen city

Source (Author, 2025d)

« Aux matériaux, le brick cru est le meilleur isolant pour la raison lie à sa conductivité thermique plus moins que du béton et de ciment. » (Fathy- YouTube, 1978)

(viii)Contemporary developments:

In recent years, Tlemcen has seen a revival of interest in its architectural heritage. Following its designation as "Capital of Islamic Culture" in 2011, new cultural facilities have been constructed that draw inspiration from Moorish design elements.(Mazouz & Triqui, 2024)

Figure 98 Tlemcen logo

This revival raises questions about authenticity—whether contemporary buildings genuinely reflect traditional styles or merely use them symbolically (Mazouz & Triqui, 2024)

(ix)"La dégradation de la Patrimoine local (**Figure 99**)" :

Le patrimoine se dégrade à cause de l'abandonnement, Sauf les monuments qui sont restaurée ouvert au public autant que muse (Fathy- YouTube, 1978)

Figure 99 ; Case study, restored monuments and degraded monuments

Source (Author, 2025o)

2.2. Functional urban study of Tlemcen city:

This functional and morphological study aims to analyse the urban fabric of Tlemcen through four organizing systems: plots, roads, buildings, and open spaces. By examining these elements, we can gain insights into the city's historical development, cultural significance, and contemporary urban challenges.

2.2.1 Plots and land use

The plots in Tlemcen reflect a diverse range of land uses that have evolved over centuries. The historical layout of the city is characterized by irregularly shaped plots that accommodate residential, commercial, and religious buildings.

(i) **Historical Context**: The original plots were likely influenced by the Islamic urban planning principles that prioritize communal spaces and accessibility. The medieval city layout facilitated trade and social interactions among residents (Britannica., 2024).

(ii) **Current Trends**: Today, many traditional plots are undergoing transformation due to urban pressures and modernization. The challenge lies in balancing development with the preservation of historical plot configurations (Sciendo, 2024).

(iii) **Built-up areas** in the grouping, human occupation in urban areas, roads and infrastructure is very important because we are in a very urbanized environment, which concentrates the majority of functions, housing - shops and services - political and administrative management - public facilities - industrial and business zones - presence of heavy infrastructures (energy - hydraulic)

2.3. Socio-economic study:

This is particularly about the analysis of the population (its structure, its evolution, its spatial distribution of economic activity) as well as household living conditions through housing and housing amenities. Research indicates that Tlemcen takes on the third place after ghardia and Oran that is 1.149,006 people than the capital Algiers **Figure 100**

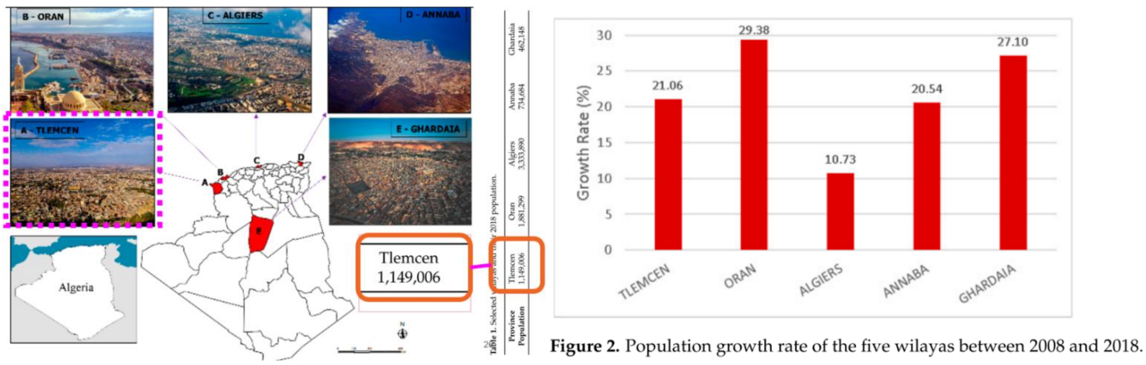


Figure 100 General Tlemcen Algeria population

Source (Bounoua et al., 2023b), PDAU

It's clear with high and rising population but with a small ISA as compared to the historical zone Tlemcen and Mansoura where its being preserved.

the urban development master plan (PDAU) of a sample group of Tlemcen groupment that is remchi, maghnia, Chetouane, sebdou, of Tlemcen The analysis that we propose to make here will be grasped in its demographic, social and economic aspects (**table19**)

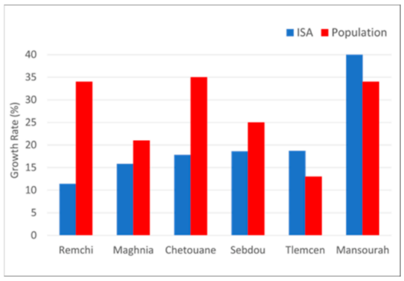


Figure 5. Change in ISA and population growth rates (%) between 2008 and 2018 for the communes with the largest populations in the Tlemcen wilaya.

Figure 101 Population growth rate

Répartition spatiale de la population du Groupement. RGPH 2008.

Commune	Superficie		Pop Totale	
	Km^2	%	Effectif	%
Tlemcen	40,11	20,23	140 158	54,84
Beni Mester	86,17	43,46	18 651	7,30
Chetouane	45,00	22,69	47 600	18,63
Mansourah	27,00	13,62	49 150	19,23
Groupement	198,28	100	**255 559**	100

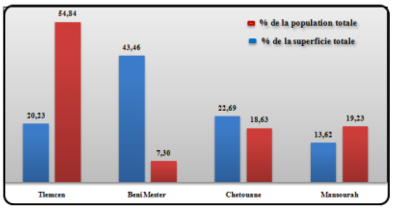


Figure 102 Population of the municipalities of the Groupment

Table 19 Tlemcen population growth rate

Source: (Bounoua et al., 2023b) Pdau

2.4. Infrastructure, roads and highways.

The road network in Tlemcen consists of narrow, winding streets typical of historical Islamic cities. These roads connect various neighbourhoods and significant landmarks, including mosques, markets, and public squares.

Roads and highways are classified into: highways and national roads (routes nationals RN), as major national or even regional infrastructures **Figure 103**. - Wilaya road (Chemin de wilaya CW), as local regional infrastructure and for the wilaya, and sometimes for the communes - Communal Road (Chemin communal CC) for the interior of the communes

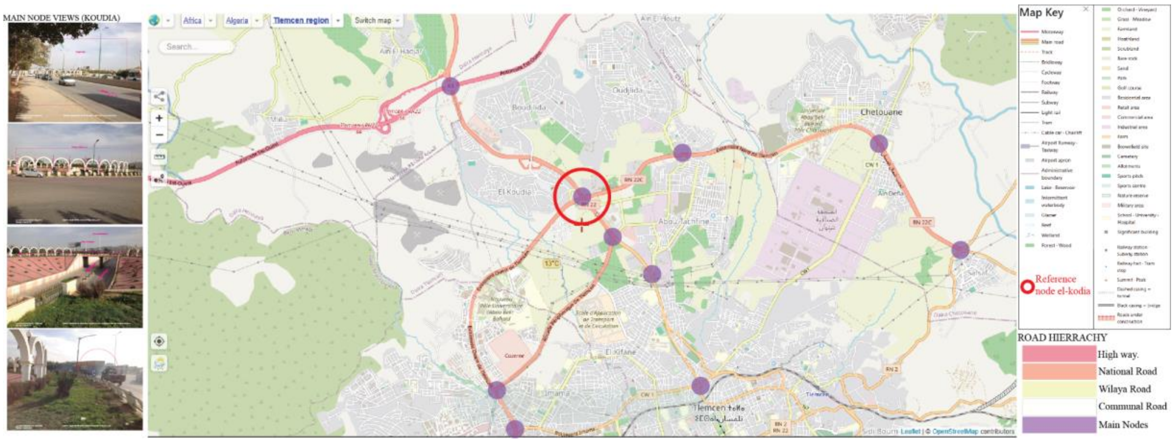


Figure 103 Main city roads from the highway entrance.

Source Photo satellite et (Author, 2025o)

2.4.1. The state of the environment and the risks of pollution:

We can classify major risks into broad classes, depending on the type and nature of the risks

(i) Risks of pollution from quarries:

The quarries near the Tlemcen group cause pollution problems of the order of: - Dust emanation- Noise emanation- Vibration on the ground and underground - Heavy vehicle traffic

(ii) Damage to the environment in urban areas

We can mention the main environmental damage in urban areas: - Insufficiency and sometimes absence of green spaces in residential areas and even in the city centre- Degradation of the living environment- Degradation of cultural heritage (e.g. Medina)- Informal and illegal housing in several areas of the group and anarchic appropriation of space- Constructions on historic sites (e.g. Mansoura)-

Absence or lack of monitoring and implementation of general and operational urban planning studies - Construction in easement areas, on unbuildable areas and on risk areas. - Intense rural exodus and including withering away of neighbouring municipalities - mixture of shapes, styles and volumes; and an urban composition without structure or harmony - Major risks are not taken into consideration in hasty decisions - Problems of access to extension areas and overloading on the city Centre.

(iii) In addition; traffic congestion:

Increased urban population and development have resulted in heightened traffic congestion and pollution, negatively impacting the historic environment. **Figure 104**

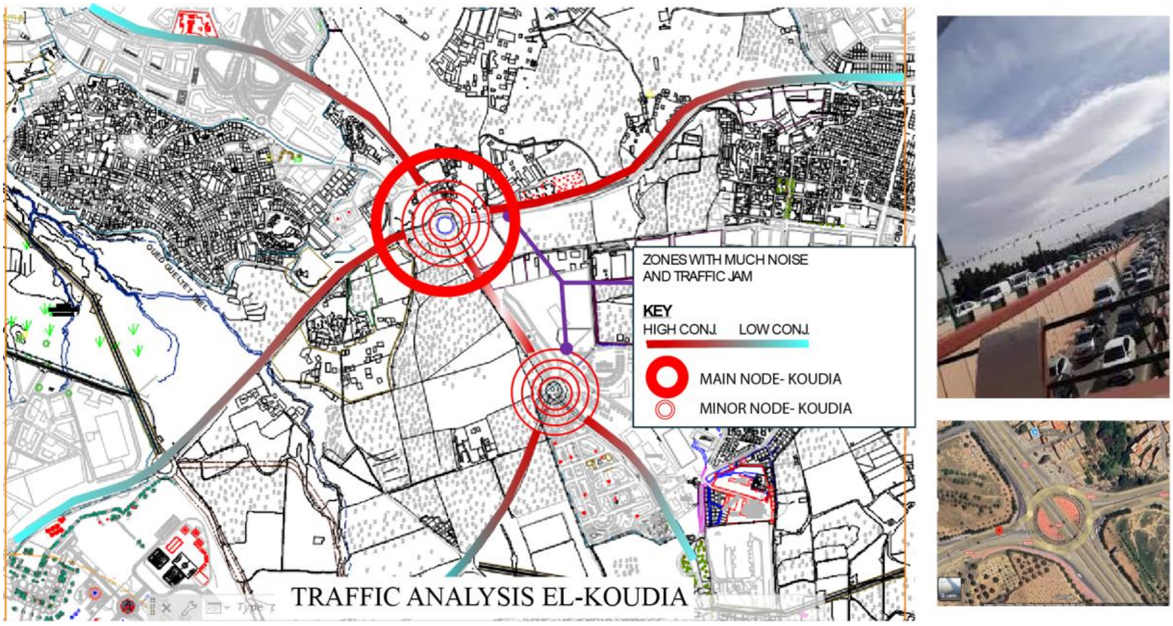


Figure 104 Traffic from the main node in Elkoudia entrance to the city

Source PDAU et (Author, 2025p)

(iv) Summary of other major risks:

water pollution risks**,** forest fire risks, flood risks, geological and geotechnical risks, risks of collapse and disorder on technical structures – (gas, electricity), risks of explosion of pipelines and gas pipelines, risks of electrocution on electricity network structures and cables, risks created by quarries at the end of their operation,

2.4.2. Urban fabric and settlements.

The rapid urbanization of Tlemcen presents significant challenges: The lack of adequate planning has led to uncontrolled development that encroaches on historic areas. This expansion diminishes the historical context of the city and alters its unique character. **Loss of Traditional Urban Fabric**: **Figure 105** New developments often disrupt the traditional urban fabric, erasing visual and cultural links to the past. Insensitive architectural designs can overshadow or replace historic buildings. **Preservation Challenges**: Many historic buildings face deterioration due to neglect or inappropriate renovations. There is a pressing need for conservation efforts that respect the original architectural styles while adapting to contemporary needs(ELYASİ & YAMAÇLI, 2023).

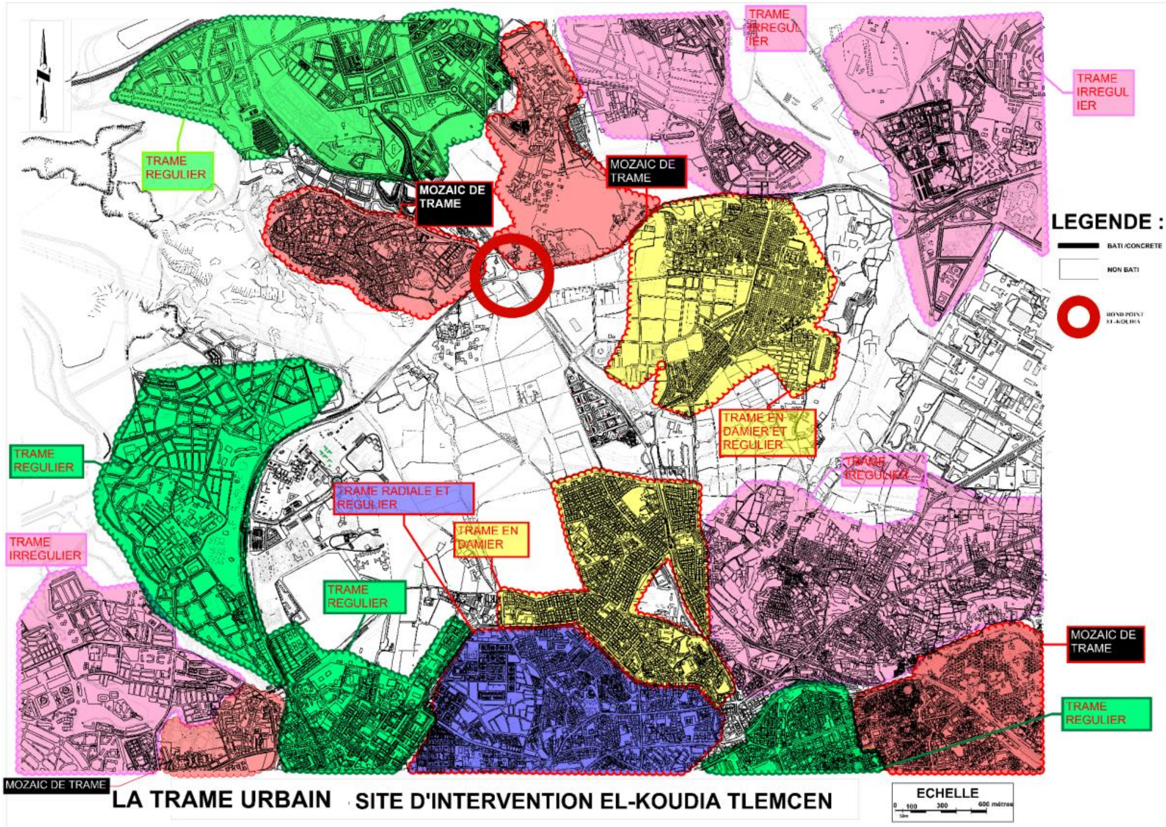


Figure 105 General urban Fabric

Source PDAU et (Author, 2025q)

(i) Open spaces

Open spaces in Tlemcen include public squares, gardens, and courtyards that serve as vital communal areas for social interaction and cultural activities. **Cultural Importance**: These spaces often host festivals and community events that celebrate local traditions. For instance, the annual Maghreb Music Festival showcases Tlemcen's rich musical heritage (Direction of Tourism and Handicrafts Tlemcen, 2024). **Urban Development Pressures**: Urbanization has led to the encroachment of built structures on open spaces (**Figure106)**. Protecting these areas is essential for maintaining the city's cultural identity and providing residents with recreational opportunities (Cultural Heritage in Action, 2021)

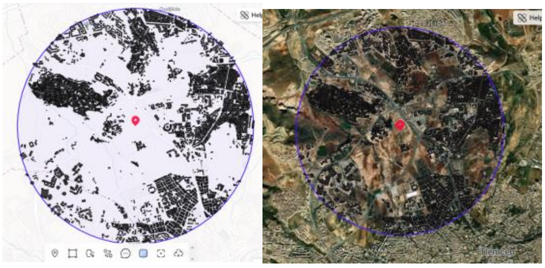


Figure 106 Occupation de sol 40% (500m2) from the general entrance round about El-Koudia zone

Source: (Aino AI, 2025)

In addition: even with the current trends of infrastructural installations (VRD) **figure 107.,** There is minimum intervention concerning these installations in the heritage site in yellow colour which hinders neglect thus creating urban sprawl to other zones:

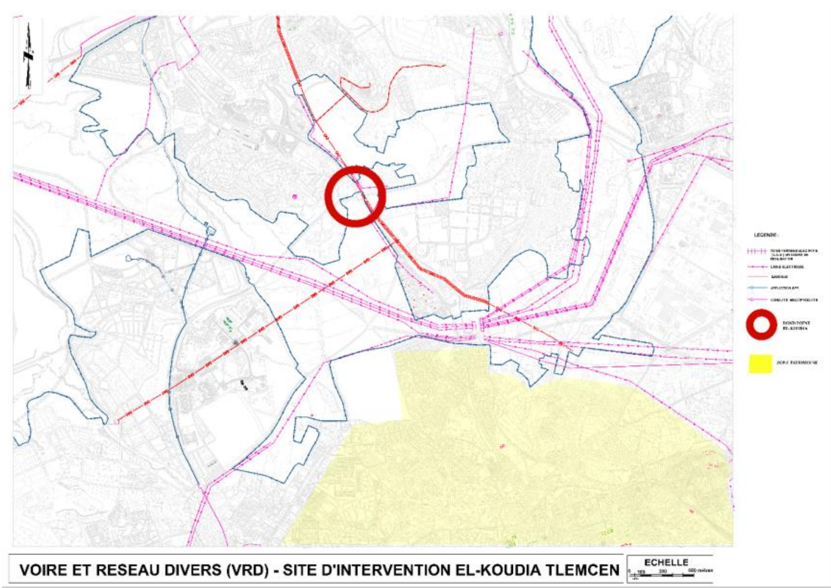


Figure 107 Infrastructure (VRD) Tlemcen

Source PDAU et (Author, 2025r)

(ii). Functions proposed by PDAU

These proposals typically address the orientation and future spatial development of unoccupied land, considering both current societal needs and anticipated future requirements. Using the Elkoudia and Aboutachfin zones (**Figure 108**) at the city's entry as case studies, the following table outlines the PDAU's recommendations:

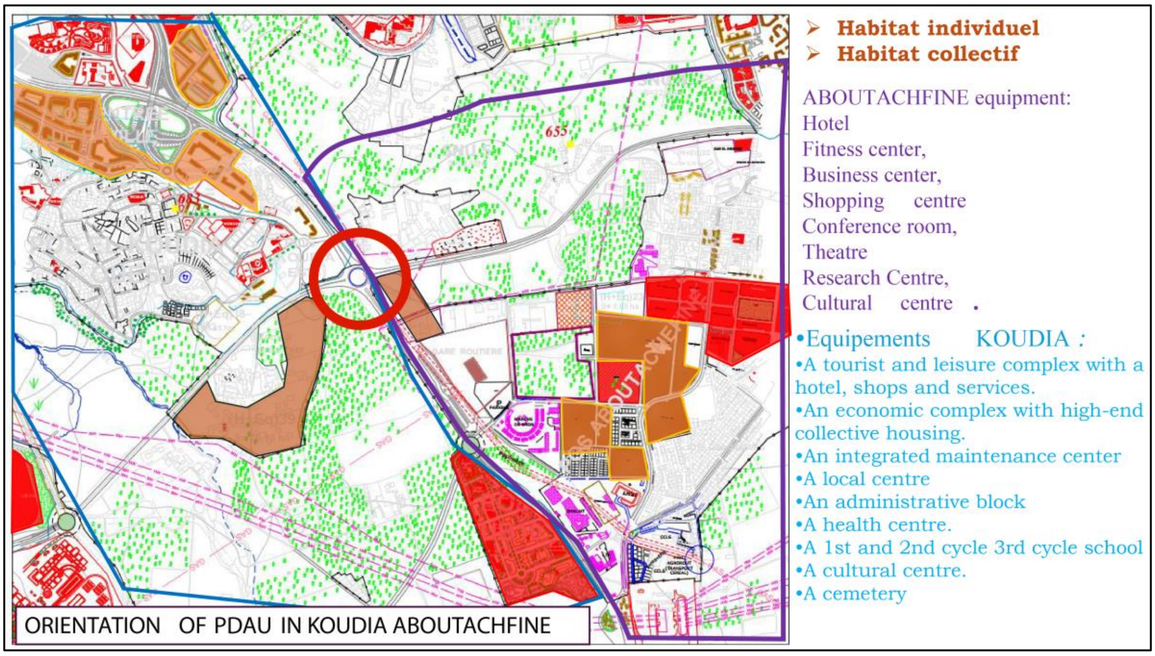


Figure 108 Orientations in Koudia and Aboutachfine

Source PDAU et (Author, 2025o)

(ii) (a) Greenhouse Gas Contributors and Essential Verticals;

Five key sectors contribute to greenhouse gas emissions: transportation, energy, industry, food production, and waste management. Furthermore, five additional critical areas, while not directly related to climate change, are essential for ensuring a sustainable human presence on Earth: biodiversity, health, pollution control, habitation, and water management.

(ii) (b) Renewable Energy, Waste Management, and Land Use;

To this end, it is necessary to harvest renewable energy and convert waste into a resource to power both industry and transportation. Optimizing land use, including restoring agricultural land to natural habitats, is also crucial. This will enhance biodiversity and facilitate carbon sequestration by vegetation. These principles should be applied systematically according to a comprehensive plan. However, the challenge remains of ensuring a consistent energy supply when renewable sources such as wind and solar power are unavailable.(Bjarke Ingels, 2024)

2.5. Potential sites of PDAU

These are sites from Pdau that are not planned for but have a potentiality and feasibility with the increase in the population **Figure 109**

Figure 109 potential sites PDAU

Source: PDAU et (Author, 2025s)

2.6. Site proposition

For project site proposition, I chose the zone Elkoudia with due to its iconic entrance to the city but with a lot of challenges related to the theme as compared to any other zone. The site is Infront of site 1 proposed by Pdau. **Figure 110**

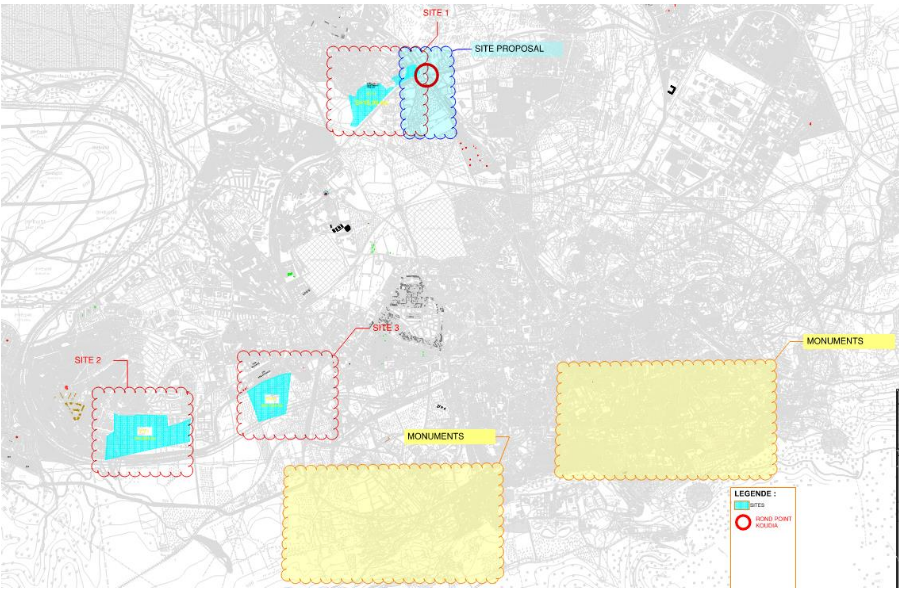


Figure 110 Site proposal.

Source: PDAU et (Author, 2025t)

2.7. Urban programming

This part delves into solution with a master plan proposition and simulations at urban scale to solve some of the problems at urban scale and later at an architectural scale. So here we start with site relationship recapture with the monuments and the heritage zones. **Figure 111**

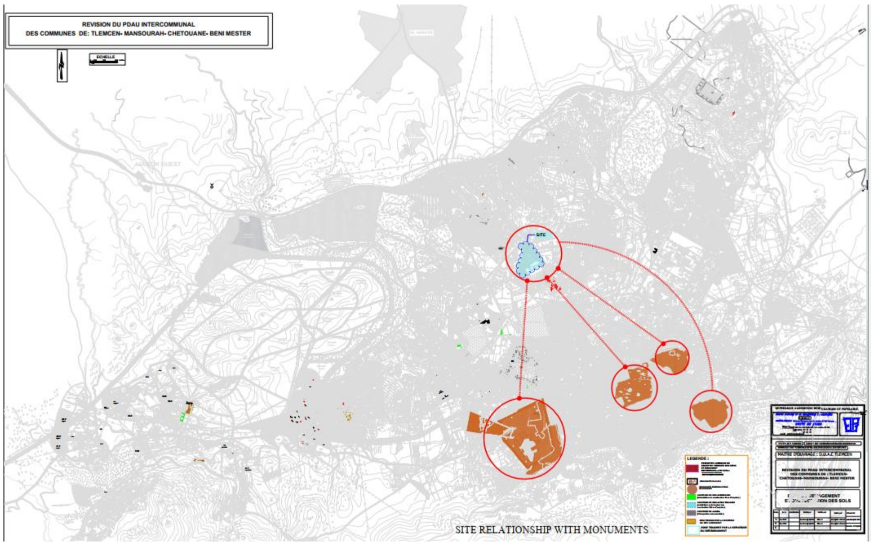


Figure 111 Site relationship with the monuments

Source PDAU et (Author, 2025a)

The existing function are monofunctional and since PDAU proposes monofunctional zoning. These projects become obsolete without this function; we shall presume of adaptive reuse projects that are multifunction to the context **(figure 112)**

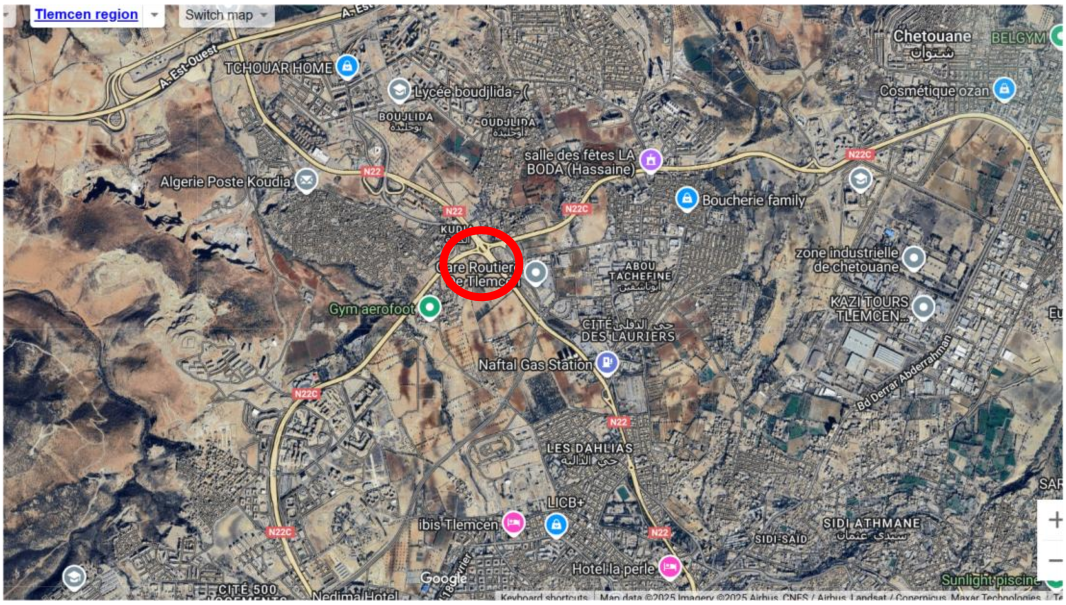


Figure 112 monofunctional equipment existing in koudia(in red is the site)

Source: (satellites pro image, 2025)

2.7.1. Summary of all the general study and challenges around the proposed site

Below is the site illustrating a 5-kilometre radius challenges around the proposed site spanning from the general entrance node Figure **113**

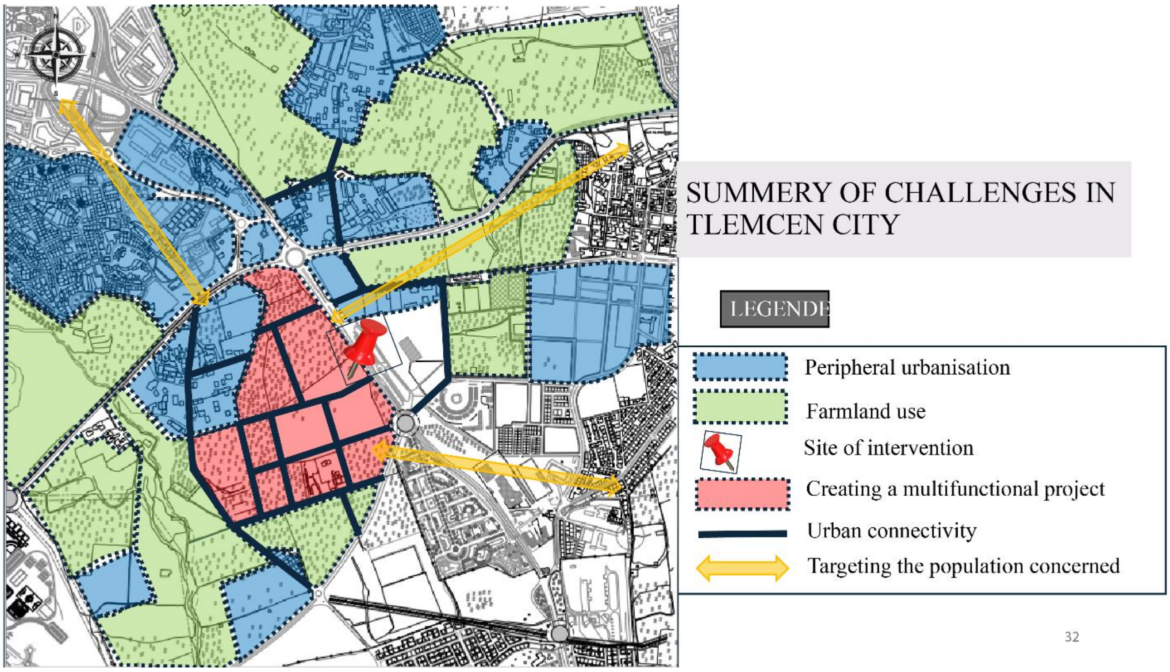


Figure 113 Summery of Tlemcen challenges

Source: PDAU et (Author, 2025n)

2.7.2. Proposed solutions and master plan

These are related to a holistic approach to sustainability and adaptive reuse: by combining these strategies, Tlemcen can mitigate environmental degradation, build resilience against climate change, and create a more sustainable future for its residents which will be elaborated by a master plan level.

Urban Examples and summery from AIA recommendations when dealing with city professions. The same examples will be used to obtain the basic architectural program as we proceed below. This **figure 114** below illustrates four examples from different context and site but with proper planning at an urban scale.

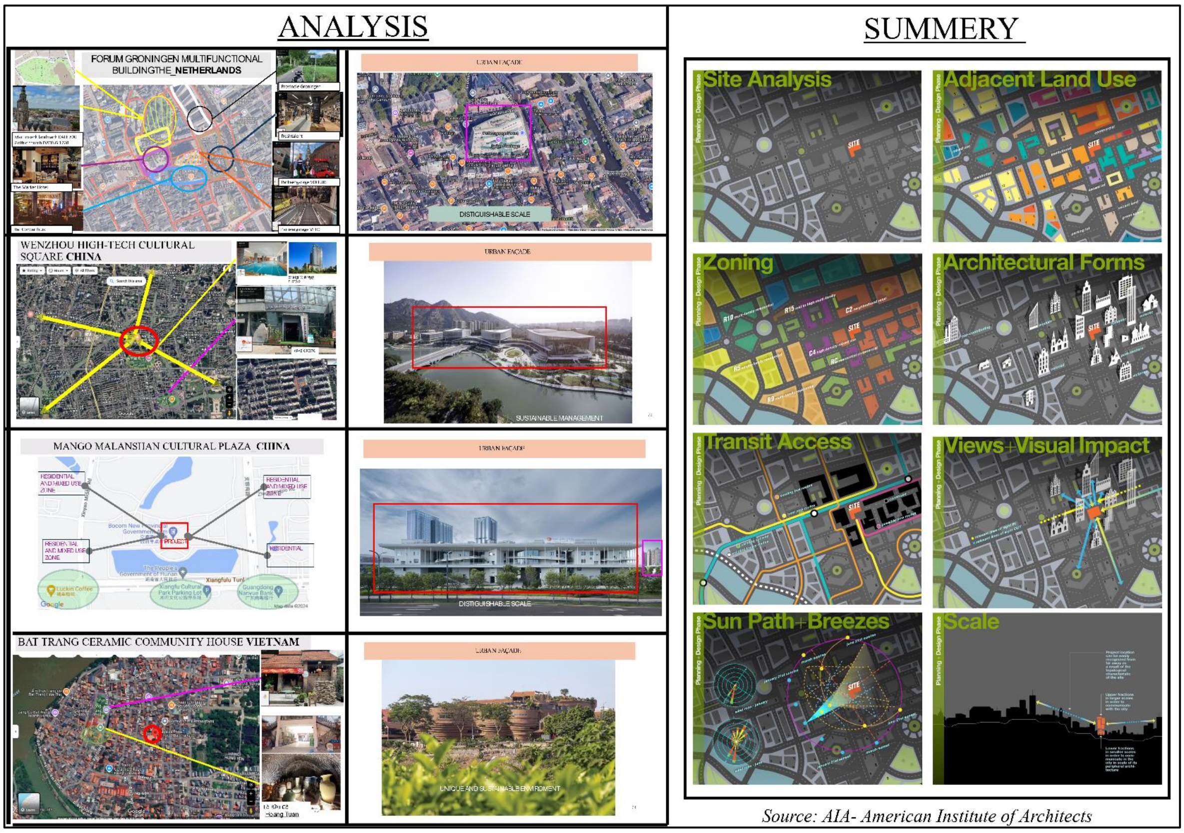


Figure 114 Urban Example Analysis

Source (Author, 2025g)

2.7.3. Intervention strategy

These priorities better connectivity and walkability with integrated public transport, reclamation of the lost green surfaces to reduce negative environmental impact creation of public places and activity nodes **Figure 115**. I will also prosome equipment from the recommendations of territorial management source PDAU

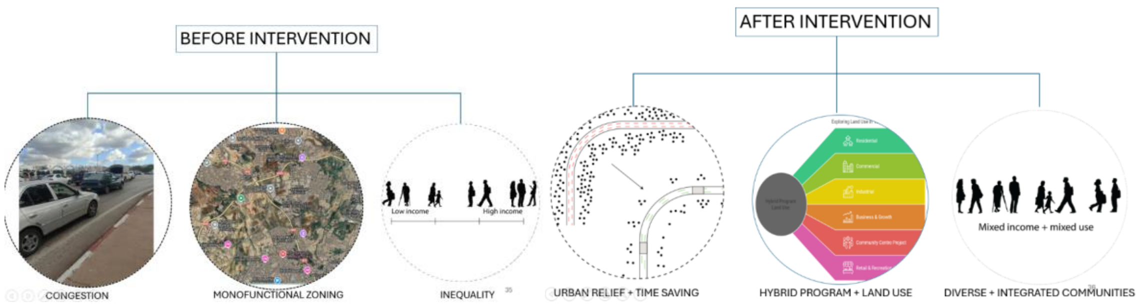


Figure 115 Intervention

Source: (Author, 2025j)

2.7.4. “Carte de master plan”

This urban plan schematic shows some of the city solutions **Figure 116**

Figure 116 Master plan Koudia.

Source satellite photo (Author, 2025n)

« …Une bonne connectivité ne s'arrête pas dans les voies intérieures du lotissement mais doit s'étendre au-delà pour assurer la continuité et l'harmonie entre toutes les entités de l'environnement bâti. Le réseau routier principal de la ville doit en outre jouer son rôle de liaison du lotissement avec son environnement… »(Djebbar Karima, 2021)

When You zoom in a bit on the site, I proposed some Equipment facilities including some of those proposed from PDAU. But since PDAU proposes monofunctional zoning, I propose multifunctional zoning and adaptive reuse projects. **Figure 117**

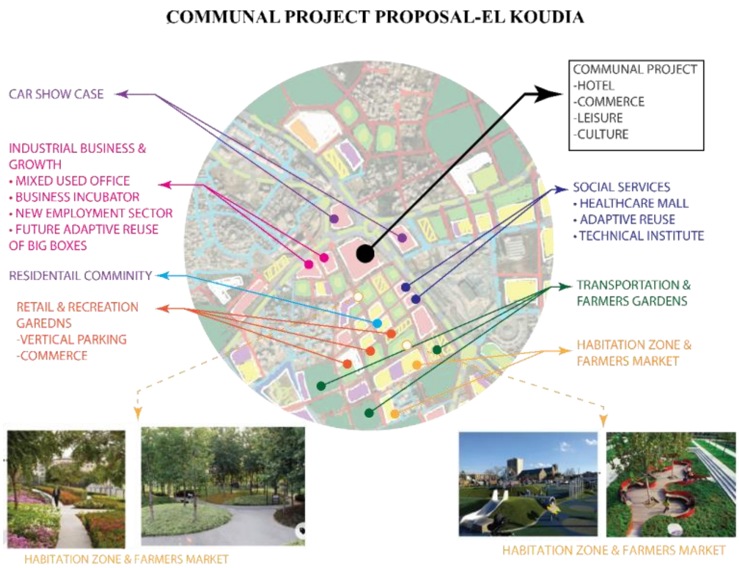


Figure 117 Project proposal

Source: (Author, 2025m)

2.7.5. Proposed functions on the site of choice

I proposed a community hub so as it will enable community members to access resources and services in a single location by clustering community facilities and integrating services. This will not only bring people together but as well create harmony for aging population, youth and the young children and integration of innovative technologies of at today and tomorrow. Below is schematic flow of the principle and secondary functions **Figure 118**

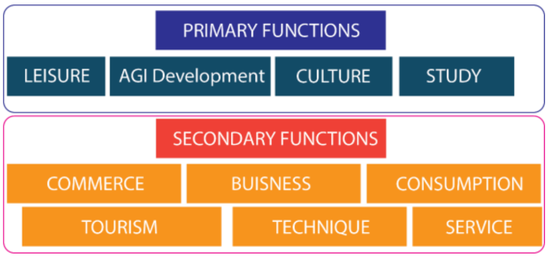


Figure 118 Functions that delve to meet the demands and needs of Tlemcen people

Source (Author, 2025i)

3.Conclusion

This urban study gives insight on the context and accurate thought on project integration so as it can adapt to that particular site chosen but not any other as its roots are deepened profoundly with aid of this study. The next chapter contains more details especially site analysis that will root the architectural project to the context sustainability and innovative functions space and program, lastly flexibility and adaptive today's usage and to tomorrow's needs—so as to render existing projects obsolete that don't fit in the environment nor context and flexible adaptability nor sustainability.

CHAPITRE 3:

PROGRAM, SITE ANALYSIS AND GENESE

1.Introduction:

In this chapter, we will explore the origin of the project, after the elaboration of the thematic examples in the urban study and the programming that allowed us to qualify the appropriate functions that combine an optimal response to the problem posed, we were able to clarify the main orientations on which our architectural solution will be based, the response to our specific problem.

2.Project Genese

Its organized into three key components: first the program, which outlines the various functions of the project and their corresponding spaces, drawing inspiration from selected thematic examples described in details; second, the analysis of the intervention site, which enables us to plan and position the project accurately on our land; and finally, the conceptualization and form, which will transform these elements into the language architectural philosophy and a functional three-dimensional space that fulfils the identified requirements.

2.1. Project description:

The proposed Community-Integrated project in the preceding chapter is now merges the core principles of a community hub—social interaction and leisure, inclusivity, resource-sharing, and adaptability—with the infrastructure and goals of AGI development Key Functions: Social and Technological Synergy: Acts as a shared space for fostering social cohesion, cultural exchange, and collaborative AGI research.

2.3. Program

Based on determining criteria and the issues to be met, the interest of programming is to identify the appropriate functions that form the basis of an optimal response to the problem posed in order to develop the appropriate theme for the site while ensuring its effectiveness and functionality.

2.3.1. Example analysis

Before detailing the program of a community hub. We first analysed the proceeding urban examples in architectural details since they as well respond to my theme to arrive at a core program sum up below in **figure 119**

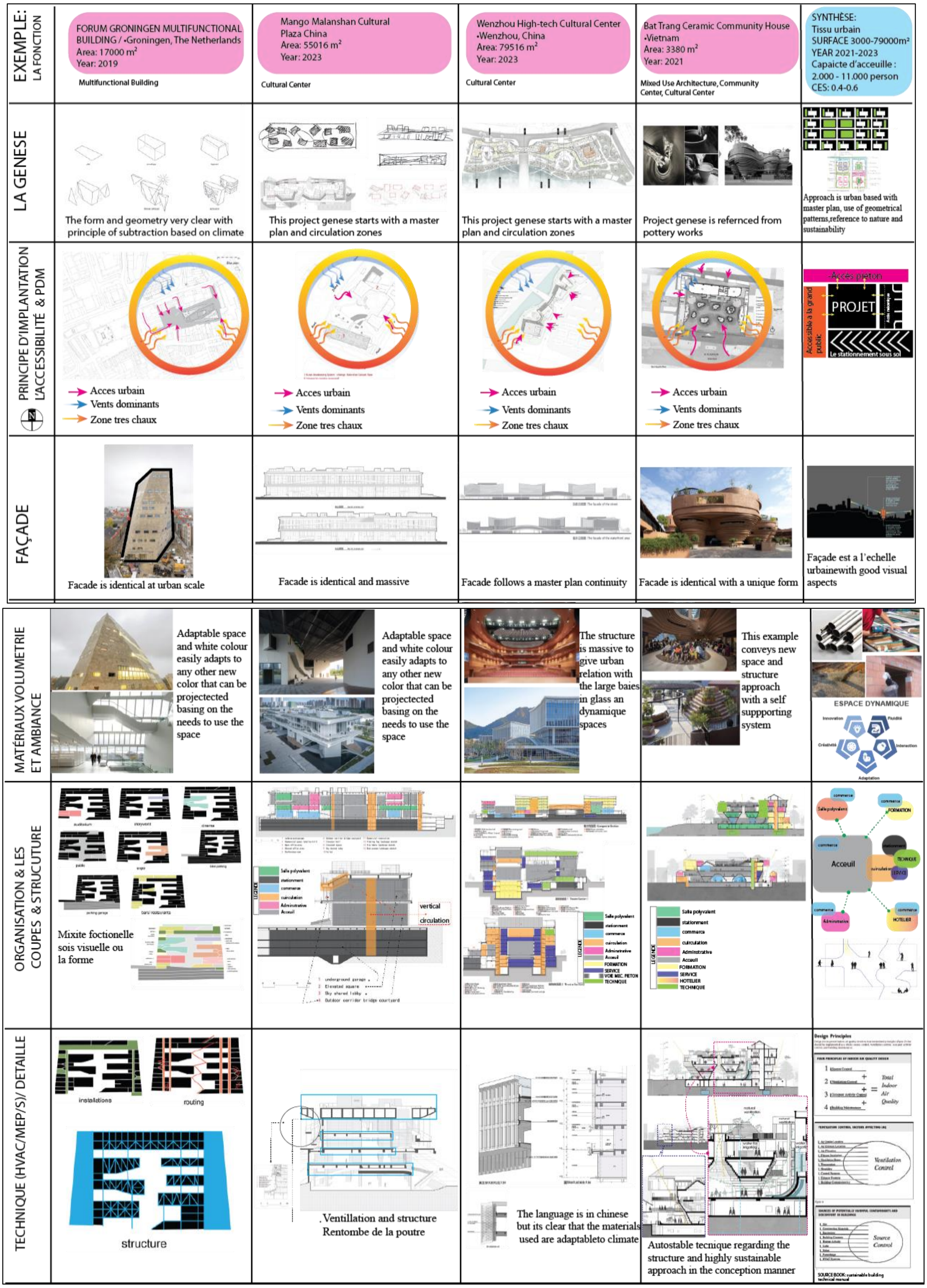


Figure 119: urban- architectural Example analysis

Source (Author, 2025m)

2.3.2 User response.

With illustration used in **table 20,** that is to say that, in order to be successful in our programming, we need to answer the following questions

(i) For whom? "Usages/utilisations"

This leads us to define the users of the structure as well as their necessary needs, several categories are targeted by our project including: residents, students, high school students, tourists and different age groups. **"Les usages**:" defining the users of the structure as well as their needs is more than necessary, several categories are targeted: residents, students, pupils, film lovers, tourists and different age groups. **"Les utilisations**:" those who use the structure to serve users: managers, administrators, technicians, traders, trainers.

(ii) Why? Heritage service and innovation through sustainability:

To enhance the rich heritage, to strengthen the tourist and cultural attractiveness of the site. Strengthen the neighbourhood's links with its environment. Taking advantage of the city's port potential

(iii) How? Program and urban sequoia

Based on our intervention strategy master plan we can identify the previous urban functional layout

In addition to the user response, in figure 118, the **circulation analysis table** in the **annex** shows different user groups circulating from one level to another

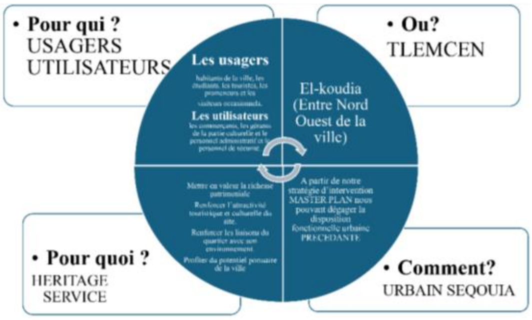
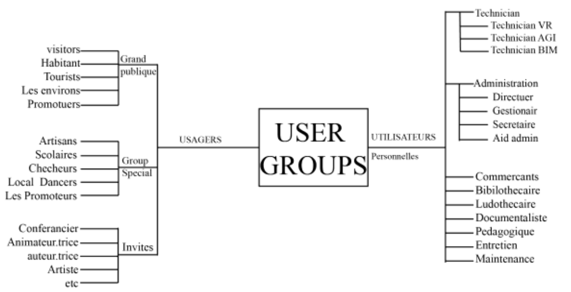
 **Figure 120** Architectural Programming Source Author	 **Figure 121** User group diagram Source (Author, 2025u)

Table 20: user response

2.4. Basic program:

According to the thematic research, the bubble diagrams below (**Figure122)** summarise the general programme

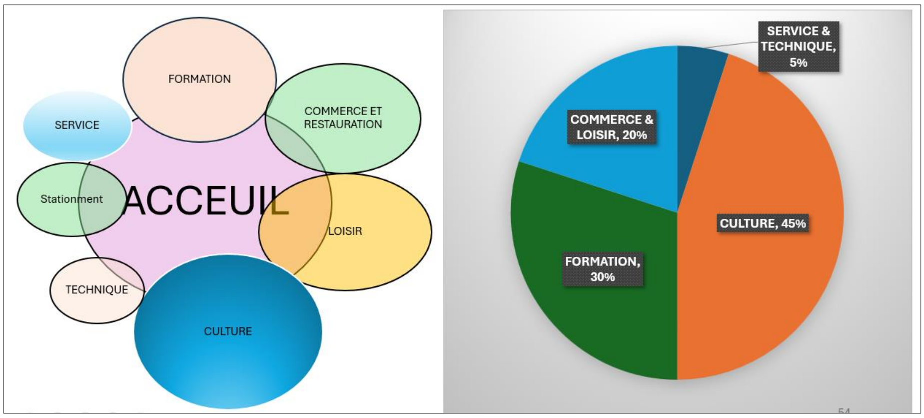


Figure 122 Basic Programming

Source Author

2.5. Quantitative et qualitative program:

This is summed up in the table below illustrating spaces and sub spaces with a capacity they can be held in that space: The core difference of this program (**table 21**) is that its Yanique bringing about spaces being multifunctional. Thus, spaces can evolve to newer functions basing on the need of the users. With minimum of total capacity of 3000 people in a day.

Fonction	Espace	Sous Espace	S
Accueil	Hall Accueil Capacite: 150	Hall d'accueil Réception Exposition Temporaire	200 - 100
Gestion	Administration Capacite : 20	Secrétaire Directeur Salle de réunions Bureau Réception Salle de documentation Sanitaires Local du gardien	20 25 25 20 - 25 6 20
JEUX Détente Sport et loisir	Cinéma Capacite : 400 – 600 person	Sas d'entrée Salle de cinéma Bureau Salle de control StudioVFX et CGI	100 1200 25 20 300
	Gym Capacite: 200 people	Salle de gym Accompagnent Bureau Réception Vestiaries	500 25 - 25
	JEUX COLLECTIF	Jeux PSN /PC Billiard et Jeux cartes	200 200

	Capacite :400 – 500 persons	Squash et ping Pong + Vestiaires Jeux Enfants Autre jeux (laser Games.	400 200 300
Formation et la Culturelle	Ateliers Capacite: 200 persons	Atelier de dessin peinture sculpture poterie couture photographie	500
	Salle polyvalent Capacite :300 – 400 persons	<u>Manifestations DIVERS :</u> Exposition et Commerce Temporaire projection Networking Salle sur demande Réunion et séminaires Enseignent Soirée dansante Rencontre personne âgée et jeunesse	200
		<u>Accompagnement :</u> Toilettes Loge Salon Bureau	 6 20 50 25
	Salle de Prière Capacite :25 Person	Hall Salle H /F Ablutions	10 50 10
	Formation AGI et ASI Capacite :200 Person	Atelier Dynamique Hall Stockage Sanitaire Salle de recherche Zone de simulation Laboratoire AGI Locaux serveurs	100 50 20 6 40 50 50 20
	Mediatheque Capacite: 300 persons	<u>Polyvalent</u> Salle multimédia Séminaires Conférence Projections Réunion	100
		<u>Polyvalent</u> Bureau d'animateur | Bureau gestion Zone de détente	100
		<u>Polyvalent</u> Formation et recherche | Bibliothèque Rayonnage adulte | Rayonnage jeune	100
		<u>Accompagnement</u> Salle audiovisuelle Sanitaires	 80 6
	Cite de Formation Enfants Capacité :800	<u>*Enfants 2-7 ans</u> Je me découvre | Je sais faire |Je me repère J'expérimente	900
		<u>*Enfants 7-12 ans</u> Le studio tv | Le jardin | Le corps |Les jeux d'eau Communiqué | L'usine	900
Commerce	Bureau commercial Capacite :200 – 300 persons	Cabine de bureau (Espace de conférence, réception, coffee room, Cuisine, stockage, sales départements, bureau	200 a 300
	Boutique(500+person)	Souk	800
Hébergement	Suite hotelier (100 person)	Chambre standard Salon Restaurant Lingerie Bureau	25-50 50 150 50 100
C on so m	Cafétéria	Cuisine	50

	Capacite :400 – 500 Person	Salle de consommation Dépôt	150 25
	Restauration Plus, Atelier	Salle de consommation Cuisine Dépôt Atelier de restauration Toilettes	150 25 25 50 6
Service	Toilette public	Toilette H/F	200
	Dépôt	Dépôt Bibliothèque + musée	25
Technique	Locaux techniques	Local de chaufferie Bâche à eau Zone des serveurs Atelier d’entretien BIM Local d’électricité Local climatisation Local entretien et poubelle Local traitement de l’air et d’eau Group électrogène	50 50 100 100 20 20 50 50 50
Stationnement	Parking	Station permanent -1000 + Atelier Station temporaire (20 voitures) Aire de jeux comprise dans l’espace vert	-

Table 21 Scalable Program

Source : Author

2.4. Site analysis:

From the urban study, this part will elaborate site analysis and zoning in details with reference from the master plan, below is the site analysis of El-Koudia.

2.4.1. Description of the site with refence to figure 123 below:

Image 1: shows the form of modelled 2D site with its environment as described already in the masterplan. The site dimension is 3.4 hectares.

Image 2: shows the sections through the site, where its elevated un evenly with a range of 1metre to 2 meters from the main roads (Evitement Tlemcen) except the projected roads that are on the same level as the site.

Image 3 shows the climate analysis, accessibility plus some propositions, visual perceptions (negative and positive views) and equipment’s plus the infrastructure around the site detailed in image 4 to 7

2.4.2. Description of the site summery with refence to figure 124 below:

Image in 2D illustrates a generalised summery of the site with various propositions of access and building zones and setbacks in relationship to the environment and the context.

Image in 3D shows a modelled version from the satellite photo illustrating the environment with its proposed access in relation the “vecu” of the site.

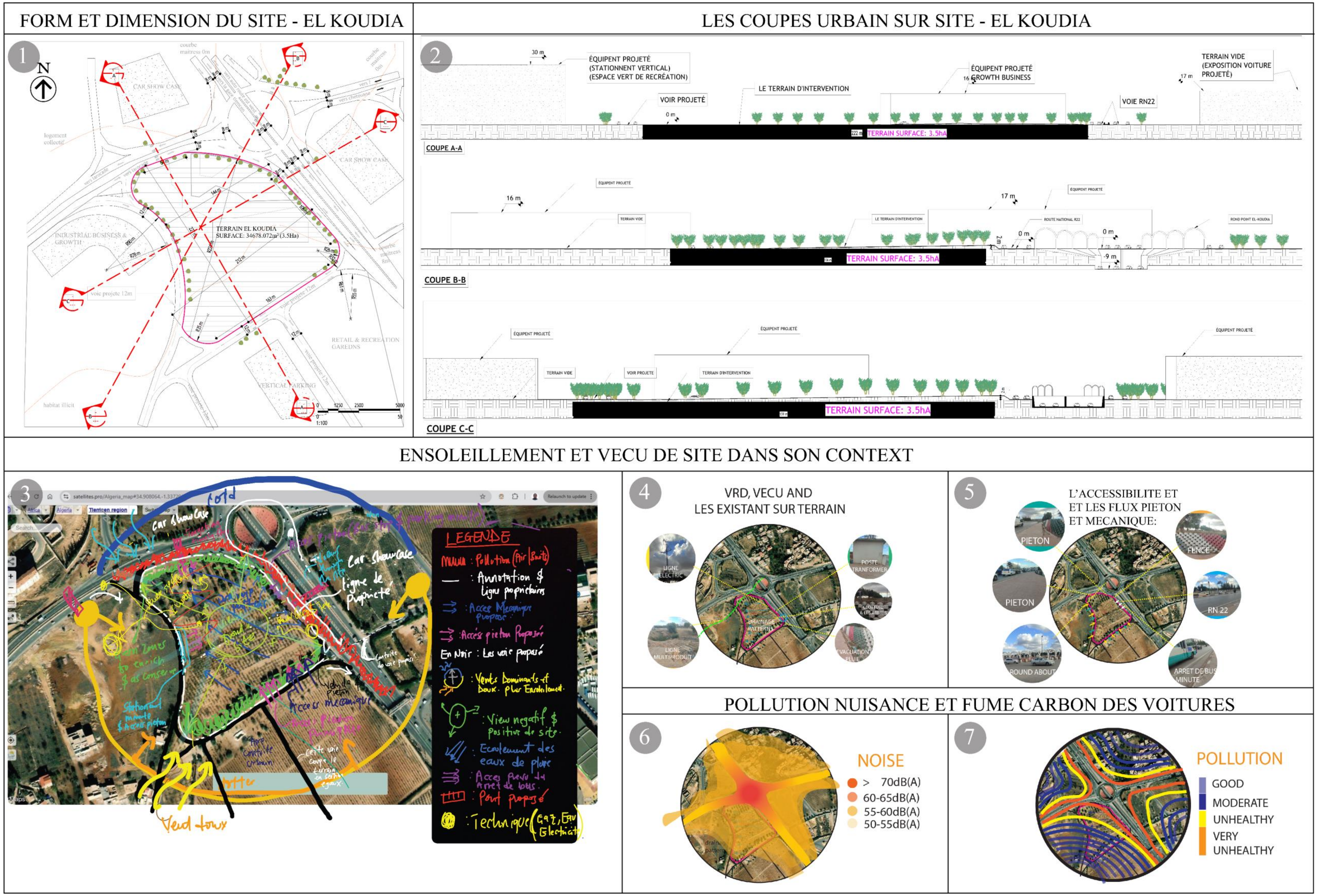
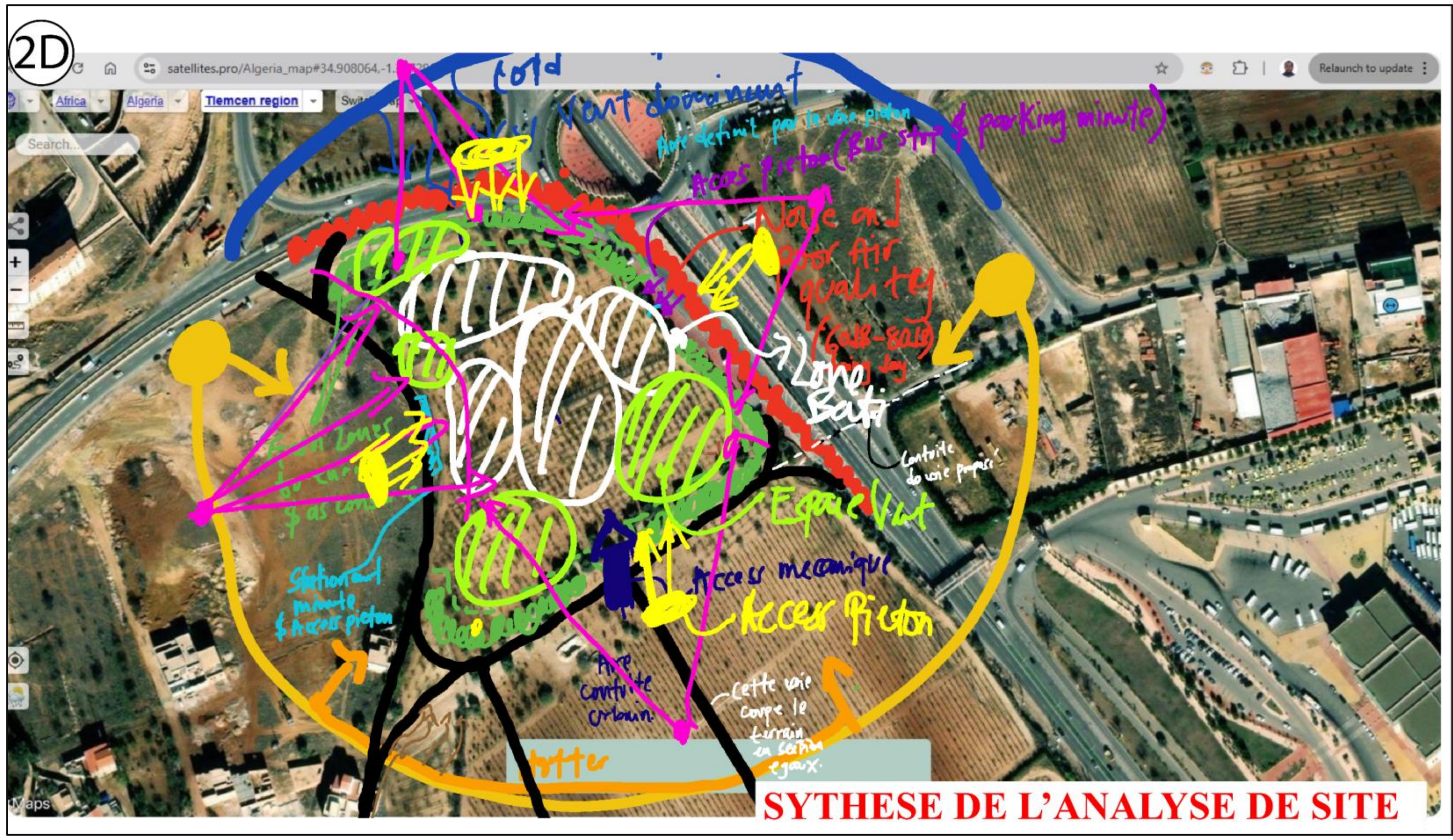


Figure 123: Site Analysis

Source (Author, 2025b)



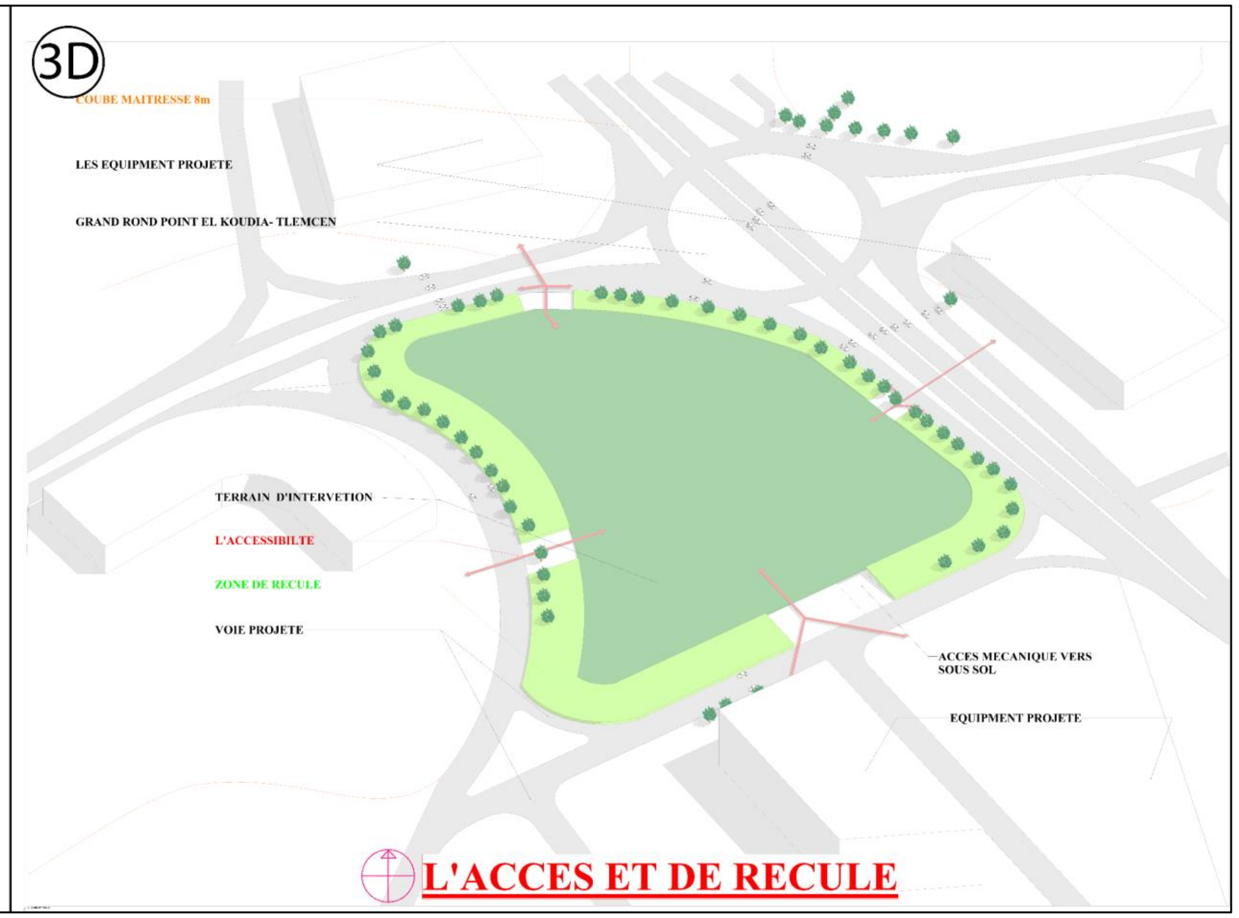


Figure 124: Site zoning

source (Author, 2025q)

2.5. Project Genese

This is elaborated into 3 phases: the first phase is decision taking based from the site analysis plus site zoning and lastly the program, the second phase is the simulation model in air, energy, sun path and flow patterns in and out base on the prior form obtained , and the last phase is the zoning where this model is given functionality in relation the site for example zoning of public and private spaces, sitting zones from the simulation, noisy spaces. That is to say its categorical space zoning in relation to the exterior environment. All these phases are in relation to adaptive reuse index, environmental impact plus sustainability in reference to the cultural heritage and contextual landscape plus the site conditions.

2.5.1. Ideation phase 1: "prise de decision"

This the decision taken from the site analysis and the prior zoning from of the site, this is all summarised in the notes takes on prior sketches below in 2d on satellite images and simulated in 3d in the photo proceeding it with a generalised summery of philosophical reasoning of the feasibility.

(i) . Description with reference from Figure 125

Image 1 illustrates setbacks varying from 10 to 20 meters with reference from flex 4.0 and the site analysis with preservation of trees and displacement of others in the building zone.

Image 2 shows the proposed initial form with reference from heritage forms aligned on the access proposed earlier on. With the various principles, there was need to reduce the mass if the block and properly align the elements on the access as we as the medina of Tlemcen. This is done with geometrical section in image 3. And a centralised alignment of the children blocks (2 and 3) in image 4.

Since the communal spaces are compose of patio and different court yards the serves as well as a link of connectivity of all the buildings. I used this principle to sculpture block 2 and 3 and linked them to the mother block 1 with the aid of geometry. Image 6 shows the parti pris of making basement level since the zone is an ex-agriculture.

This is simulated in 3D as seen in **figure 126** with a small description for referencing from that of 2D

(ii) Description with refence from figure 127

Image 1 shows the feasibility of the form min relation to the site analysis and site zoning given by geometrical forms. And with image 2 show scale of the building and the climate opportunity and challenges plus the setback and building impact to on the site

DESCIPTION 2D- LES PETIT SKETCH DE L'IDEATION SUR PHOTO SATELITE

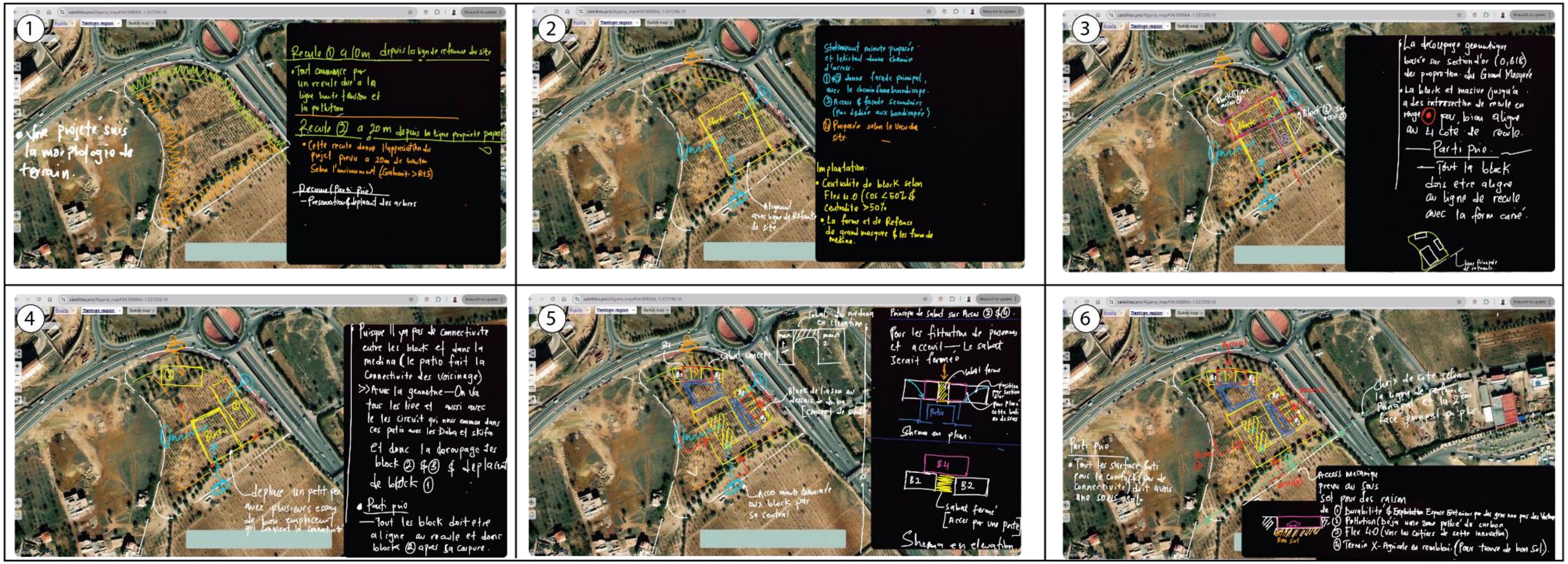


Figure 125 : Genese in 2d

Source: (Author, 2025r)

DESCIPTION 3D- OBTAINING FORM PAR LA PRISE DE DECISION

Figure 126 : Genese in 3D

Source: (Author, 2025s)

RESUME DE FAISABILITE DE LA FORM SUR LE CONTEXT DE SITE

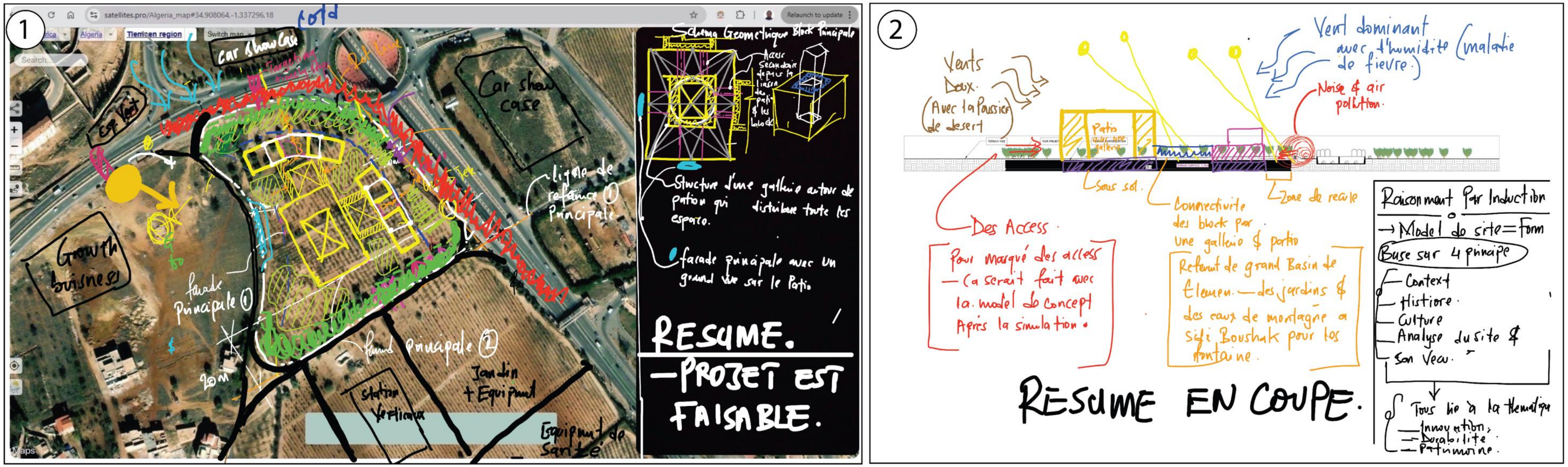


Figure 127 feasibility summery

Source: (Author, 2025w)

2.5.2. Ideation Phase 2 "model du simulation"

This phase is principled on a concept model by **simulations,** With the aid of BIM, we simulated air flow, energy plus heating effect and sun path potentials with Goal is to obtain logical reasoning of sustainable structure and form and well as the details to be used in the Schematics. From the climate study in the site analysis, we made a simulation (simulation video (Author, 2025y)) of mass proposed and below is its description.

(i). Description with reference of Figure 128 blow.

From pressure field in image 1 we obtain the pressure surface in image 2 with will help in determining the type of window and material strength to be analysed.

Image 4 shows the velocity field with its turbulence in image 5 and its impact on the façade. This helps in determining the micro climate to displace the tress on the site and technical ducts placement.

Images 7 and 8 show the velocity vectors and the streamlines. With refence of the **legend** you can determine different zones like sitting for example.

Images 3 show the sun path simulation bring lighting potential zones on the site to determine green zones and light flow in the building

Image 6 and show south and north faced respectively with preheated zones thermal conductivity surface of the mass potential **solar energy**

The description within images 10 to 12 illustrate decision taken as due to this computation simulation

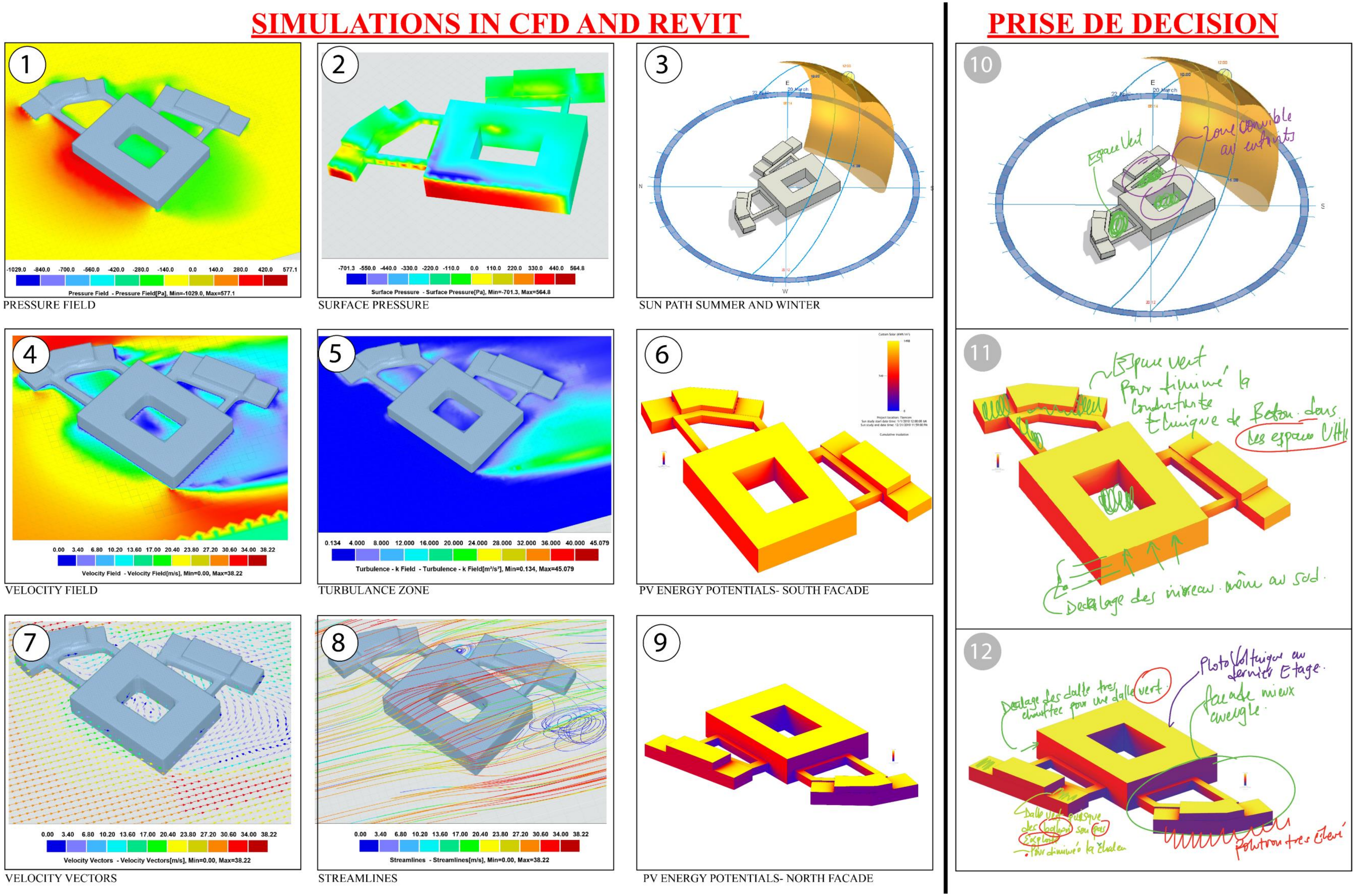


Figure 128: Simulations in BIM

Source (Author, 2025q)

2.5.3. Ideation Phase 3: "zoning"

This is the last step of the ideation phases an its goal is to distribute the functions both interior and exterior proposition this done with a principle of Form follows function (after simulation)

(i) . Description with reference from figure 129 below.

With different accesses in image 1, we zoned numerical games in the basement and the parking as seen in image 2 with distributional halls on the ground floor in image 3.

Zones with much noise like consumption (café and restaurant) and more game areas (including sports or gym) are places close to main roads where there is much noise based on site model. (image 3 and 4). The main functions that are calm like children study exhibition hall are paced in the primary block connected with a central gallery as communal space.

Image 5 contains transition space of offices towards a clam intimate zone of a hotel in image 6. Image 7 resumes all the zones plus the vertical circulations. The surface of bult up zone to excavate is approximately 30 percent to the total land.

(ii). Description with reference from figure 130 below.

The goal of images 1 to 3 is to relate interior and exterior spaces that's is to say that exterior zoning. The description in image shows the relationship between the neighbourhood and the exterior communal spaces of the building envelope with a reasoning related to sustainability and flex 4.0 of adaptive reuse.

Section 6 to 8 illustrate human reference of visual perception and site conditions and climate. With a goal to take on decisions relate to space transition and it form plus materials to be used during the schematic design phase

ZONING MODEL - FORM FOLLOWS FUNCTION(AFTER SIMULATION)

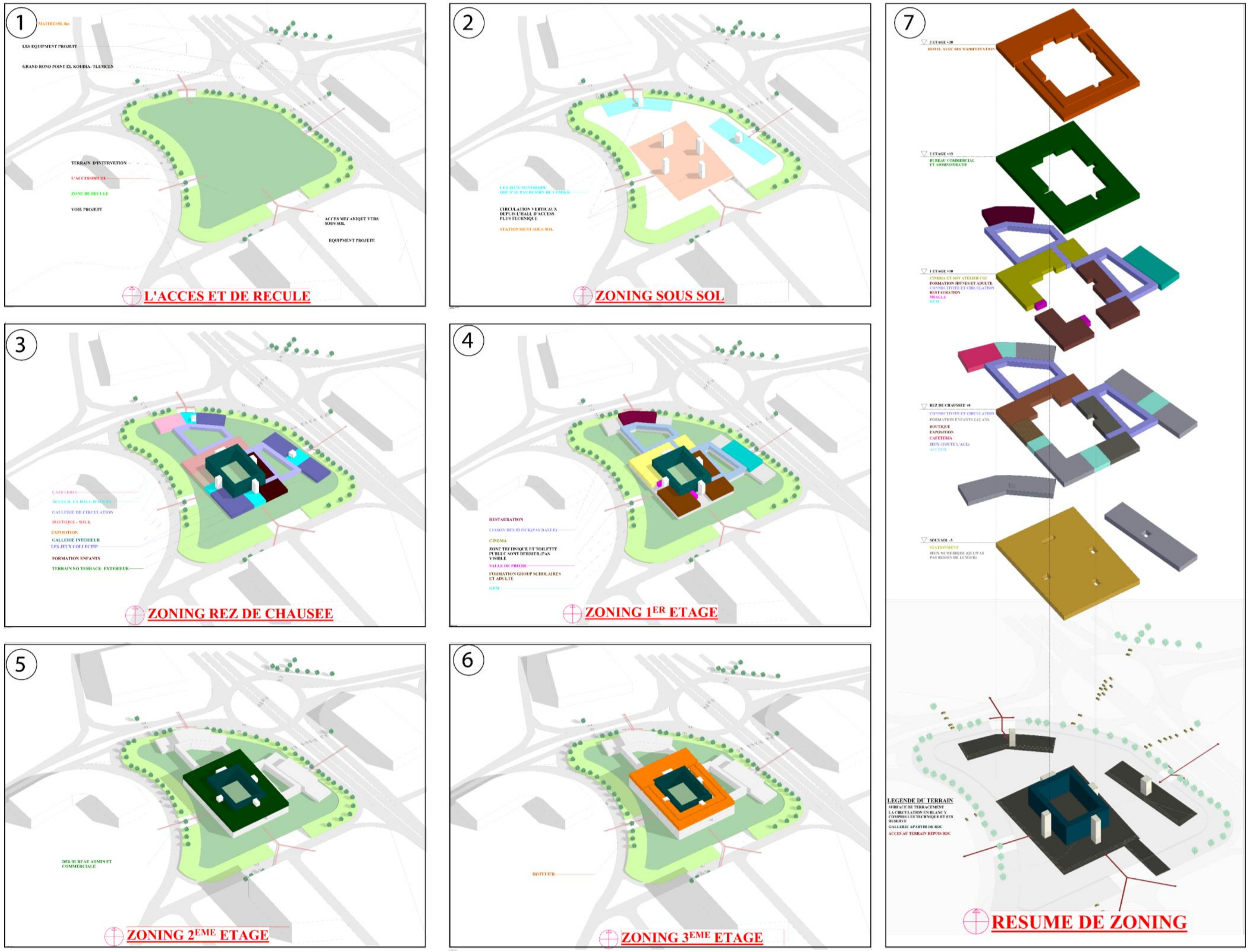


Figure 129 Zoning Model

Source: (Author, 2025p)

ZONING MODEL PLAN DE MASSE - PARTIE PRIS

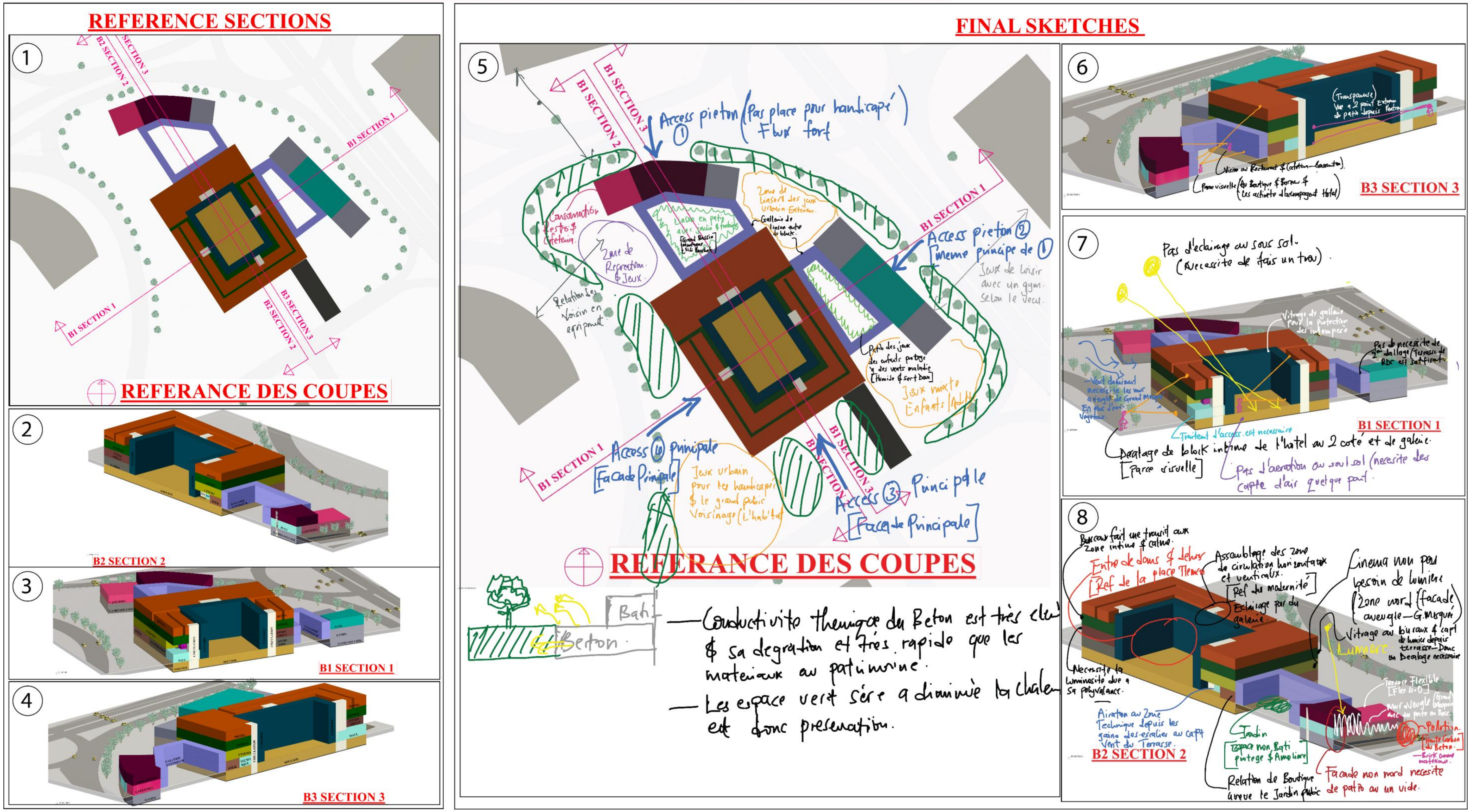


Figure 130 masse plan zoning

Source (Author, 2025v)

3.Conclusion

With this feasibility test of the program and integration to the contextual landscape of Tlemcen city in El koudia site. This part drives us to the schematic model in the next chapter that illustrates all details and interior / exteriors spaces at human scale with 3-dimension views.

CHAPTER 4: SCHEMATIC DESIGN (PLANS, INSTALLATIONS (C.E.S) AND INNOVATIVE MODEL).

1. Introduction

In addition, its aim is to integrate and as well assess of conformity of the building envelope with sustainable index, adaptive reuse with **flex 4.0** tool, innovative technologies and heritage inspiration.

This will be done through sketches that is to say: Schema HQE, lighting, energy, climate response an impact, circulation analysis and many others related to principles of **heritage** sustainability and flex 4.0

2.Shematic design.

This chapter gives a graphical summery of the schematic details in graphical dossier that is to say: (i)Architectural and site engineering works, (ii)infra structure and civil works and lastly (iii) technical works and installations (Corps D'etat Secondaires)

2.1. Architectural schematics

The general overview of the project implantation on the site is elaborated on the mass plan and different general functioning of plans and circulations in and out of the building

2.1.1. Mass plan

The **figure131** below shows urban relationship and Connectivity, all the exterior spaces are dynamic in relation to the blocks: that is to say urban games, sitting and public gardens. In addition, the mass plan elaborates the traffic and parking, service and stuff circulation, pedestrian and public access (including handicaps) the fire emergence access. and its connectivity

2.1.2. Plans

The section of the plans is based on **figure 132-133** and sections in **figure 134** with a generalised summery in figure **135**. With reference from floor plans in **figure132** and **figure 133**; Image 1 to 6 shows generalized functions for example in image 1, it's the ground floor zoning in relationship with the exterior spaces and image 2 shows basement floor dedicated for parking with car workshops inclusive, in addition to its general technical zones and plus vertical circulation: all summed up in the legend and public floors are generally ground and first floor (image 3). Then offices in image 4 make a transition to intimate space of visitors: this overview of the functions and vertical circulation is seen in the section in **figure 134**

The last **figure 135** sums up all the functions in an elevated overview showing that all spaces are adaptive to new an evolving program.

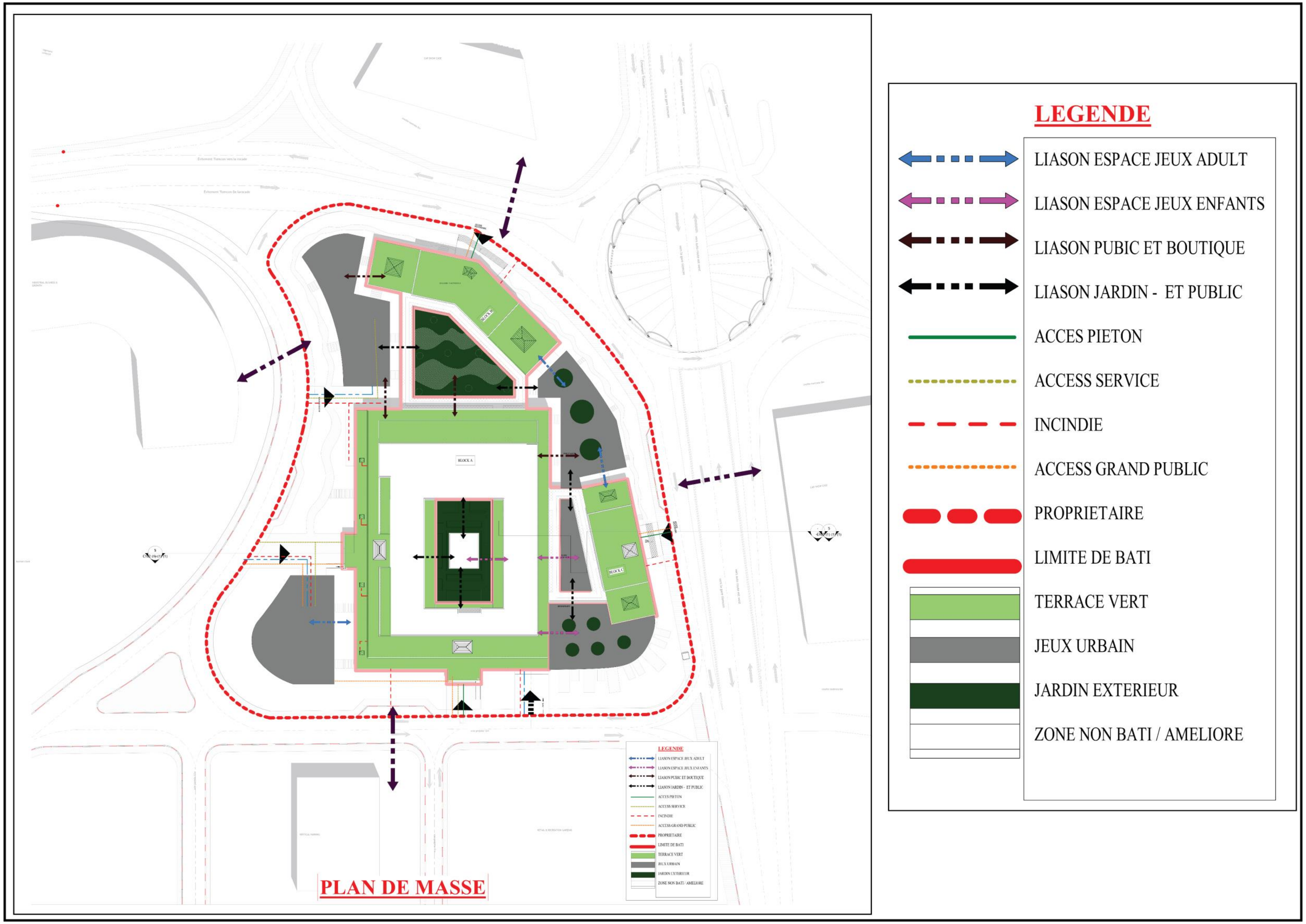


Figure 131 Mass plan

Source:(Author, 2025r)

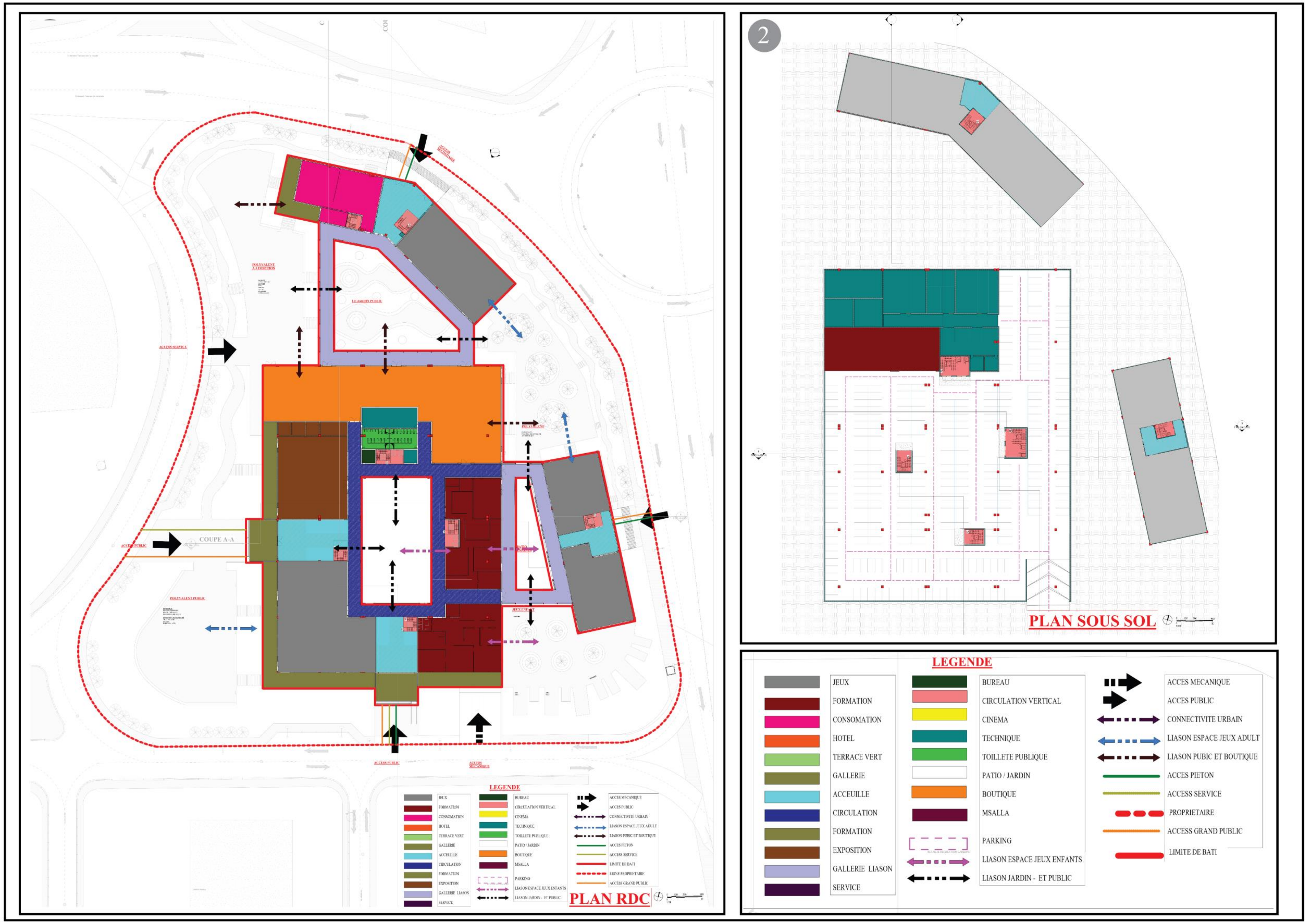


Figure 132: Zoning plans

Source:(Author, 2025l)

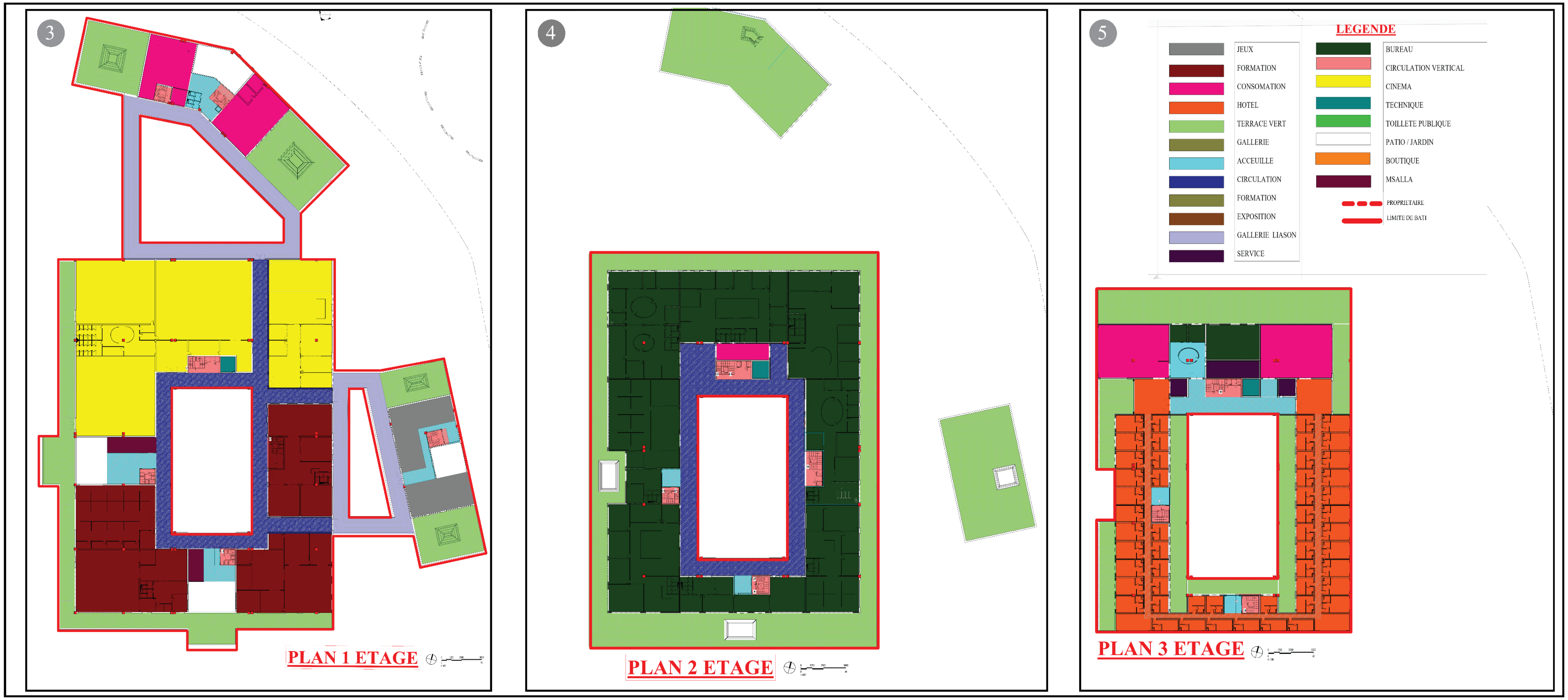


Figure 133: Zoning plans

Source: (Author, 2025l)

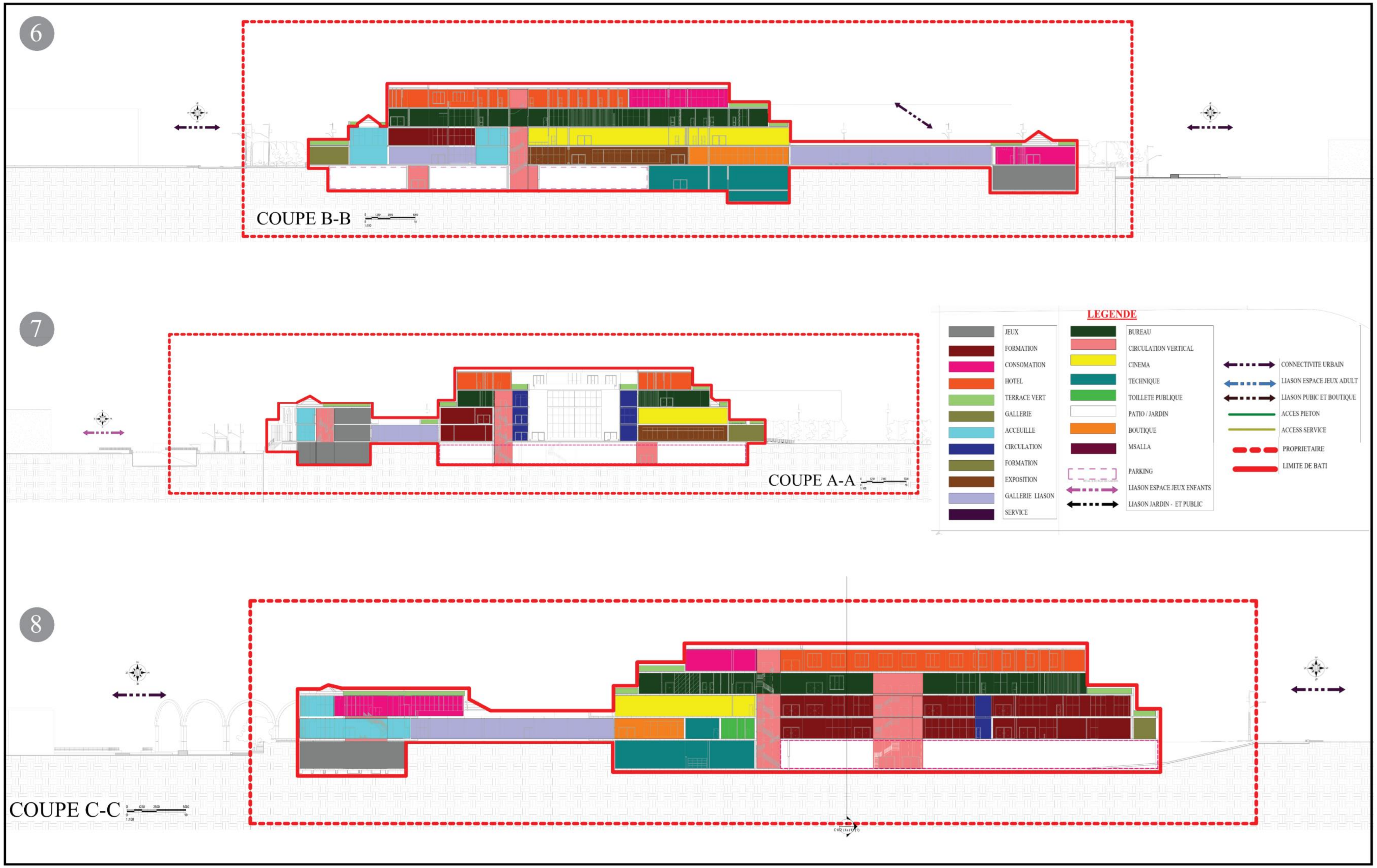


Figure 134 Zoning sections

Source:(Author, 2025l)

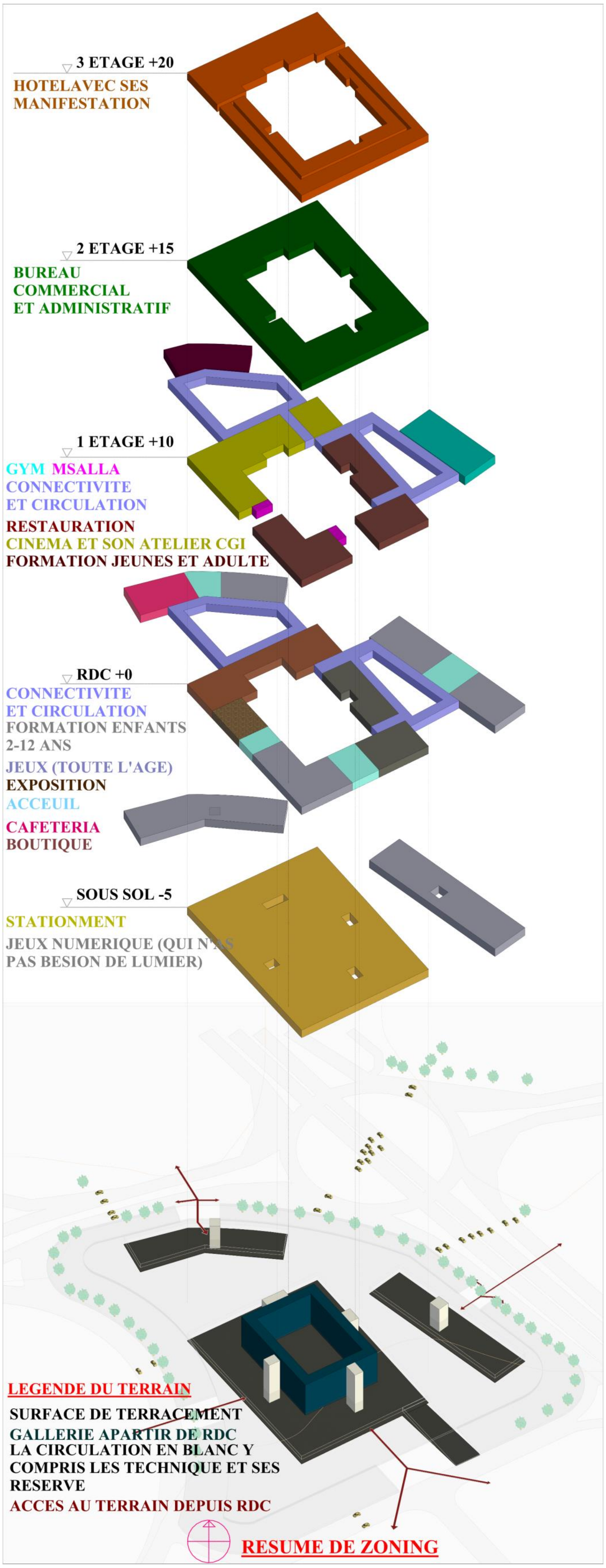


Figure 135: Summarised Zoning of the plans;
All plans are flexible to newer functions

Source(Author, 2025t)

2.2: Project Sustainability, Flex 4.0 And Innovation with Bim Sensors

These sketch commentaries on some of the plans illustrate these bench marks.

2.2.1 Description with refence from figure 136 below;

Image, I show **expandible zones** with reference from the adaptive index of flex 4.0 in the **annex**, and image 2 is a section showing sustainability of air flow, solar energy storage

Image 2 illustrates sustainably graphical sketches of the building that is to say: Stormwater collection from green roofs that are in visual site and physical access for servicing. solar collector system for hot water and energy reduction

In addition: (i)**Ventilation and air quality:** Narrow floors platers increase natural daylight while cross ventilation reduces colling loads and energy usage, Louvered vents and large roof overhangs provide maximum shade reducing heat gain an increasing thermal comfort. Exterior courtyard combined with opposite side high and low windows provides good cross ventilation and natural light, Insulation at all perimeter walls reduces infiltration and thermal bridging in combination with the vent skin cement boar siding system

(ii)Maximizing daylight to lower operation costs: Light coloured roof materials with sharing and insulation. General light from the courtyard towards the basement level. Solar collection on the highest level, Panels also provide roof shade to reduce heat gain and increase roof life: High ceiling creates chimney effect for cooling in summer and winter months,

(iii)Integration of technologies

The digital twin model (Revit model plus integrated sensor systems in the building) helps in monitoring the building performance with its statistical data with integrate sensors in the in the building

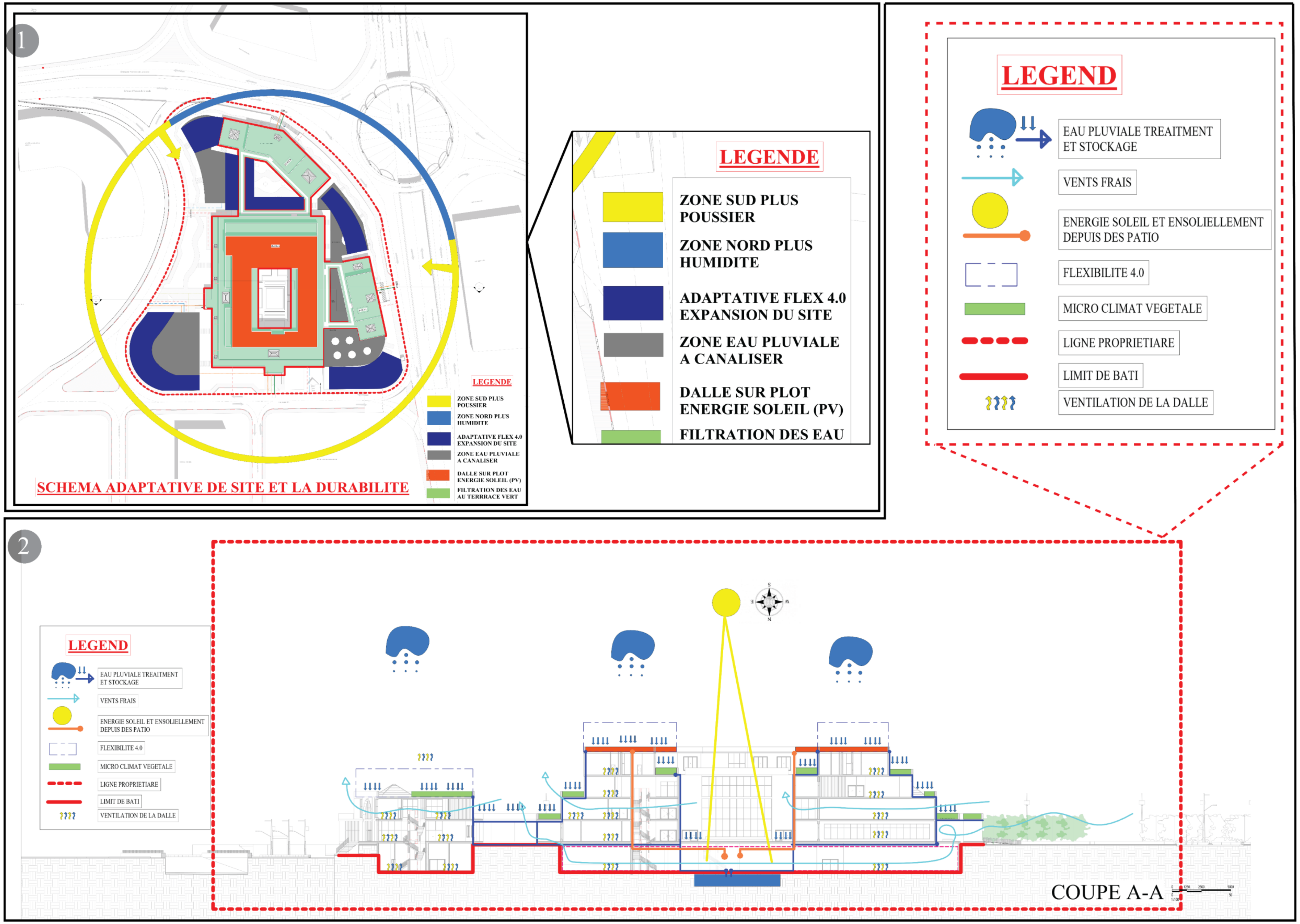


Figure 136 sustainability sketches.

Source: (Author, 2025u)

2.3: Architectural style (Facades)

This is generally Façade style with reference from heritage, sustainability and **flex 4.0** index of adaptive reuse. The descriptions made are relate to the material choice, colour and texture, access identity or ornamentation and lastly la parti pris of opening and other elements within the façade.

2..3.1. Description of the facade style with reference from Figure 137 and 138

From Tlemcen heritage, we got inspired ad reinterpretation of some elements like arc and use of geometry faience (zellige de Tlemcen) and **moucharabieh** wall screens. Seen in all images 1 to 4. The façade is neutral in colour white and a smooth texture in reference of heritage materials, the wall made in pisé is used for sustainable reasons described in images.

Image 1 shows the principal façade marked with a dynamic element in brick texture the breaks the linear geometry for visual perceptions to the general public. Its partially modern façade with intimate zone having arc faience combined with moucharabieh. the Courtyard of in image 4 is a combination of modernity as Islamic era as well with access in arcs and visual contrast of the public and intimate zone made opening distinctions that's arcs for intimacy zone and glass panels for public

The secondary access in image 2 and 3 have same faience and similar arcs reference from Tlemcen grand mosque courtyard that is to say secondary access of to the building have heritage elements of polylobed arcs mixed with plain centre arcs as a sign of entrance with similar decoration origine of Tlemcen Islamic culture. (zellige de Tlemcen). In addition, façade in image 2 is a mixture of modernity and Islamic style as to façade in image 3 being completely Islamic style with blind wall.

2.4Facade Sustainability and discours. (figure138 and 140)

Description of Sustainability and flex 4.0 in relation to figure138: The choice of materials in the courtyard like pisé in image 1 is related to thermal conductivity and glass panels for flexibility as the primary functions. For the secondary facades that is to say image 2, using compressed brick and mineral plaster as material gives longevity and flexible materials for protection from climate and withering Integration of Bim sensors within the facades serves as detectors of climate change and thermal regulation. They analyse the life span cycle of these materials in relation to the environment.

This is summed up with renders in figure 139 and commentaries in figure 140.

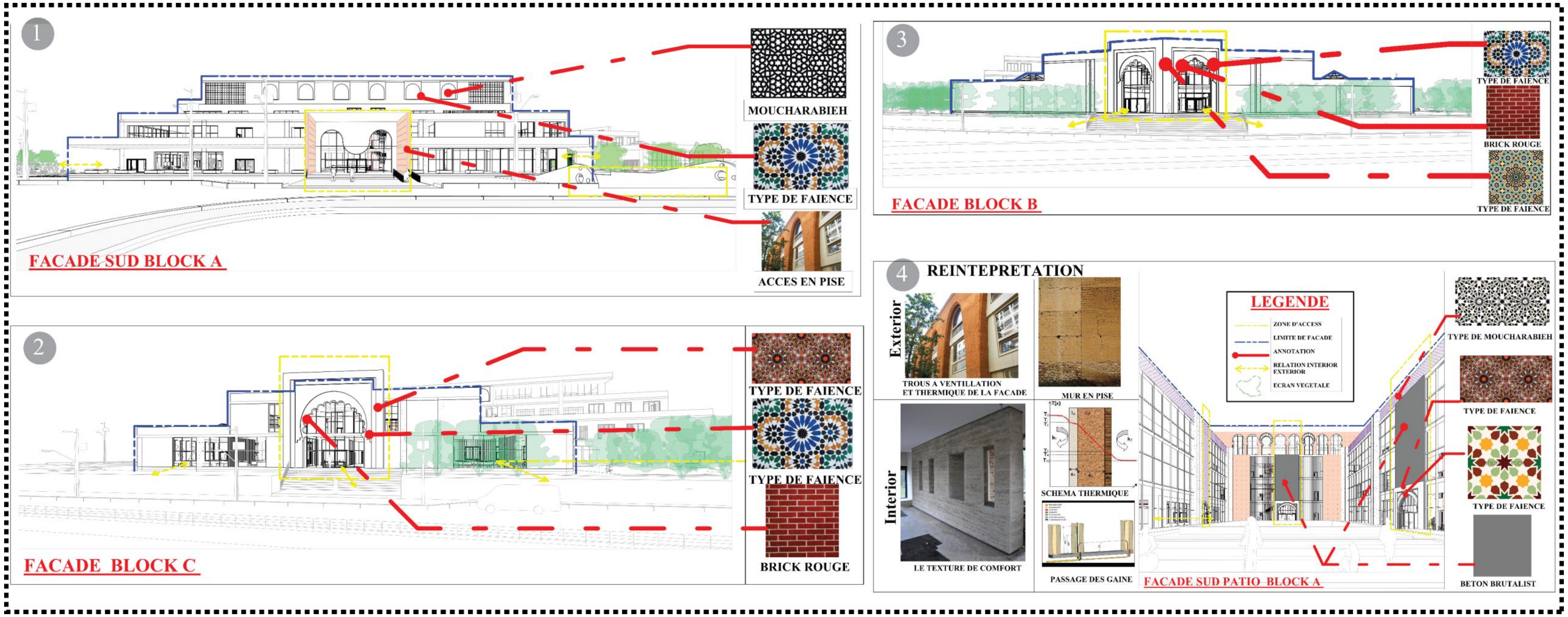


Figure 137 Façade Style and deco

Source: (Author, 2025h)

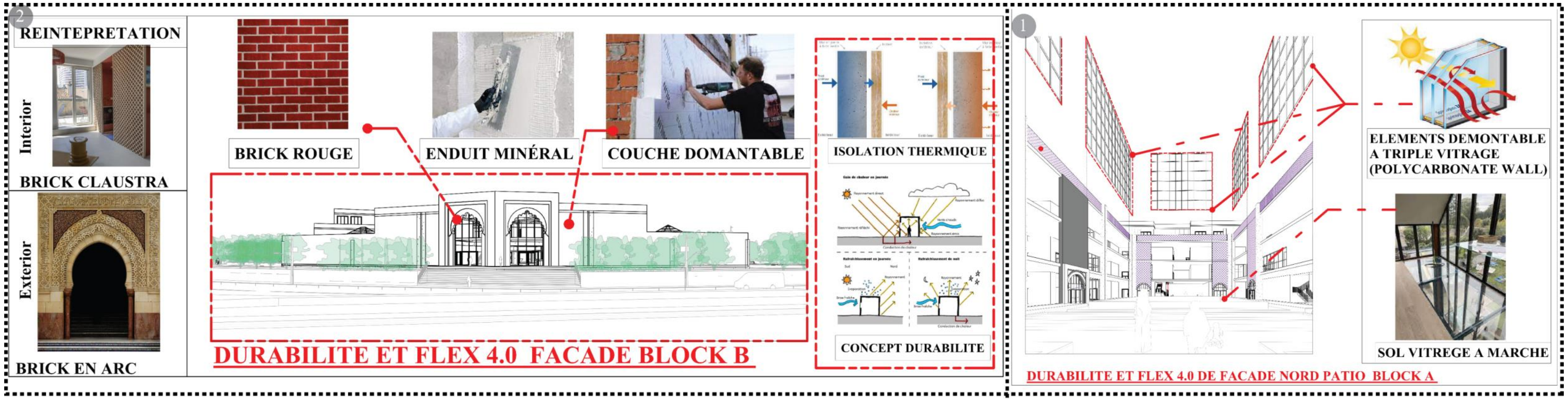


Figure 138; Façade Sustainability and flexibility

Source (Authors, 2025)

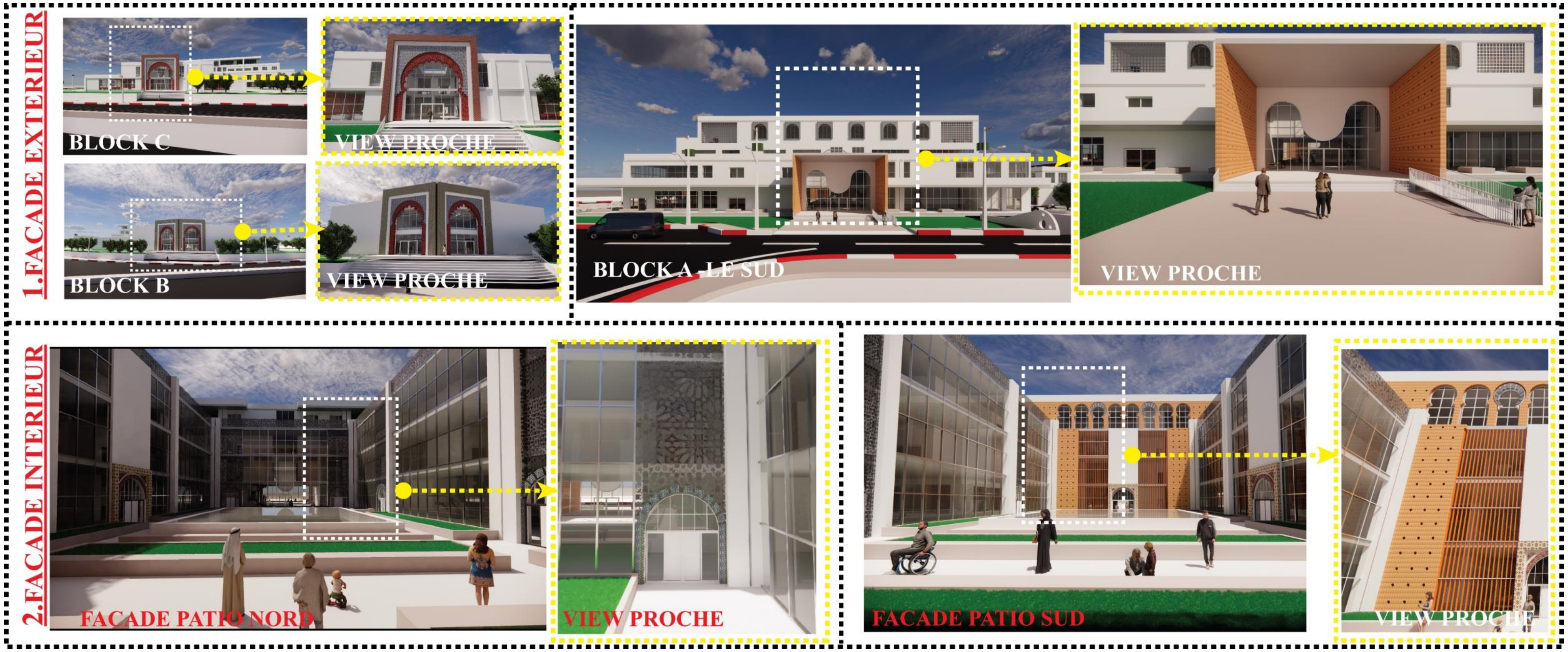


Figure 139: Rendered images of results 1

Source(Author, 2025f)

Figure 140: Façade description by comments« Discours de façade par commentaires»

Source (Author, 2025e)

2.5. Infrastructure and civil engineering schematics

This is combination exterior mass plan of infrastructure utility an equipment and the interior in relation to the technical zones to serve the spaces. For the detailed partial sections and the structural plans are made from block b as seen the general infrastructure plan in figure 134

2.4.1. Description with refence to figure 141

The infrastructure in image 1 summarises all the networks of telephone gas sewage and water conservation from the pervious subsystem in the external works of the site towards the technical zone in the basement flow.

Image 2 shows block A foundation plan with different manhole placing both for foundation drainage and as well as sewage in addition with pumps the link to the external city sewage.

Image 3 shows waffle slab as the principle most stable structure with square columns referenced from flex 4.0 index for adaptability of future usage.

2.6. Infrastructure sustainability, flex 4.0 and innovation with BIM sensor

With refence from **figure 142**: Image 1 shows a section sample of a 3d layout structure of same block B. with expansion joint and its roots that can adopt to upper floor charges and as well as wind loads of the added structure in the time lapse with future needs (image 2 illustration)

Image 3 shows a smaller section from the foundation (image 2 or 3 from figure above) to the ground floor detailed further in image 4 of the preceding explanation of image 1 and 2 of the same figure below

The sensor integration in the building will help in determining the structural monitoring as a digital and climate change adjustment with its effects on the building.

Safety and durability: Wind loads ground, pressure seismic forces moisture control, use and occupancy live loads, rain water and snow load, thermal stress and wind loads structural weight ‘dead loads are analysed with BIM to allow flexibility.

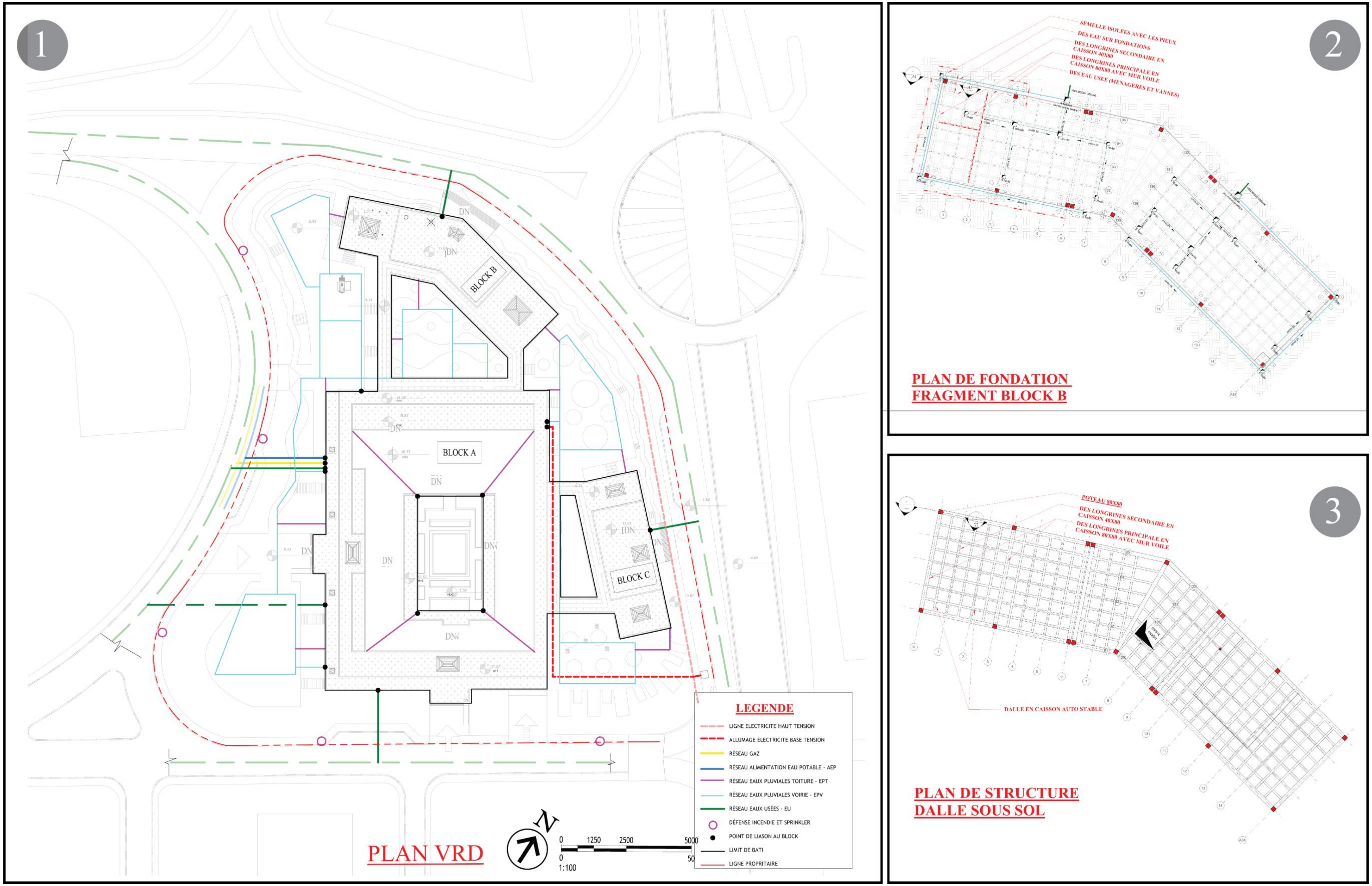


Figure 141 Infrastructure plan

Source: (Author, 2025ak)

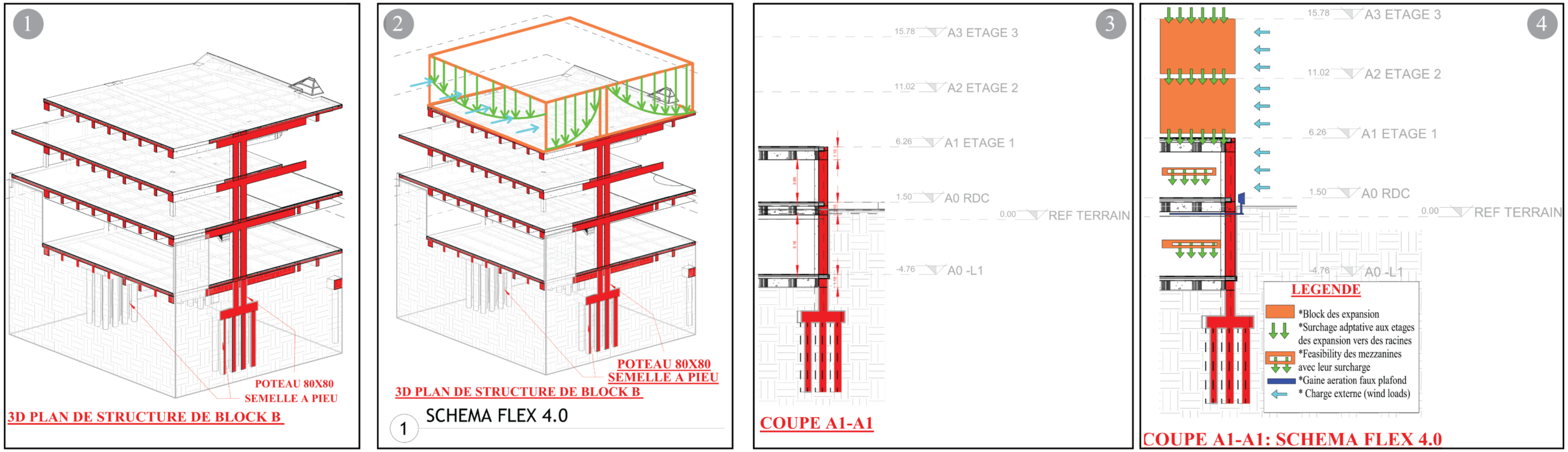


Figure 142: Structural 3D overview with Flex 4.0

Source: (Author, 2025ac)

2.7. Technical schematics (mechanical, electrical, plumbing. MEP)

The technical schematics of the plans elaborate mechanical electrical and plumbing systems including fire safety and emergency exits. We integrated suitability and adaptive reuse in these technical zones for longevity of the building and future installations with low energy consumptions.

2.7.1. The mechanical plan description with reference to figure 143

The image 1 shows the mechanical plan with various ducts visible in the legend and image 2 shows the flexibility of the ducts end elevated slab (dalles sur plots)

2.7.2. The electrical plan description with refence to figure 144

Image 1 shows various electrical equipment installation including telephone an internet fibre optics as seen in the legend and image 2 show the adaptability of future usage of the ducts reserved

2.7.3. The plumbing plan description combined with the emergency route plan. Figure 145

Image 1 shows the wate supply to the Fire reserve ducts and the hot water the radiant flow for thermal comfort. In addition to different ducts to floor water evacuation image 2 shows how flexible the floors can go with technological advancements of the future usage.

Lastly **figure 146** shows some of the details of the different type of floors used and the integration of sustainability and **flex 4.0**

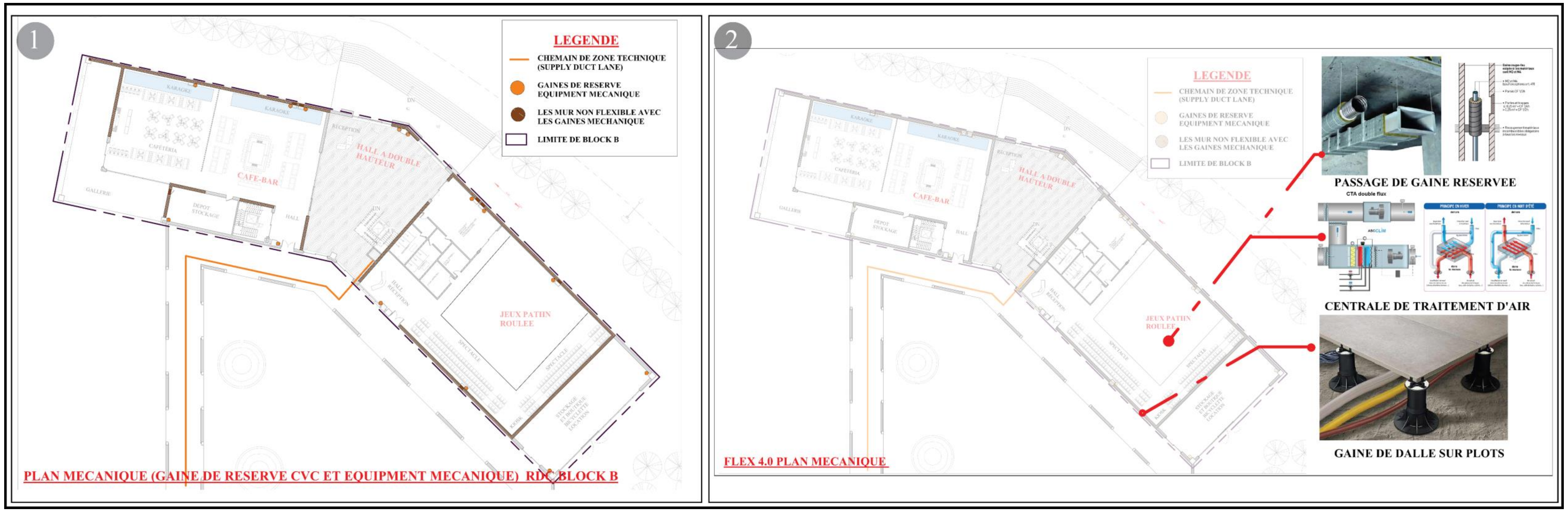


Figure 143 Mechanical plan

Source: (AUTHOR, 2025M)

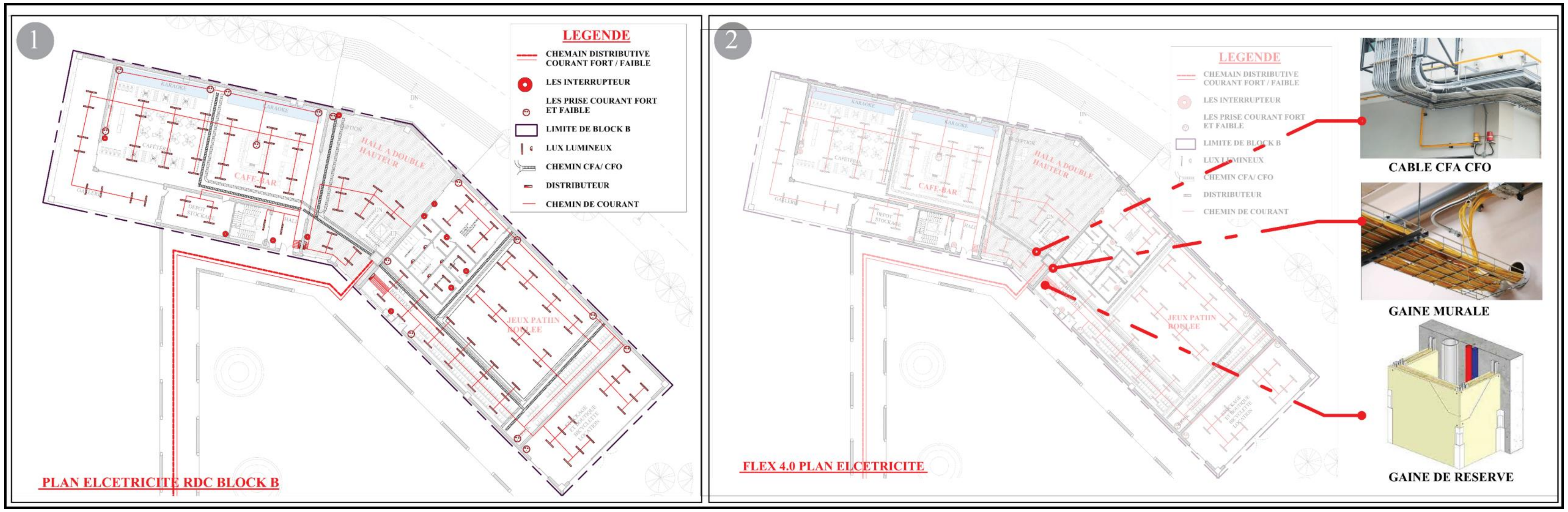


Figure 144 Electrical plan

Source: (AUTHOR, 2025M)

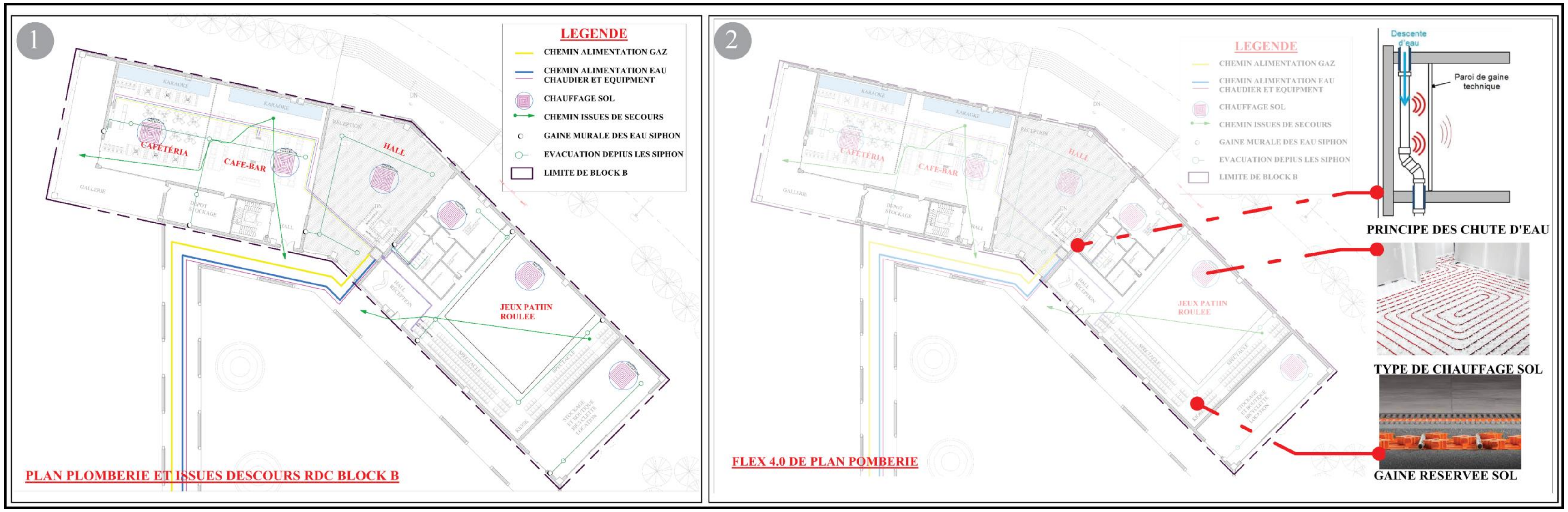


Figure 145 Plumbing plan

Source: (AUTHOR, 2025M)

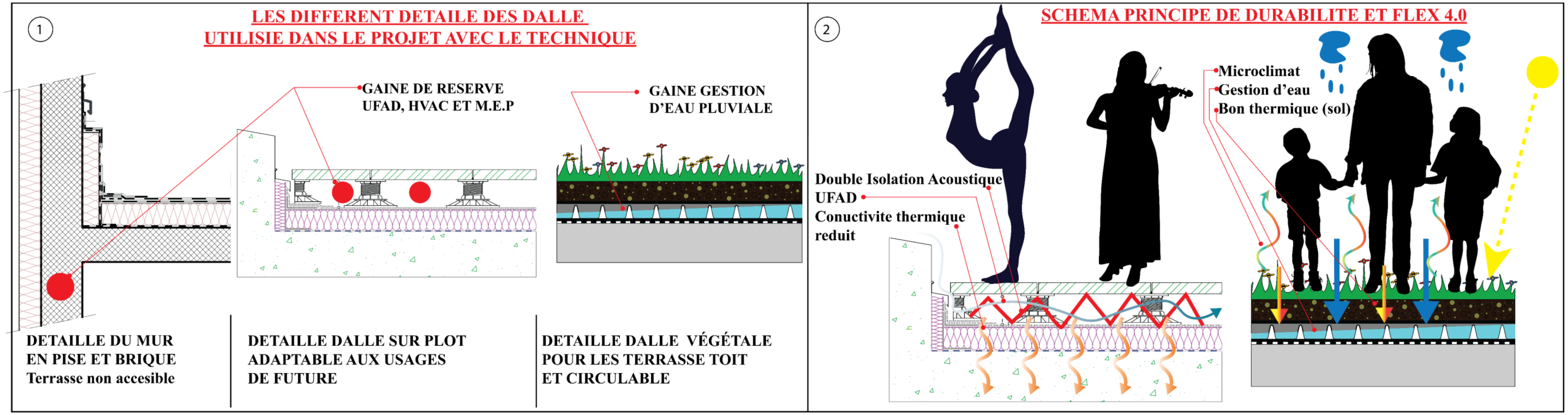


Figure 146 Detail summery of slabs

Source (Author, 2025s)

3.Conclusion:

The schematic design gives a clear understanding of projects feasibility and execution both in 2 and 3d. with project scale being at **city level** With advancing technologies in AEC Autodesk collection, ("we can do more and more with less and less until we ca do everything with nothing…Buckminster fuller") without rebuilding and demolishing. The flex 4.0 index and sustainability benchmarks marks show project evolution for the future needs in respect to the context.

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GENERAL CONCLUSION

1. Summery.

This dissertation has explored the intersection of cultural heritage preservation, sustainable urban development, and innovative architectural practices in the context of Tlemcen, Algeria—a city rich in history yet facing pressing challenges of urban degradation, climate vulnerability, and rapid modernization. By focusing on the northwestern entrance of El-Koudia, the study has proposed a holistic revitalization framework that reconciles the past with the future, demonstrating how adaptive reuse, bioclimatic design, and community-centric planning can transform neglected urban spaces into resilient, vibrant hubs.

1.1.Key Contributions

Bridging Heritage and Innovation: The research underscores the value of traditional architectural wisdom—exemplified by Tlemcen's Great Mosque and Medina—as a foundation for contemporary sustainability. By reinterpreting vernacular strategies (courtyard thermoregulation, geometric proportioning, and souk-inspired spatial networks) through modern tools like BIM and parametric design, the project demonstrates how heritage can drive innovation rather than hinder progress. The integration of Flex 4.0 principles ensures that the proposed community hub remains adaptable to future needs, avoiding the obsolescence plaguing many contemporary structures.

Sustainability as a Cultural Imperative**:** The study moves beyond technical metrics (e.g., LEED certification) to position sustainability as a cultural and social responsibility. By employing life-cycle assessment (LCA), the research quantifies how adaptive reuse reduces embodied carbon by 40% compared to demolition and new construction. Passive design strategies—such as natural ventilation, radiant barriers, and photovoltaic arrays—are not merely energy-saving measures but extensions of Tlemcen's climatic resilience traditions. The masterplan's emphasis on pedestrian connectivity and mixed-use programming further aligns ecological goals with social equity, ensuring that sustainability benefits all residents.

A Model for Mediterranean Cities: The challenges Tlemcen faces—urban fragmentation, seismic risks, and identity erosion—are shared by many historic cities across the Mediterranean. This research offers a scalable methodology for addressing these issues: Diagnostic Tools: GIS mapping and CFD simulations to assess environmental and structural risks. Participatory Design: Community workshops to ensure interventions reflect local needs. Policy Integration: Recommendations for updating heritage laws and incentivizing adaptive reuse.

The success of this approach in El-Koudia suggests its potential for replication in cities like Fez, Tunis, or Palermo, where similar tensions between preservation and development persist.

Broader Implications: The project challenges conventional notions of urban "progress" that prioritize new construction over heritage conservation. By proving that historic buildings can be retrofitted to meet modern standards—without sacrificing cultural authenticity—the study advocates for a paradigm shift in how cities manage growth. Key takeaways for policymakers and practitioners include: Adopting BIM for Heritage Conservation: Digital tools can streamline restoration while preserving craft traditions. Prioritizing Circular Economy Practices: Material reuse and low-carbon techniques must become standard in urban projects. Engaging Communities as Stakeholders: Sustainable development cannot succeed without local ownership.

Future Directions: While this research provides a robust framework, further work could explore: Long-term Monitoring: Tracking the performance of the El-Koudia hub post-implementation. Expanded LCA Studies: Comparing adaptive reuse outcomes across different building typologies. Regional Collaborations: Creating a Mediterranean network for heritage-based climate adaptation.

Final Reflections: Tlemcen's architectural legacy is not a relic of the past but a living resource for addressing 21st-century challenges. This dissertation has shown that by marrying tradition with technology, cities can achieve ecological resilience, economic vitality, and cultural continuity. The El-Koudia project is more than a masterplan—it is a manifesto for inclusive, sustainable urbanism, proving that the path forward must be rooted in respect for the past.

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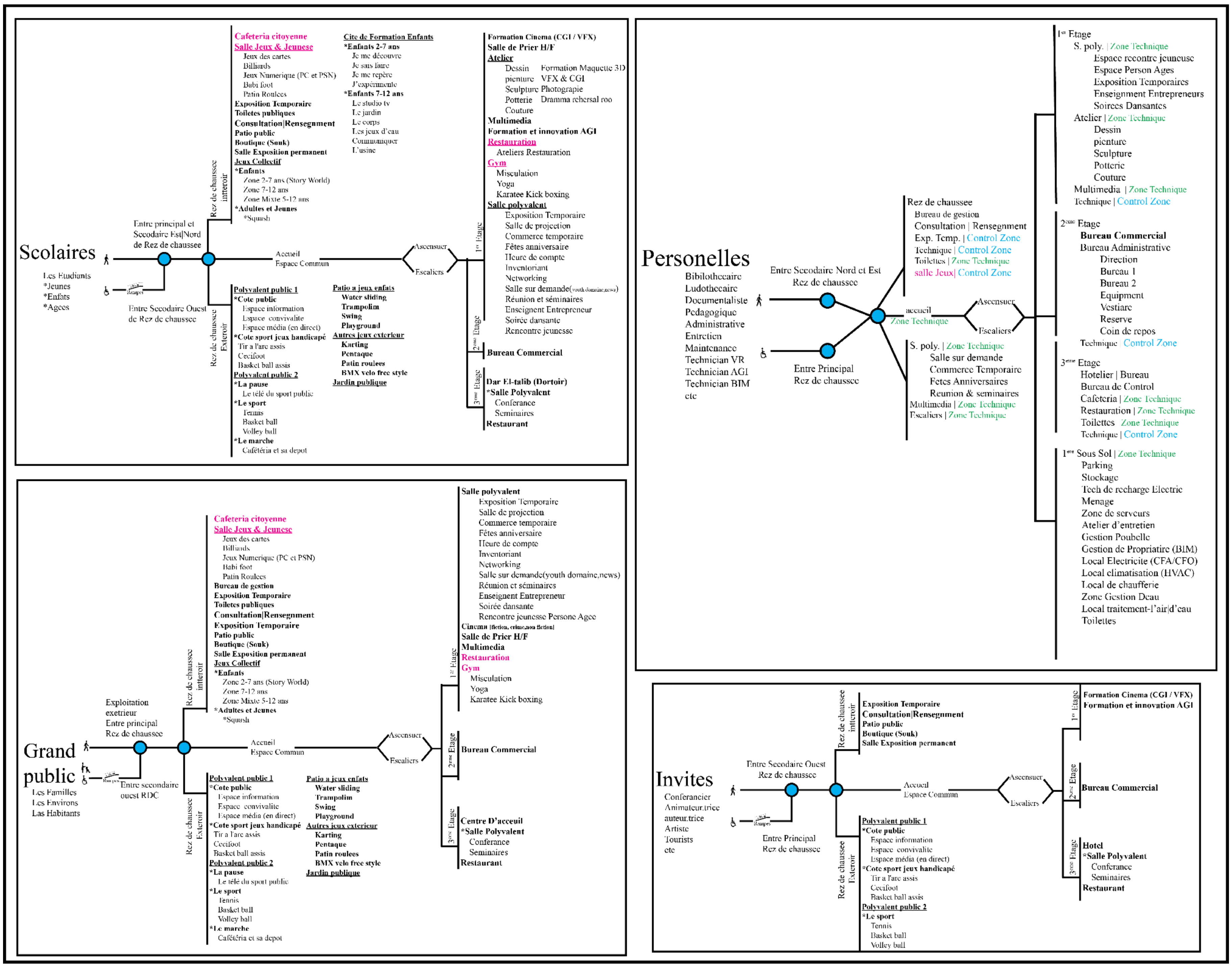
Annexes

1.Circulation Analsys Table summary:



Source: (Author, 2025u)

2. FLEX 4,0 CRITERIA. OF ADAPTIVE REUSE

Layer	Sub-Layer	Flexibility indicators	Assessment value
Site		1. Expandable site/ Location Dose the site have a surplus of space and is the building located at the centre?	1. No, the site has no surplus at all (Bad) 2. 10-30% surplus (Normal) 3. 30-50% surplus (Better) 4. The site has a surplus space more than 50% (Best)
		2. Multifunctional site/ location Is the location capable to support more functions, like offices, living, care and shops?	1. Just one function is suited (Bad) 2. two functions (Normal) 3. Three functions (Better) 4. > Three functions (Best)
Structure	Measurement	3. Surplus of building space/floor Does the building or the user units have a surplus of the needed usable floor space?	1. Not oversized (Bad) 2. 10-30% oversized (Normal) 3. 30-50% oversized (Better) 4. > 50% oversized (Best)
		4. Surplus of free floor height How much is the net free floor area?	1. <2.60 m (Bad) 2. 2.6-3.00 m (Normal) 3. 3.00-3.40 m (Better)

			4. > 3.40 m (Best)
		5. Size of floor buildings What is the size of the usable floor surface?	1. The usable floor space < 400m² (Bad) 2. 400-600 m² (Normal) 3. 600-1000 m² (Better) 4. The usable floor space is > 1000m² (Best)
		6. Measurement system Have positioning/ measurement modular rules for construction components been used?	1. Rules for modular coordination are not implemented (Bad) 2. < 50% implemented (Normal) 3. > 50% implemented (Better) 4. Rules for modular coordination are > 90% implemented (Best)
		7. Horizontal zone division / layout Has use been made of a horizontal zoning system, including in the building?	1. No zoning system without intermediate margins (Bad) 2. Yes, with 10-30% intermediate margins (Normal) 3. Yes, with 30-50% intermediate margins (Better) 4. Yes, with met > 50% intermediate margins (Best)
		8. Presence of stairs/ elevators Are sufficient stairs and elevators present in the building.	1. Only one decentred located stairs/ elevator core is available in the building (Bad) 2. There is one centrally located stairs/ elevator core is available in the building (Normal) 3. The building divided into different wings each with a central stairs/ elevator core (Better) 4. The building has one central and several decentred stairs/ elevator cores per wing (Best)
		9. Extension/ reuse of Is there a possibility to add new stairs/ elevators to the building and reusing the existing ones?	1. No stairs/ elevators can be added without drastic expensive measures (Bad) 2. A new stairs/ elevators core can be accidently added and existing reused (Normal) 3. New stairs/ elevators can be limited added and existing ones reused (Better) 4. New stairs/ elevators can be easily added without drastic expensive measures (Best)
	Access	10. Access to building To what extend a centralized building access has been implemented?	1. Decentralized/separated building entrance/ core (Bad) 2. Decentralized/combined building entrance/core (Normal) 3. Building divided in different wings, each with entrance (Better) 4. One centralized building entrance and different wings with separate entrance (Best)
	Construction	11. Positioning obstacles/columns Is adaptation of building obstacle by load bearing obstacles or columns?	1. Adaptation completely obstructed by difficult to replace load bearing obstacle(Bad) 2. <50% of the building adaptation is by load bearing obstacle (Normal) 3. <10% of the building adaptation is by load bearing obstacle (Better) 4. No building space is obstructed by difficult to replace load bearing obstacles (Best)
		12. Surplus of load bearing capacity How large is the load bearing capacity of the floors in the building?	1. <3 kN/m² (Bad) 2. 3-3.5 kN/m² (Normal) 3. 3.5-4 kN/m² (Better) 4. >4 kN/m² and several areas > 8 kN/m²
		13. Shape of columns How are the columns in the building shape?	1. The columns are shaped round and/ or have vertical different sizes (Bad)

			2. The columns are shaped octagonal (Normal) 3. The columns are shaped rectangular (Better) 4. The columns are shaped square (Best)
		14. Positioning of facilities zones Are facilities zones and vertical shafts located at central building level and/or local unit level?	1. All facility zones and vertical shafts are only located at central level(Bad) 2. Facility zones/ shafts are located at central level and occasionally at local level (Normal) 3. Facility zones/ shafts are located at central level and limited at local level (Better) 4. Facility zones/ shafts are located at central level and at local level as well (Best)
		15.Fire resistance main bearing How many minutes is the fire resistance of the main load bearing construction?	1. The fire resistance of the load bearing construction is 30 minutes (Bad) 2. The fire resistance of the load bearing construction is 60 minutes (Normal) 3. The fire resistance of the load bearing construction is 90 minutes (Better) 4. The fire resistance of the load bearing construction is 120 minutes (Best)
		16. Extendible building/ units horizontal Is it possible to expand the building horizontal for new extension to the building/ user units?	1. Horizontal extension of building/units is not possible at all. (Bad) 2. Horizontal extension of building/units is very limited possible. (Normal) 3. Horizontal extension of building/units is limited possible at some parts. (Better) 4. Horizontal extension of building/ units is easily possible at all. (Best)
		17. Extendible building/ units vertical Is it possible to expand the building vertical for new floors or a new basement?	1. Vertical extension of building/units is not possible at all. (Bad) 2. Vertical extension is limited possible, only for few units in the building. (Normal) 3. Vertical extension (added floor or basement) is possible after total arrangement. (Better) 4. Vertical extension (new floors/ basement & individual user unit) is easily possible. (Best)
		18. Rejectable part of building/ unit? Is it possible to reject part of the building for selling/ renting to third parties?	1. It is not possible to reject part of building/units. (Bad) 2. It is possible to reject 10-30% of the building/ units. (Normal) 3. It is possible to reject 30-50% of the building/units. (Better) 4. It is possible to reject > 50% of the building/ units. (Best)
		19. Insulation between stories/units How is the thermal and acoustic insulation between the different storeys in the building?	1. Insulation does not meet the current demands for building. (Bad) 2. Insulation meets the current demands for building. (Normal) 3. Insulation also meets the current demands for other building functions. (Better) 4. Insulation meets 10% above the current demands of building and other functions. (Best)
Skin	Facade	20. Facade windows to be opened	1. No or <10% of the windows can be opened (Bad) 2. 10-30%(Normal)

		Can windows in the façade be opened per planning grid size?	3. 30-80% (Better) 4. 80-100% (Best)
		21. Daylight facilities What is the daylight factor for the spaces in the building?	1. Daylight factor* <1/20 (Bad) 2. Daylight factor 1/20-1/10 (Normal) 3. Daylight factor 1/10-1/5 (Better) 4. Daylight factor >1/50 (Best)
		22.Dismountable facade To what extend can façade components be dismantled in case of transformation?	1. Façade components cannot or hardly be dismantled without demolition. (Bad) 2. A small part of the façade components can be dismantled, <20< 50% (Normal) 3. A large part of the façade components can be dismantled, >50< 90%. (Better) 4. All façade components are easily dismountable, < 90% (Best)
		23. Location/ shape daylight In what way are the façade/ daylight openings positioned and shaped?	1. There is large closed surface in the façade. (Bad) 2. There is small horizontal open surface in the façade. (Normal) 3. Large open surfaces in the façade, but with different height size. (Better) 4. Large continuous horizontal, open surface; connections according to planning grid. (Best)
		24. Insulation of façade How is the thermal and acoustic insulation quality of the façade?	1. Insulation does not meet the current demands for building. (Bad) 2. Insulation meets the current demands for building. (Normal) 3. Insulation also meets the current demands for other building functions. (Better) 4. Insulation meets 10% above the current demands of building and other functions. (Best)
Faciliti es	Measure	25. Customisability / controllability Is it possible to customize the facilities: temperature, ventilation, electricity, ICT?	1. Bad/ not customizable; mono-functional or fixed centralized use (Bad) 2. Limited customizable; after drastic interventions (Normal) 3. Partly customizable; after simple interventions (Better) 4. Good and easy customizable without any interventions (Best)
		26. Measure & control techniques Is it possible to control/ measure facilities on building level as well as user unit level?	1. Control/measurement takes place only at central building level. (Bad) 2. On central level and occasionally on unit level. (Normal) 3. On central level and limited on unit level. (Better) 4. As well central on building level as well completely on unit level. (Best)
	Dimensio ns	27. Surplus of facilities shafts and ducts Do the facilities shafts and ducts have a surplus of space (heating, cooling, electricity, ICT)	1.Shafts and ducts have no surplus at all (Bad) 2. 10-30% surplus (Normal) 3. 30-50% surplus (Better) 4. Surplus of space of more than 50% (Best)
		28. Modularity of facilities Are the facilities assembled by modular components according to the façade planning grid?	1. No facilities in the building is divided in modular components (Bad) 2. 1 of the 4 facilities is divided in modular components according to the grid (Normal)

			3. 2-3 of the 4 facilities are divided according to the façade planning grid (Better) 4. all of the 4 facilities are divided according to the façade planning grid (Best)
	Distribution	29. Distribution facilities Does the building have a specific distribution facility for hot/ cold water, heating, cooling and gas?	1. There is a specific distribution for all the different sources. (Bad) 2. There is a specific distribution for some of the different sources (Normal) 3. There is a specific distribution for 2 of the different sources (Better) 4. There is no specific distribution for one of the different sources (Best)
		30. Location sources facilities What is the location of the central facility sources?	1. The facilities sources are located at only one central location in the building. (Bad) 2. The facilities sources are located at several locations in the building. (Normal) 3. The facilities sources are located at only one central location and decentred location as well. (Better) 4. The facilities sources are located at outside the building at city level. (Best)
		31. Disconnection of facility Can the components of the facilities be easily disconnected?	1. Facility can't be disconnected or demounted; wet connections (Bad) 2. Hardly be disconnected, demounted (Normal) 3. Partly be disconnected, demounted (Better) 4. Facility can be disconnected very easily (Best)
		32. Accessibility of facility To what extend are facility components good accessible?	1. Hardly or not accessible, components are in support level. (Bad) 2. Limited accessible and partly in infill level. (Normal) 3. Good accessible, a lot of components in infill level. (Better) 4. Very good accessible. (Best)
		33.Independence of user units In what way are the user units independent related to services as toilet facilities?	1. No service available at user unit level. (Bad) 2. 1-2 services available (Normal) 3. 3-4 services available. (Better) 4. >4 services available. (Best)
Space	Construction	34. Distinction between support - infill* To which degree deals the building with the division between support and infill?	1. <10% of the building is divided in a support and infill part (Bad) 2. 10-30% of the building is divided in a support and infill part Normal) 3. 30-50% of the building is divided in a support and infill part (Better) 4. >50% of the building is divided in a support and infill part (Best)
		35. Multifunctional building / units Is the building capable to support different functions?	1. The building supports only one function. (Bad) 2. The building supports 2 functions. (Normal) 3. The building supports 3 functions. (Better) 4. The building supports >3 functions. (Best)
		36. Horizontal access to building In what way is the horizontal access of the units in the building accomplished?	1. Horizontal access is only by a single internal corridor (Bad) 2. Horizontal access is only by a double internal corridor (Normal)

			3. Horizontal access directly by a central core in the building with a surrounding corridor (Better) 4. Horizontal access directly by a central core in the building or an external gallery (Best)
	Technical	37. Disconnectable, removable To what extend are the user units in a building removable, re-locatable?	1. The user units are not removable. (Bad) 2. The user units are re-locatable with drastic expensive measures. (Normal) 3. The user units are easily re-locatable. Constructed by demountable components. (Better) 4. Easily re-locatable. Constructed by 2D/3D modules. (Best)
		38. Disconnectable, removable To what extend are inner walls in a building easily replaceable?	1. Inner walls are not replaceable without drastic/ expensive interventions.(Bad) 2. Inner walls are not replaceable, but good destructible. (Normal) 3. Inner walls are replaceable by dismantling and rebuilding at another location.(Better) 4. Inner walls are easily replaceable without radical/expensive interventions.(Best)
		39. Disconnectable connection detail Which detailed construction is applied between the interior walls and support structure and façade?	1. The detailing connection consists of penetrating connections. (Bad) 2. The detailing connection consists of wet connections, mortar, and glue. (Normal) 3. The detailing connection consists of specific bound connection elements. (Better) 4. The detailing connection consists of project unbound dismountable connections. (Best)
		40. Possibility of suspended ceilings Is it possible to apply suspended ceilings and to adapt these to the different user demand?	1. Suspended ceilings results in free floor height of < 2.60m (Bad) 2. Suspended ceilings results in free floor height of 2.60-2.70m (Normal) 3. Suspended ceilings results in free floor height of 2.70-2.80m (Better) 4. Suspended ceilings results in free floor height of > 2.80m (Best)
		41. Possibility of raised floors Is it possible to apply suspended raised floors and to adapt these to the different user demand?	1. Raised floor results in free floor height of < 2.60m (Bad) 2. Raised floor results in free floor height of 2.60-2.70m (Normal) 3. Raised floor results in free floor height of 2.70-2.80m (Better) 4. Raised floor results in free floor height of > 2.80m (Best)

Table 22 The FLEX 4.0 a practical instrument to assess the adaptive capacity of buildings

Source (Geraedts, 2016)(Elina Amiri, 2020)

3.Project scale

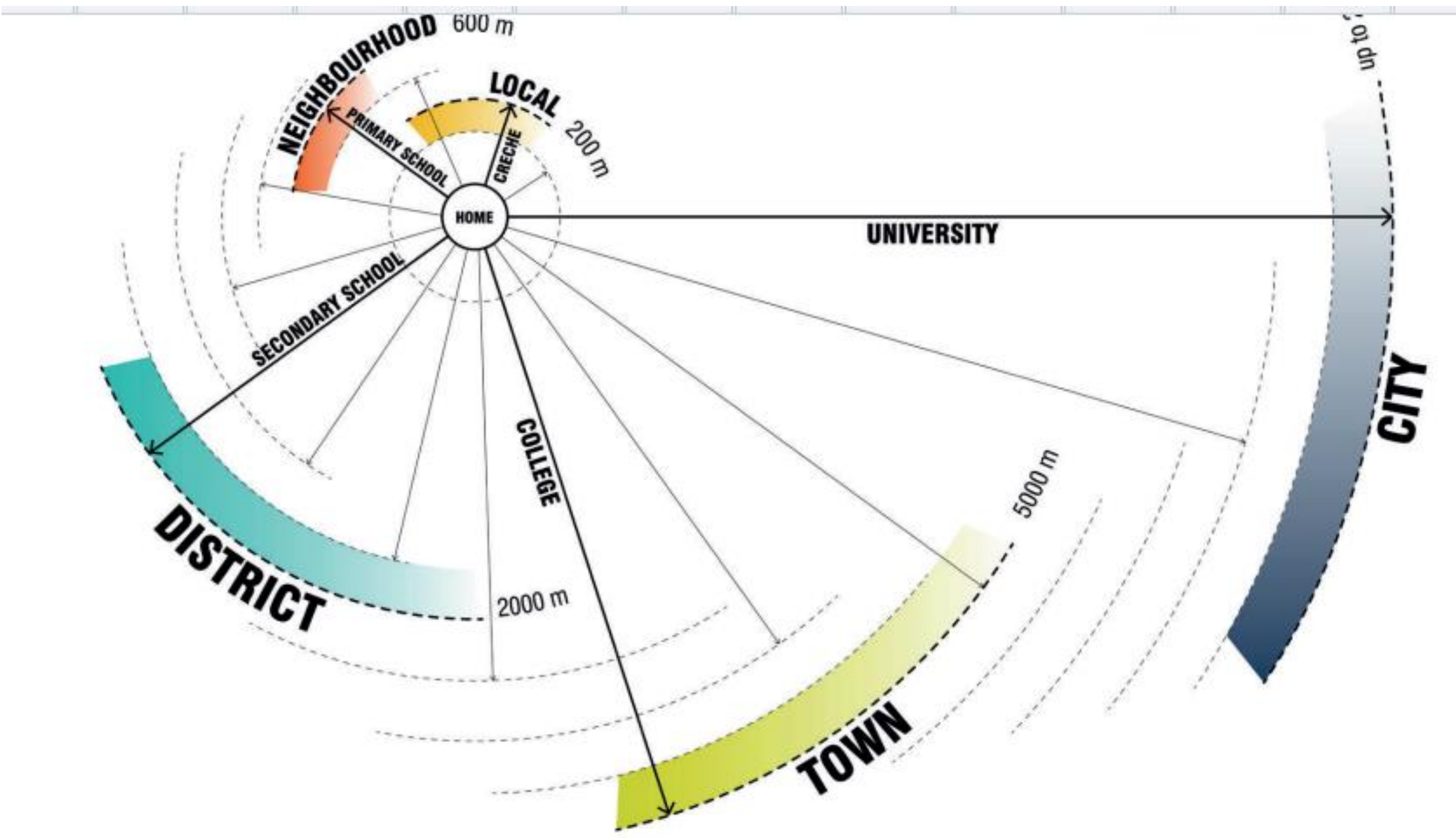
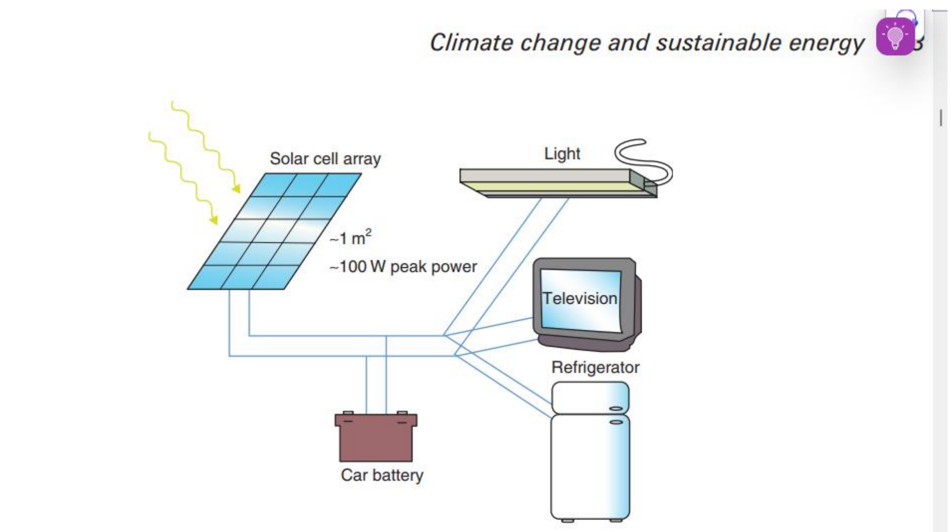


Figure 11.01 Sustainable urban planning for education (with thanks to the Urban Taskforce)

Figure 147: Project scale at city level

Source (Taylor & Wright, 2020)

4.Energetic concept (solar PV energy)



A simple 'solar home system' as is being marketed in many developing countries

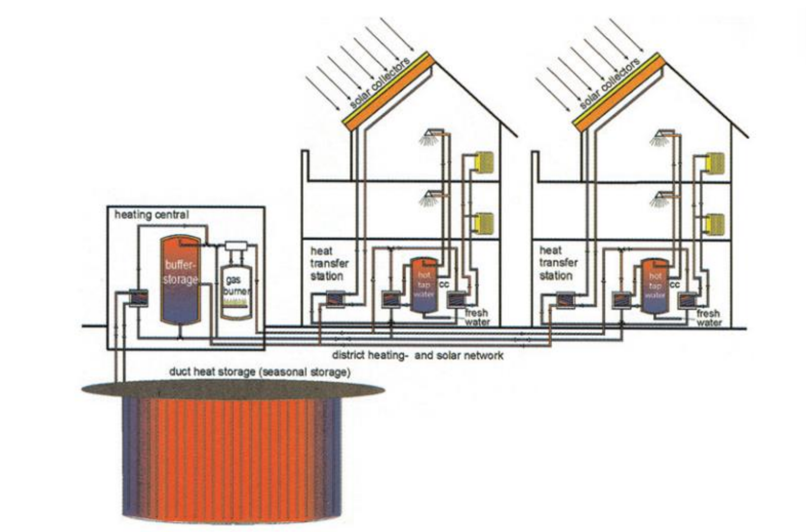


Figure 2.14 Diagram of the Neckarsulm project (courtesy of *Renewable Energy World*)

Figure 148 Energy storage concept

Source (Peter F. Smith, 2007)

5.Energetic concept (passive energy Sketches references)

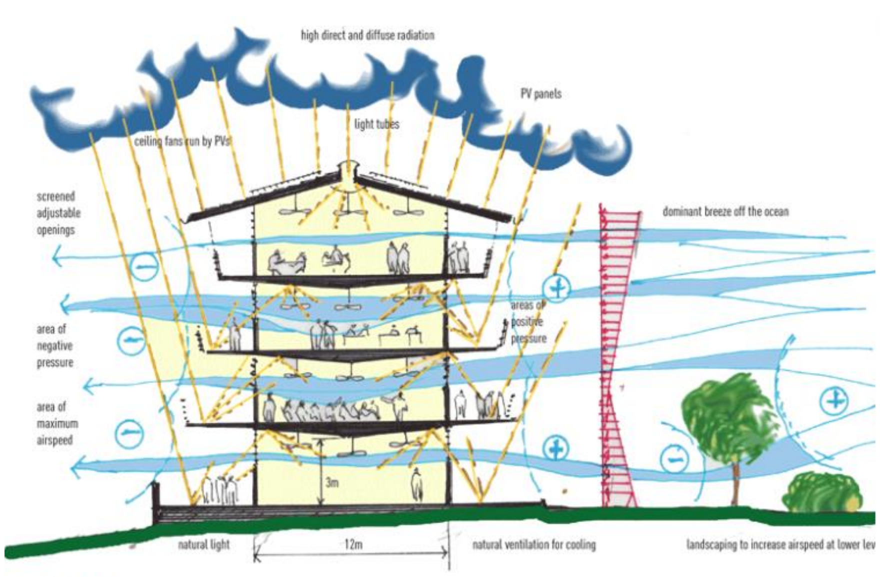


Fig. 3.16b. *Section drawing.*

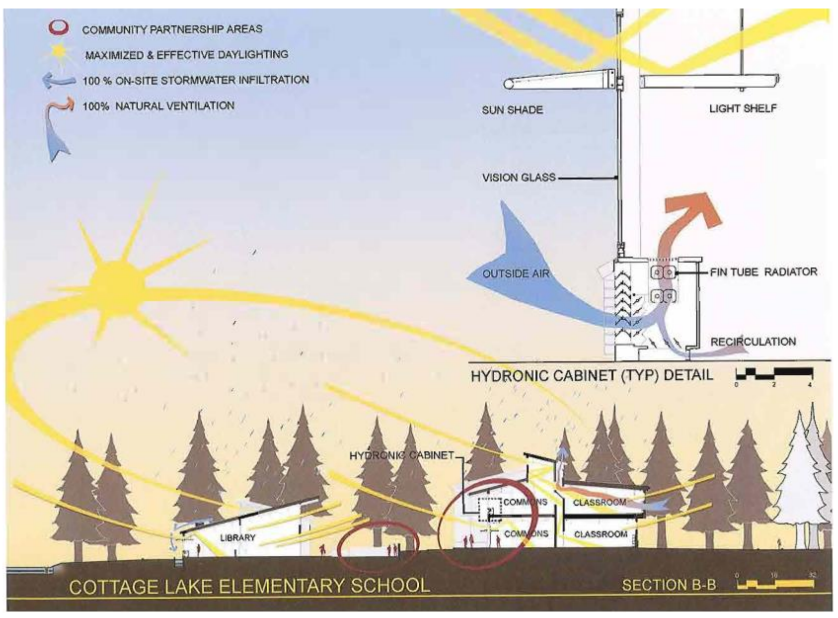


Figure 149 Sketch references

Source: (Bainbridge et al., 2011)

6.Energetic concept « dalle sur plot inspiration » (UFAD system)

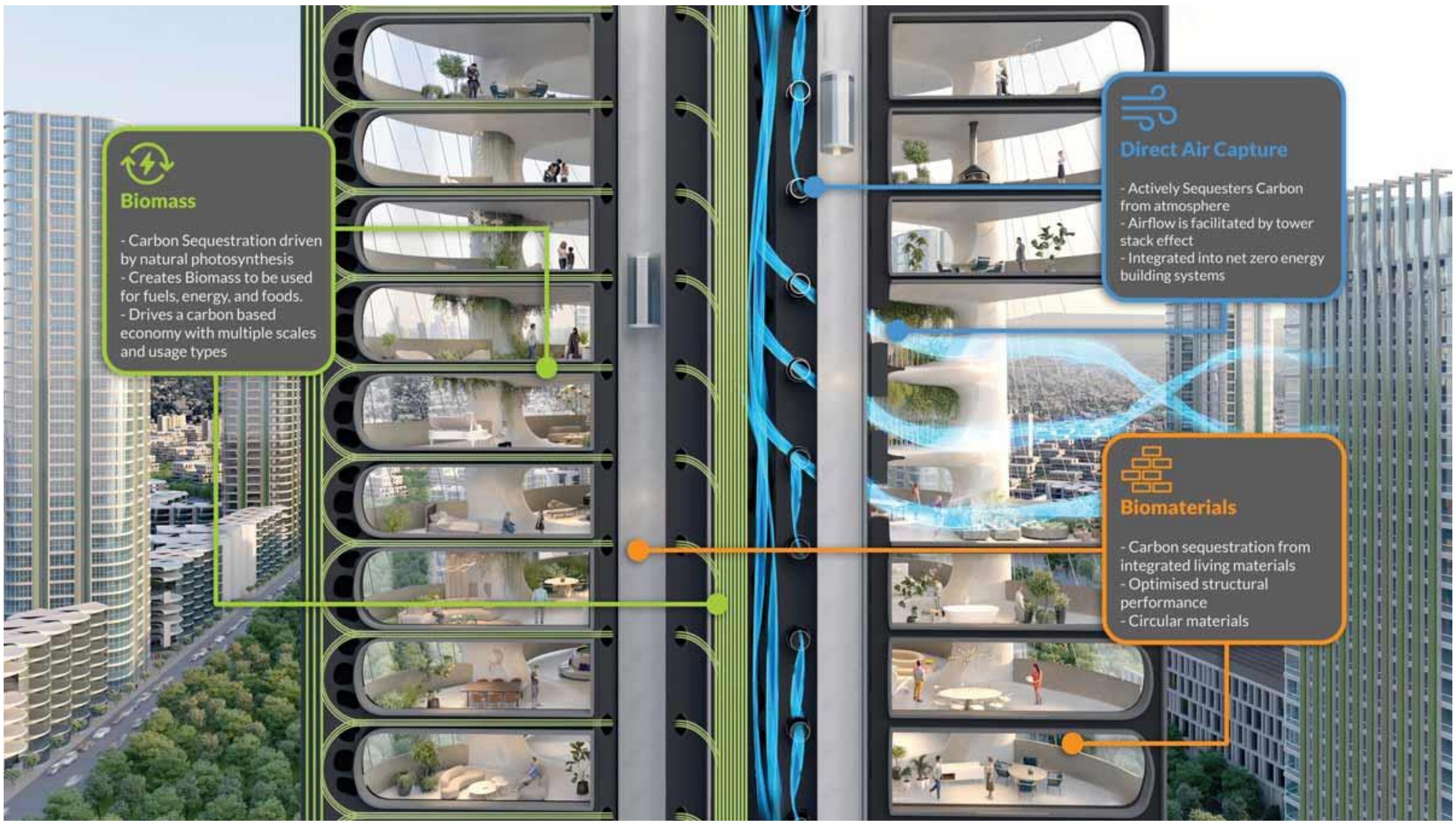


Figure 150 Urban Sequoia

Source (Sarkisian et al., 2023)(Urban Sequoia reel, 2025)(Urban Sequoia TM, 2025)

7.Energetic concept (Other references)

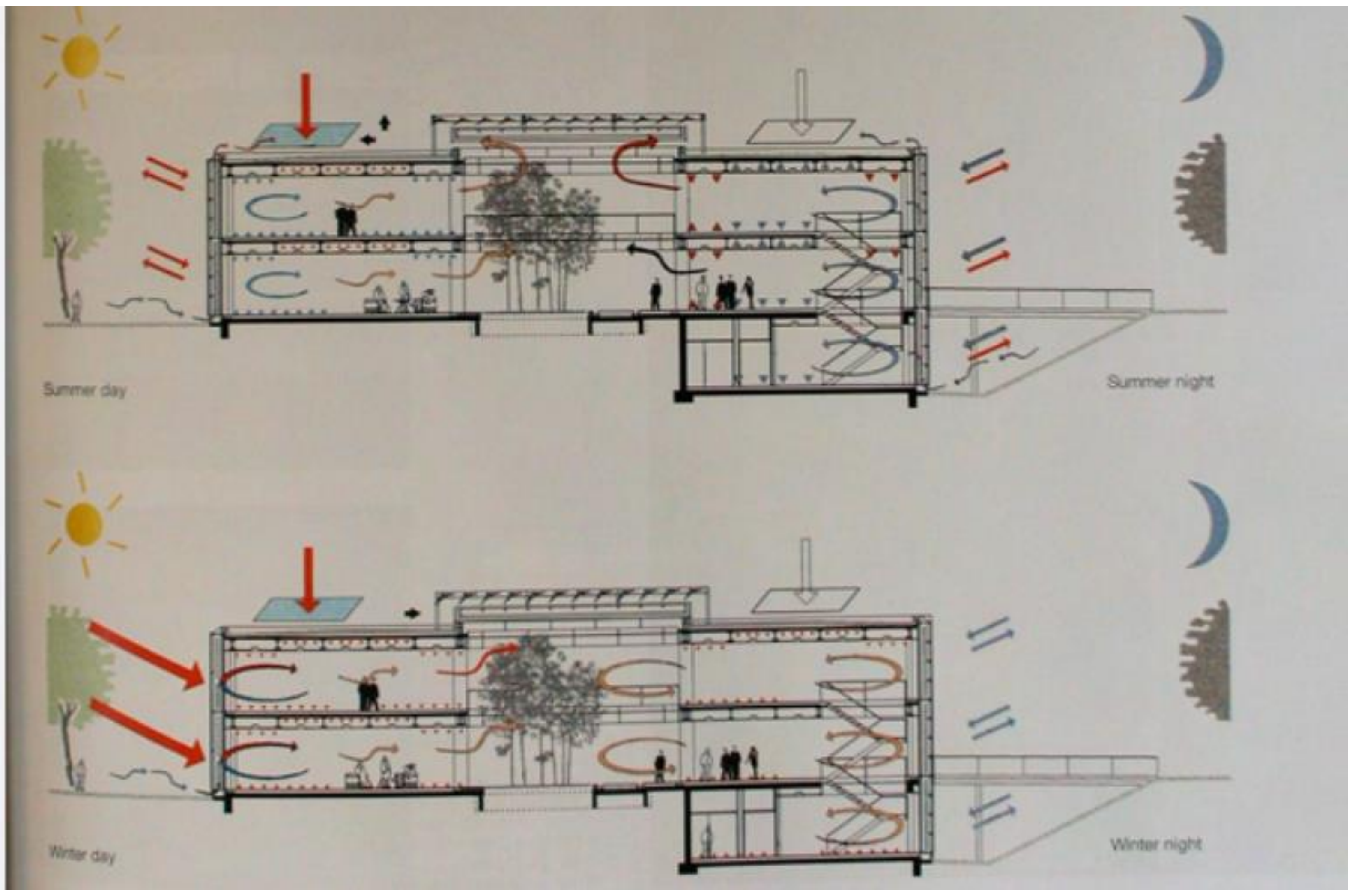


Figure 151 : Sketch refences 2
(Description in book and all videos)

Source:(Christian Schittich, 2003) (Cité de l'architecture, 2025)(*Ecole Architecture Nancy - YouTube*, 2025)(*Ensa Strasbourg - YouTube*, 2025)

8.Adaptability by modules

Figure 152 Vertical Flexibility

Source(Bayliss & Bergin, 2020)

9.Wind Simulations concept references

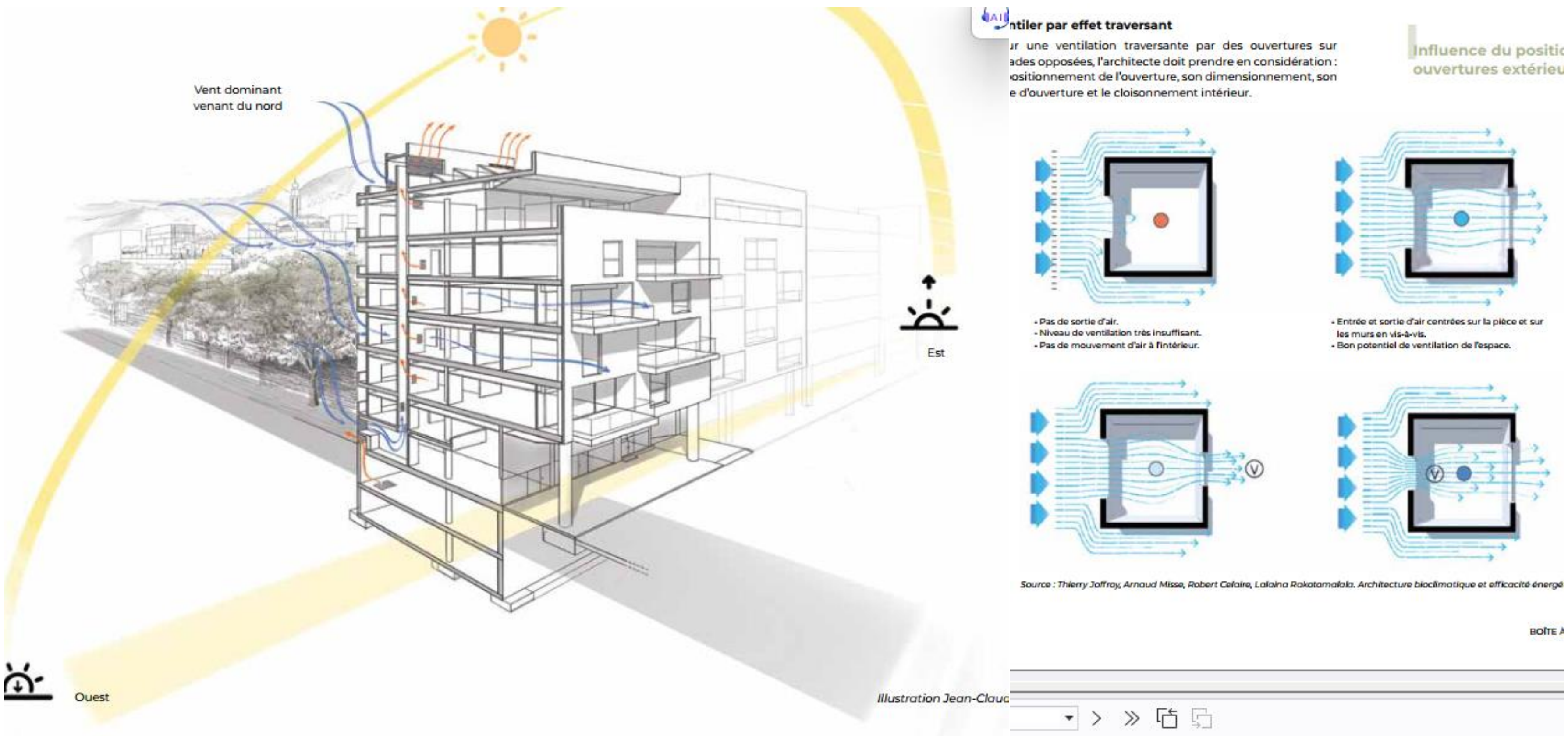


Figure 153 wind simulation reference results (more notes in second book "Heywood")

Source (Magdeline PINEL, 2020) (Heywood, 2013)

10.Sitting zones after simulation

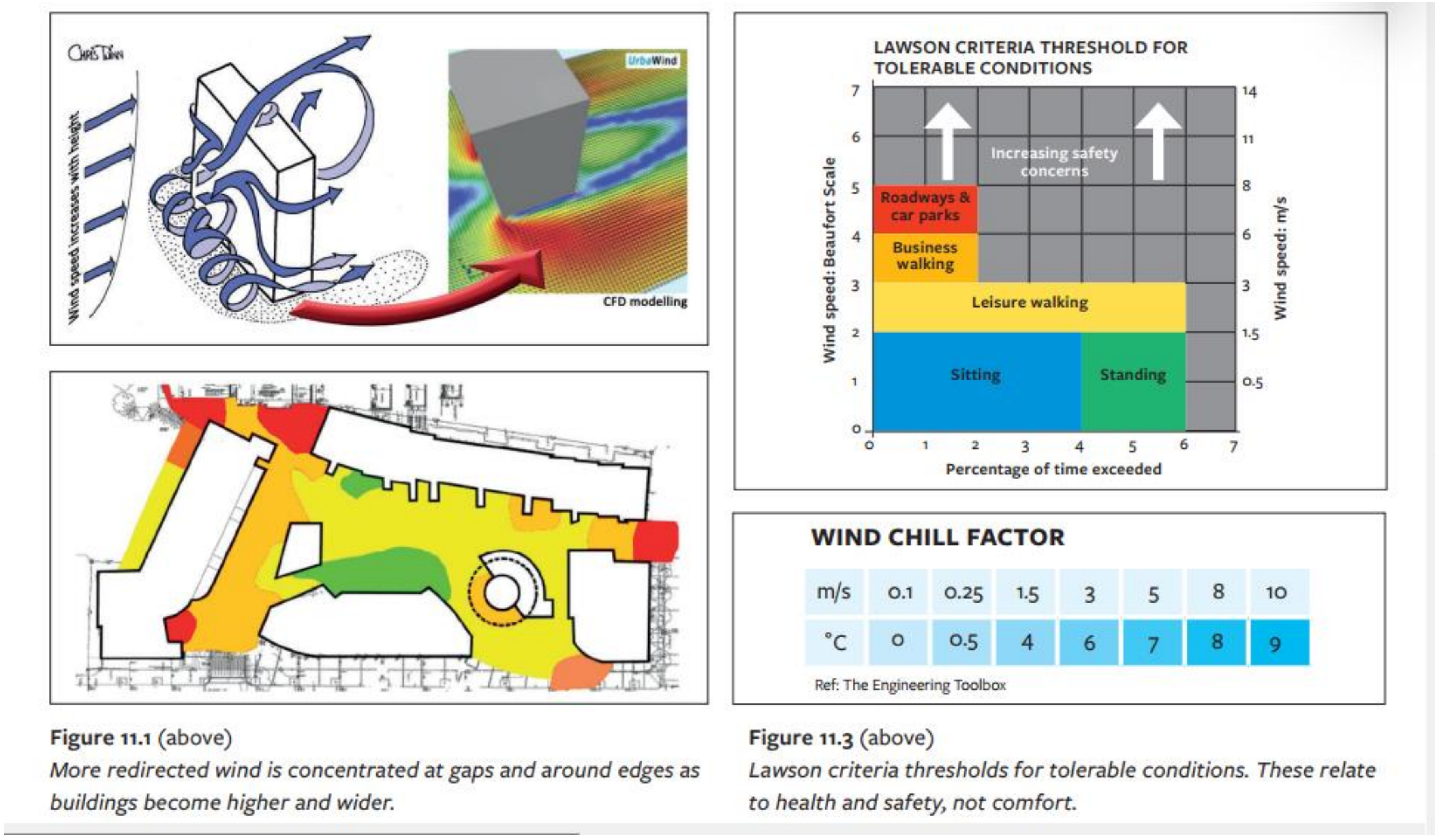


Figure 154 Air simulation legend
(more description on architecture series)

Source (RIBA Publishing, 2017) (Architects Series, 2025)

11.City water collection infrastructure reference

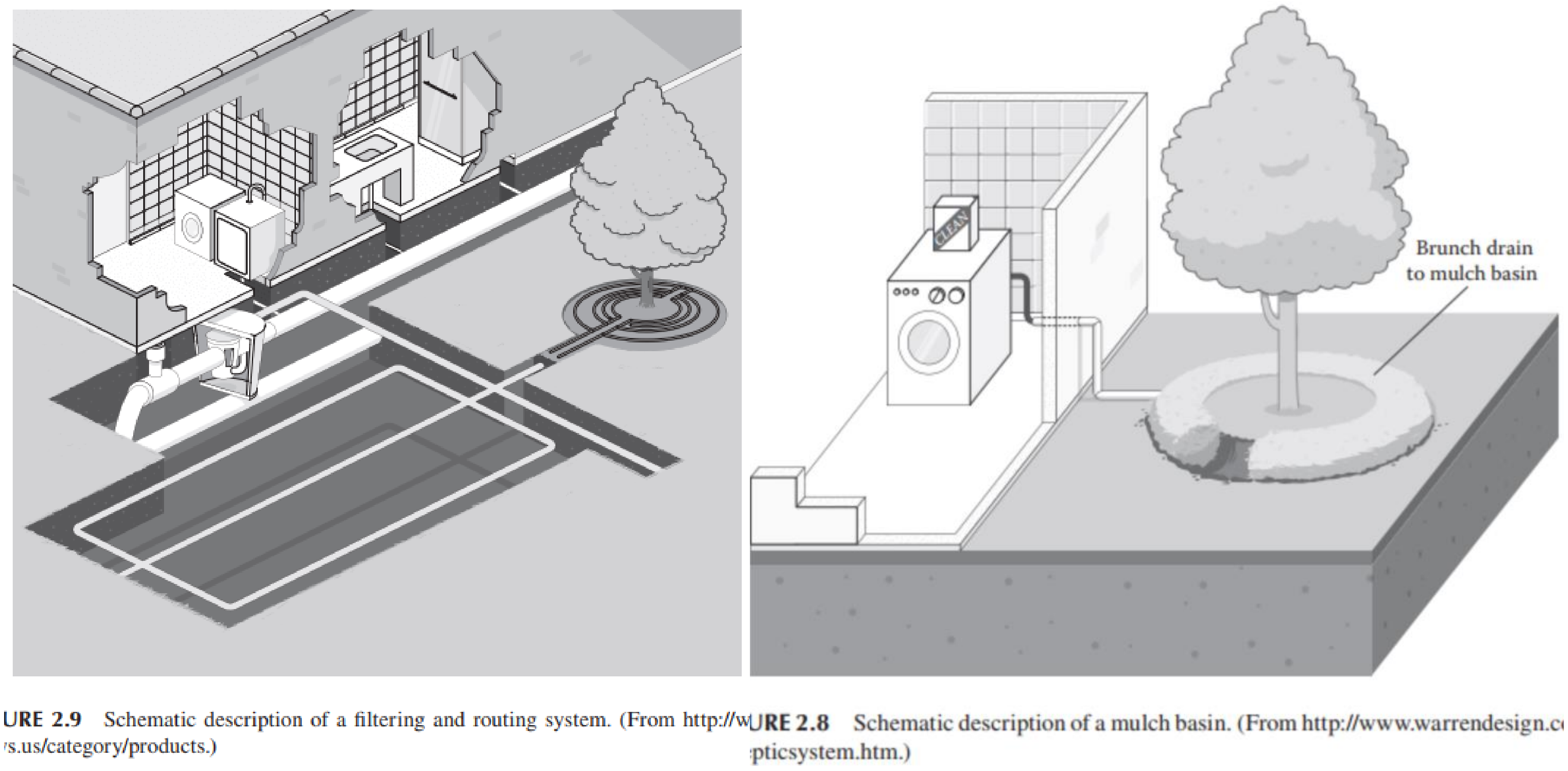
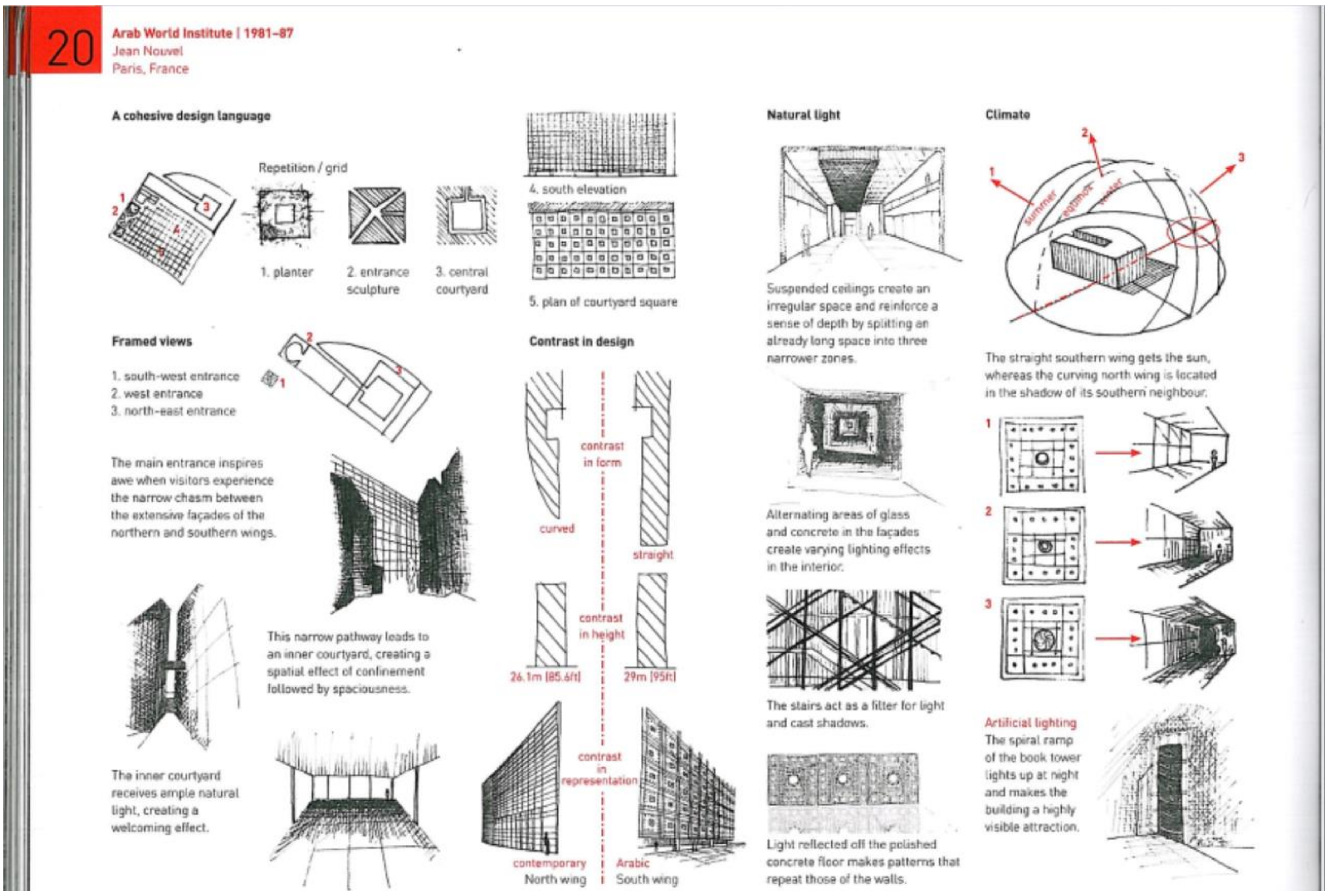


Figure 155; City infrastructure reference

Source(Gross et al., 2015)

12.Moucharabieh and courtyard sketch references



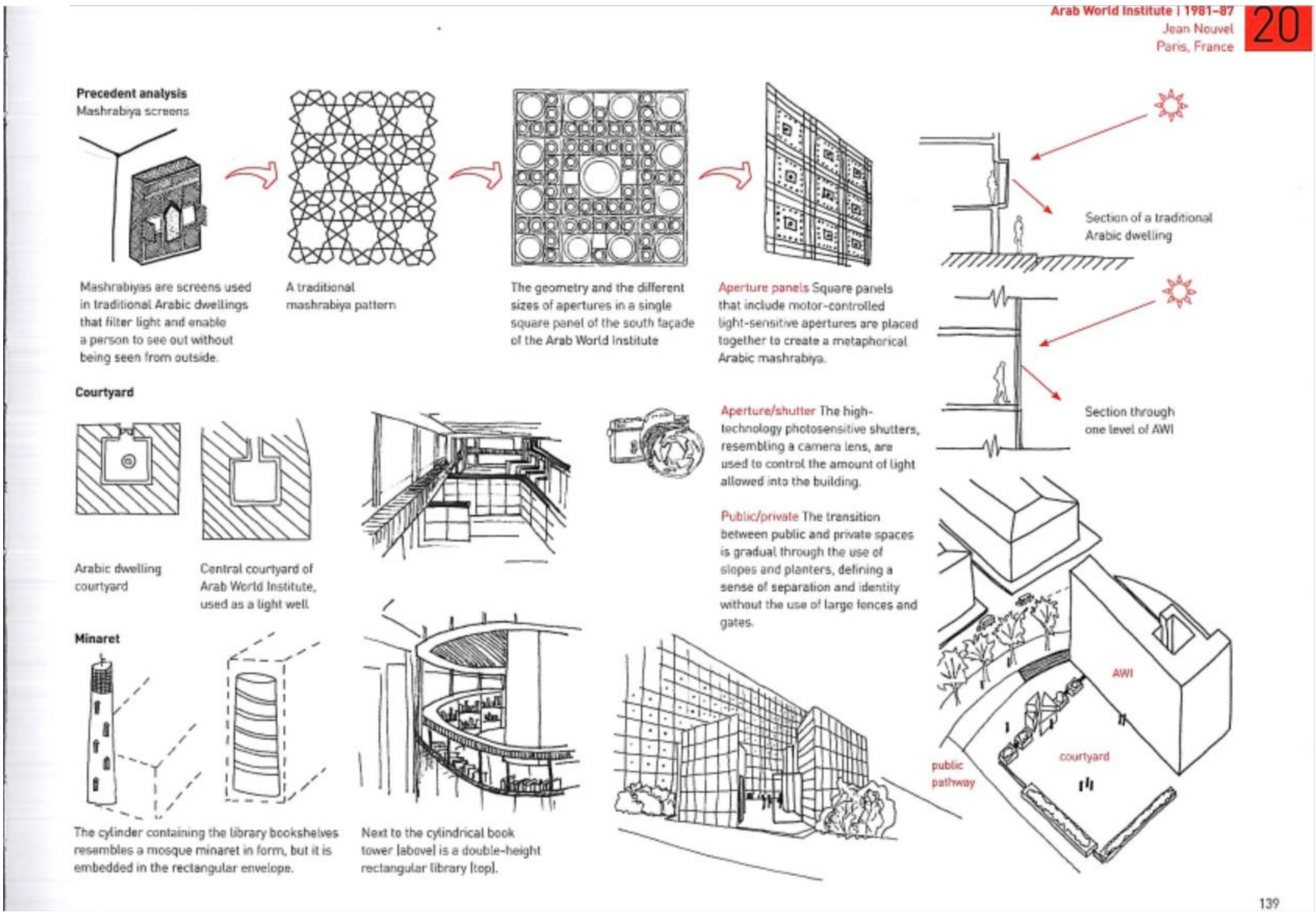


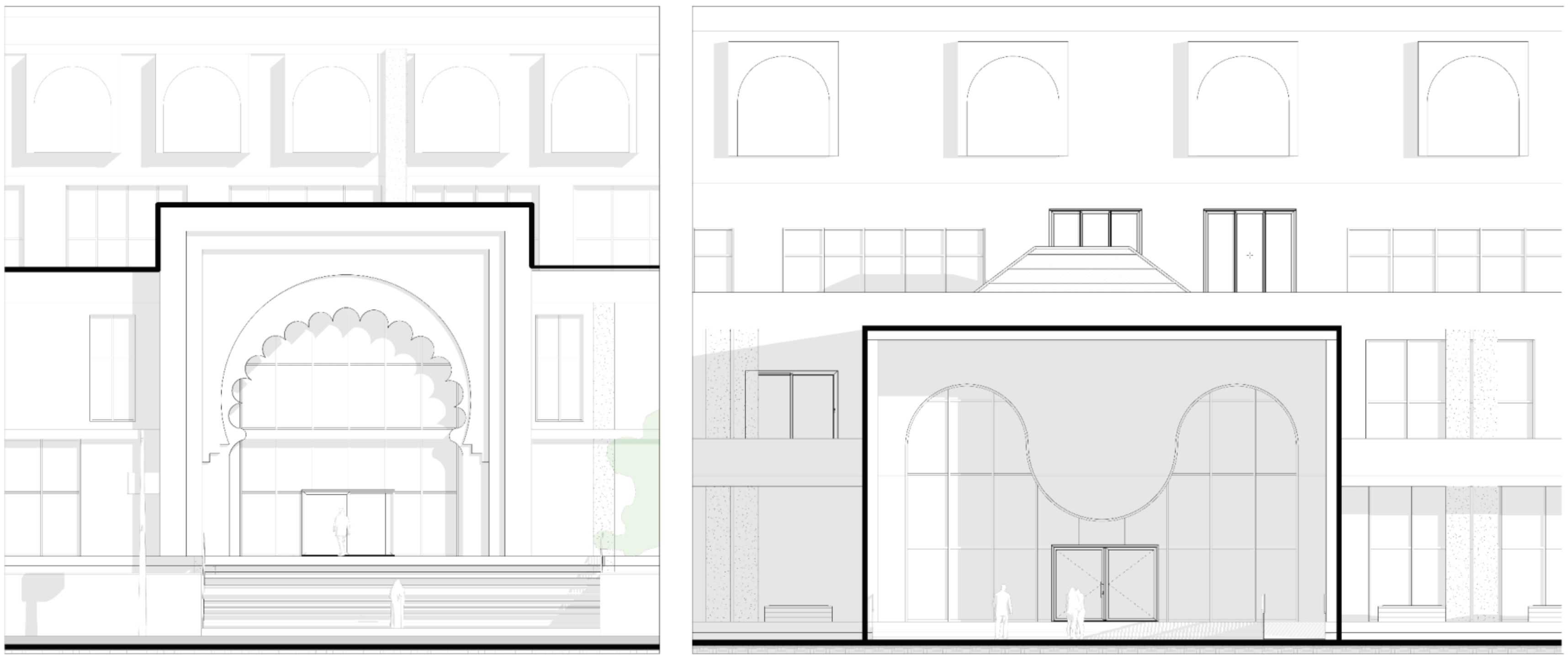
Figure 156 Rethinking modern Arab context

Source: (Thames & Hudson, 2014)

Graphical Documentation | Dossier Graphic

جامعة أبو بكر بلقايد
كلية التكنولوجيا
UNIVERSITÉ DE TLEMCEN
Faculté de Technologie

DOSSIER GRAPHIQUE CENTRE COMMUNAUTAIRE-EL KOUDIA

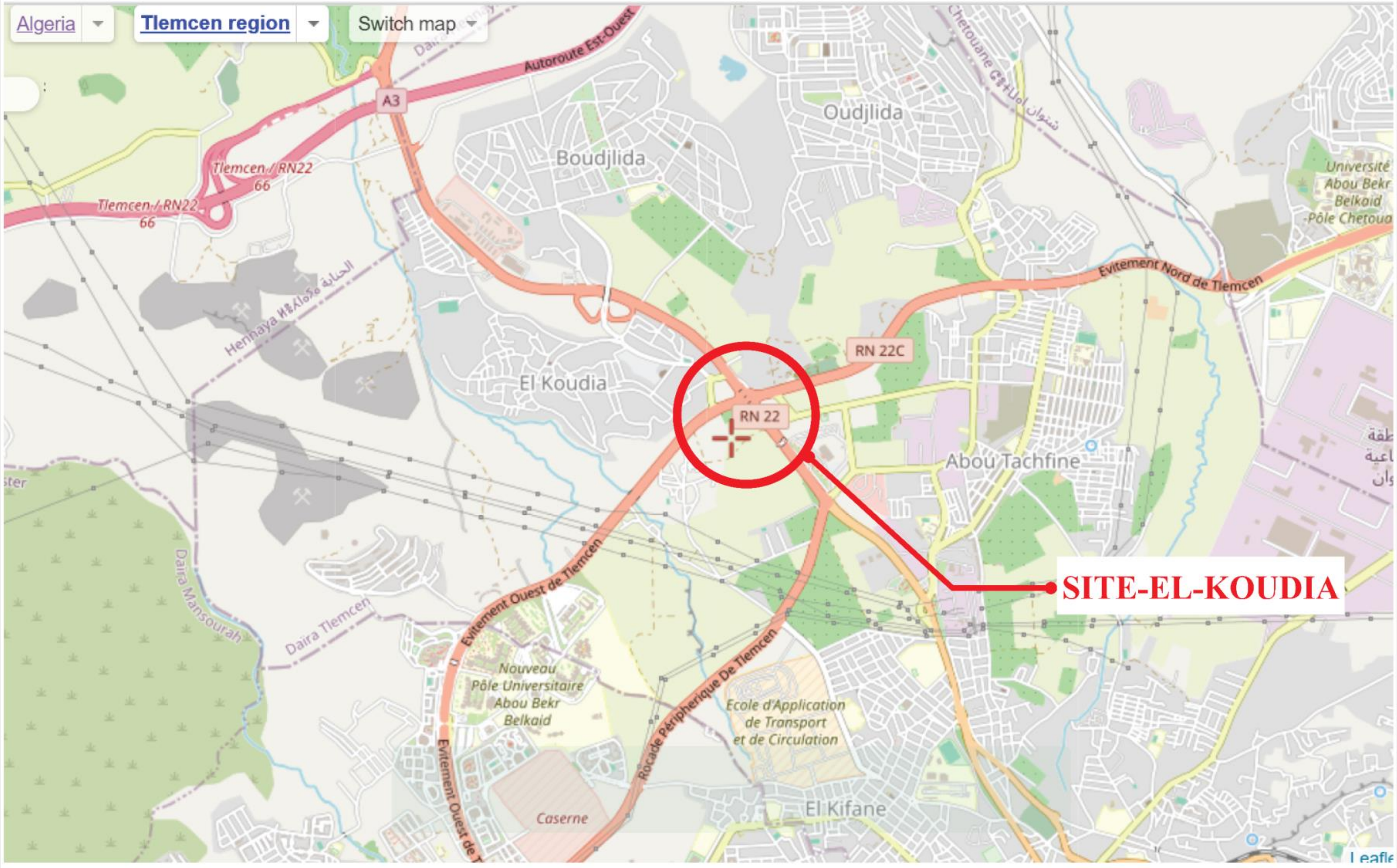


PAR; Mr. DAKA DAN : 2024/2025

ENCADREUR: Dr. SELKA CHIHAB

THEME DE PFE: L'INNOVATION AU SERVICE DU PATRIMIONE ET DE LA DURABILITE

CONTENU:



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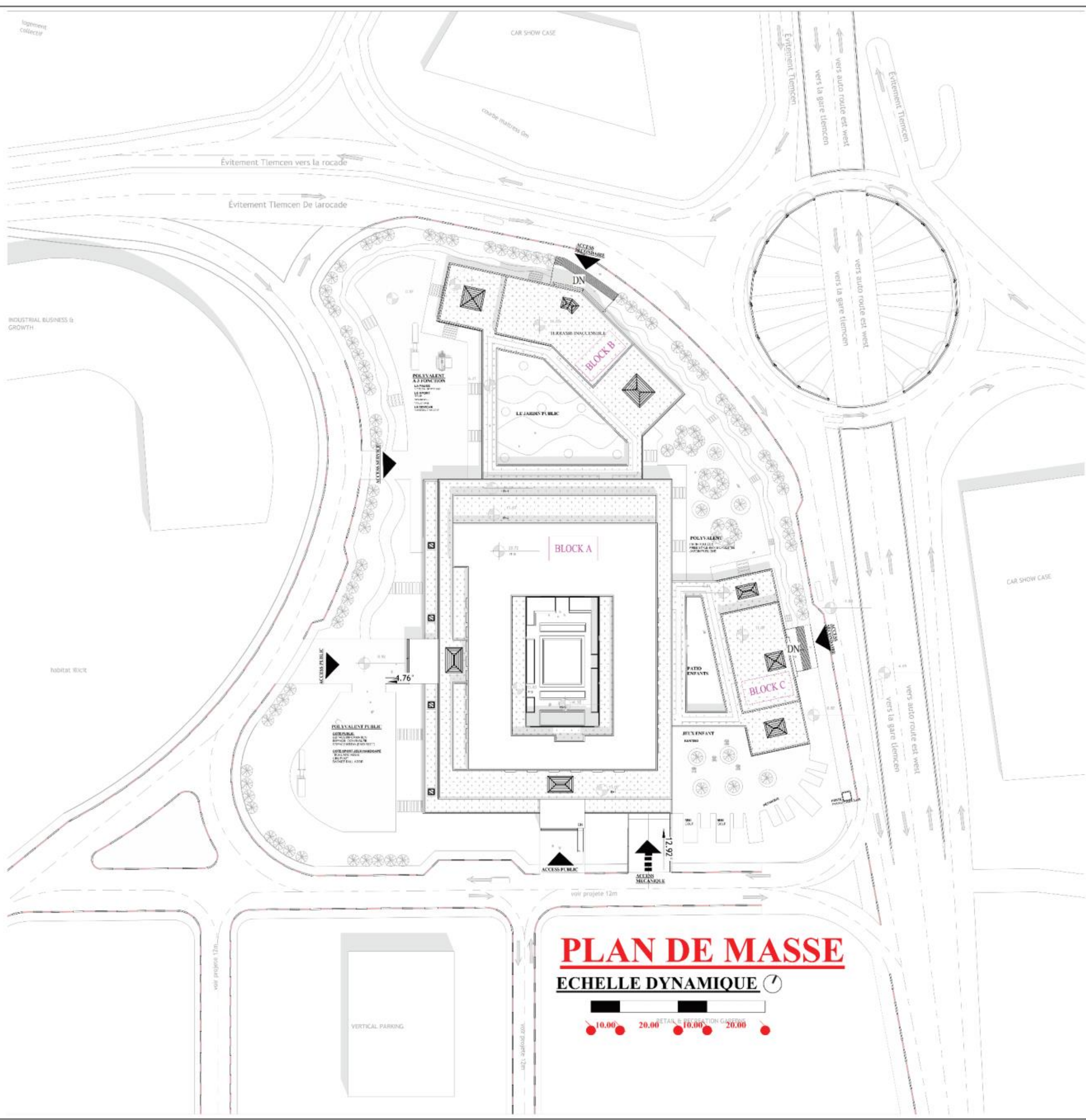

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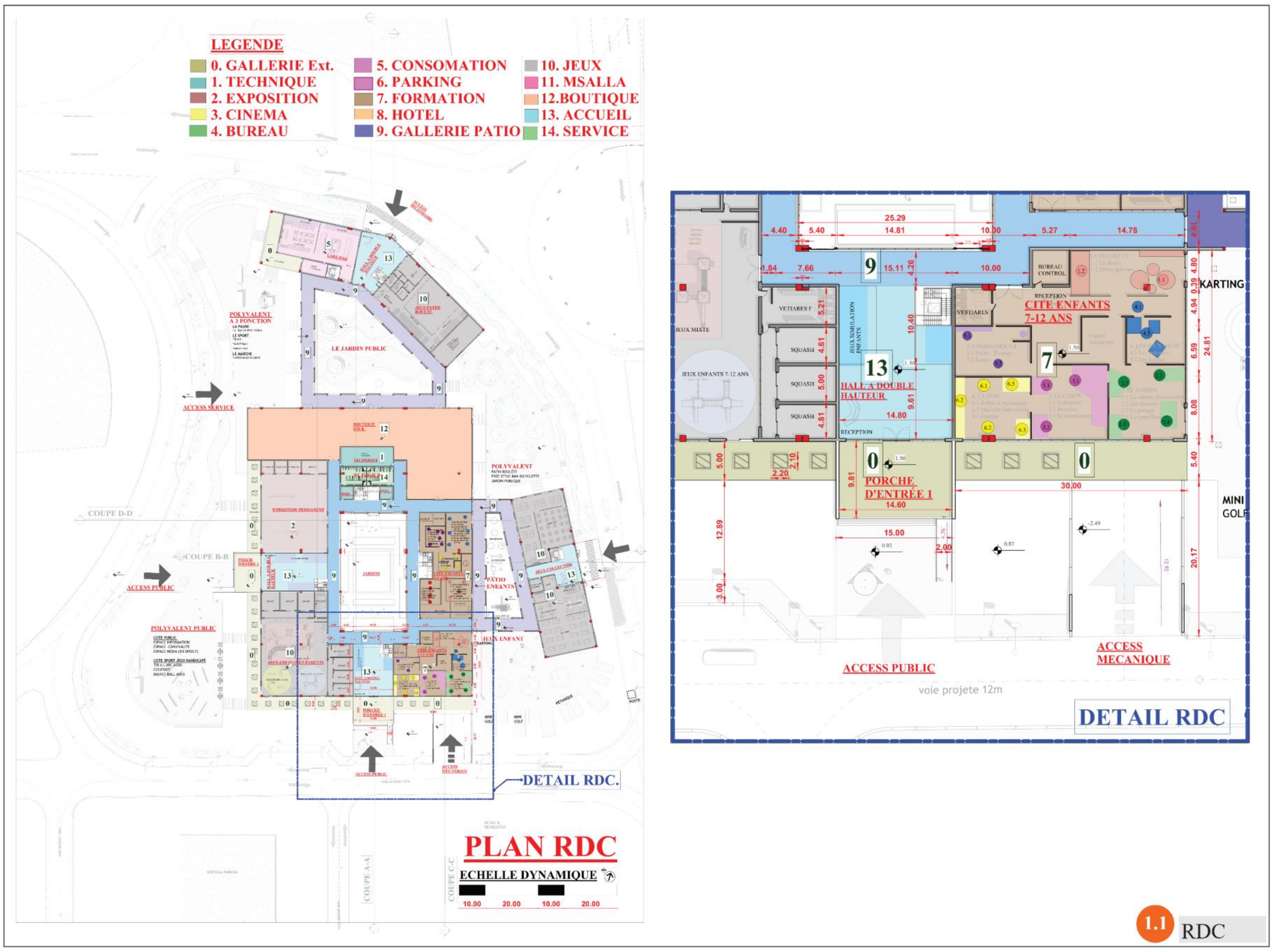
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1. TECHNIQUE
2. EXPOSITION
3. CINEMA
4. BUREAU
5. CONSOMATION
6. PARKING
7. FORMATION
8. HOTEL
9. GALLERIE PATIO
10. JEUX
11. MSALLA
12.BOUTIQUE
13. ACCUEIL
14. SERVICE
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PLAN RDC
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CITE ENFANTS
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HAUTEUR
PORCHE
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GOLF
ACCESS PUBLIC
ACCESS
MECANIQUE
voie projete 12m
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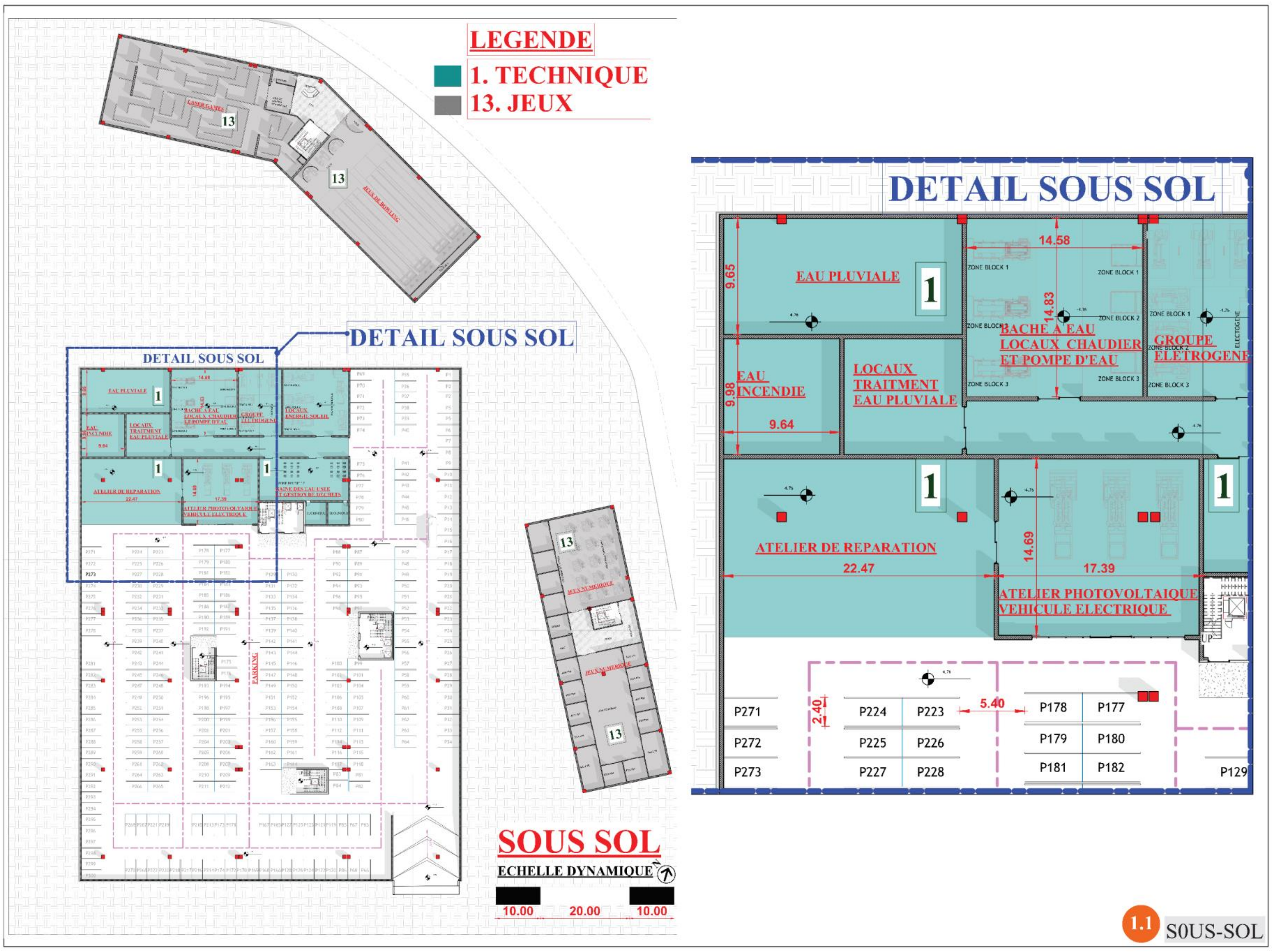
RDC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BACHE A EAU
LOCAUX CHAUDIER
ET POMPE D'EAU
GROUPE
ELETROGENE
EAU
INCENDIE
LOCAUX
TRAITMENT
EAU PLUVIALE
ATELIER DE REPARATION
ATELIER PHOTOVOLTAIQUE
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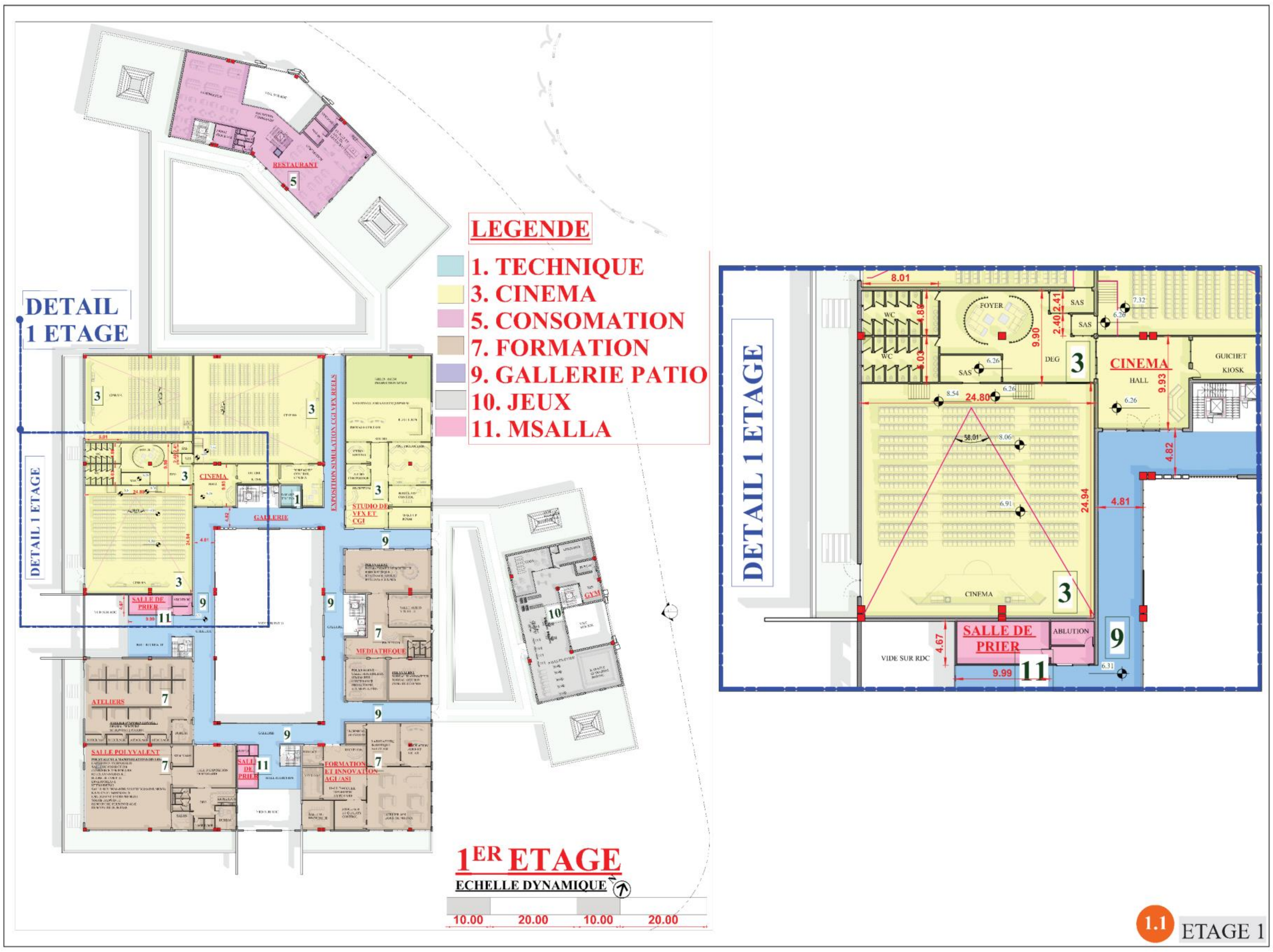
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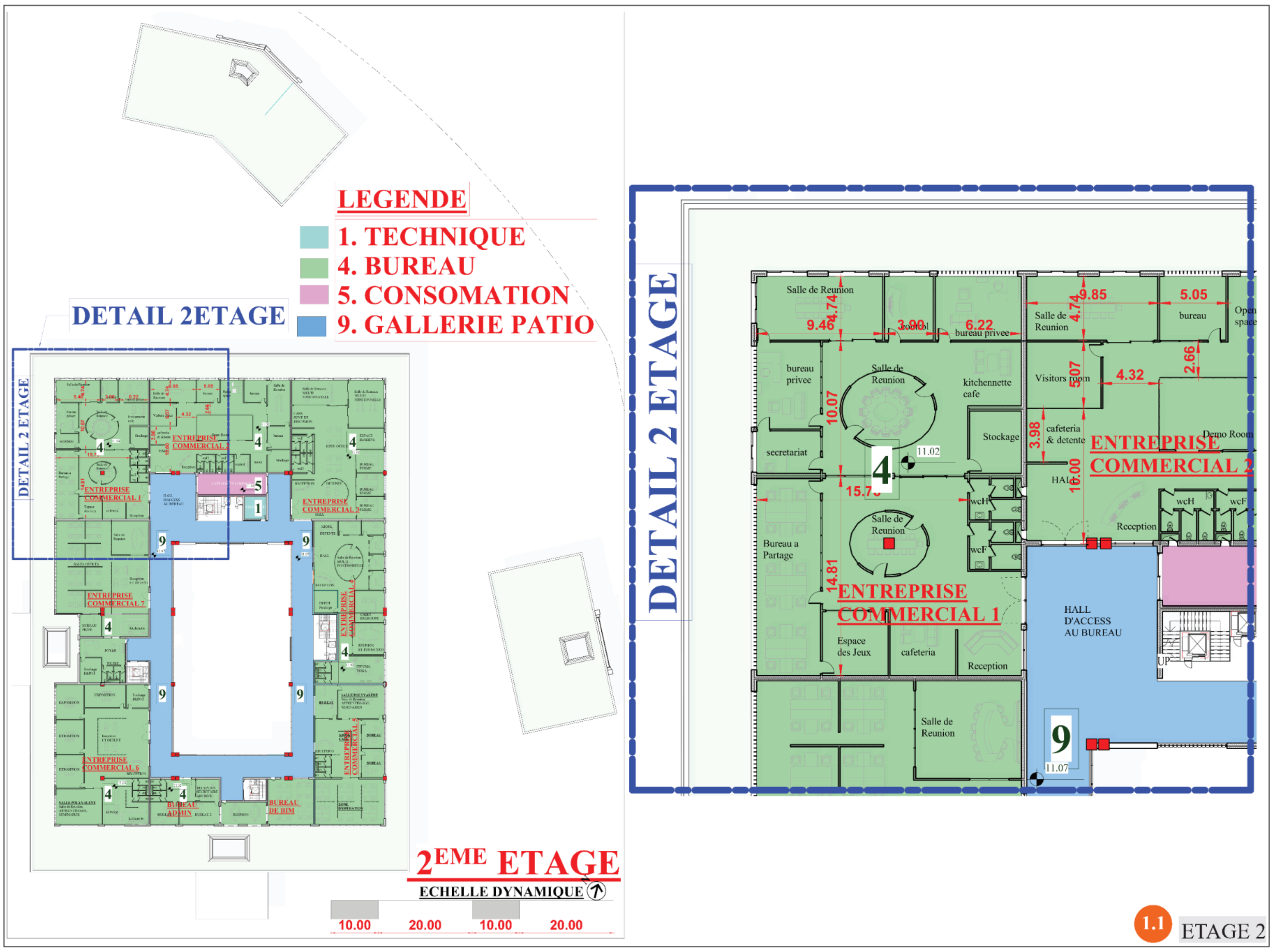
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5. CONSOMATION
9. GALLERIE PATIO
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DETAIL 2 ETAGE
ENTREPRISE COMMERCIAL 1
ENTREPRISE COMMERCIAL 2
2EME ETAGE
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Salle de Reunion
bureau privee
secretariat
Bureau a Partage
kitchennette cafe
Stockage
Visitors room
cafeteria & detente
Demo Room
Reception
HALL D'ACCESS AU BUREAU
Espace des Jeux
cafeteria
9.46
4.74
3.90
6.22
9.85
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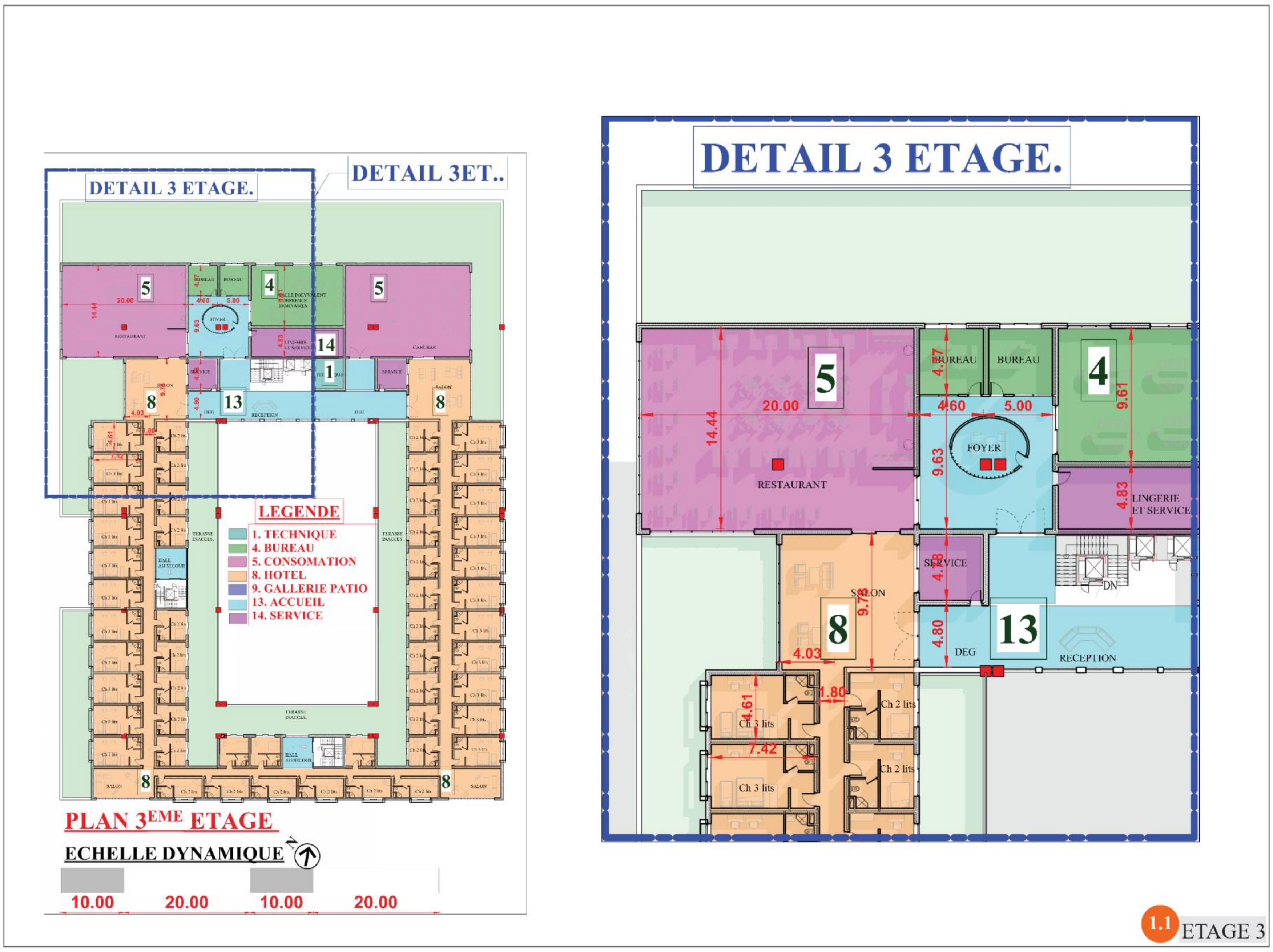
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FACADE COUPE OUEST
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FACADE COUPE EST
FACADE COUPE NORD
EQUIPMENT
EVITEMENT TLEMCEN
ROND POINT KOUDIA
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TERRASSE A CIRCULATION
BLOCK A
ACCESS PRINCIPAL 1
ACCESS PRINCIPAL 2
VOIR PROJETE
JARDIN
ACCES PARKING
BLOCK C (ACCESS)
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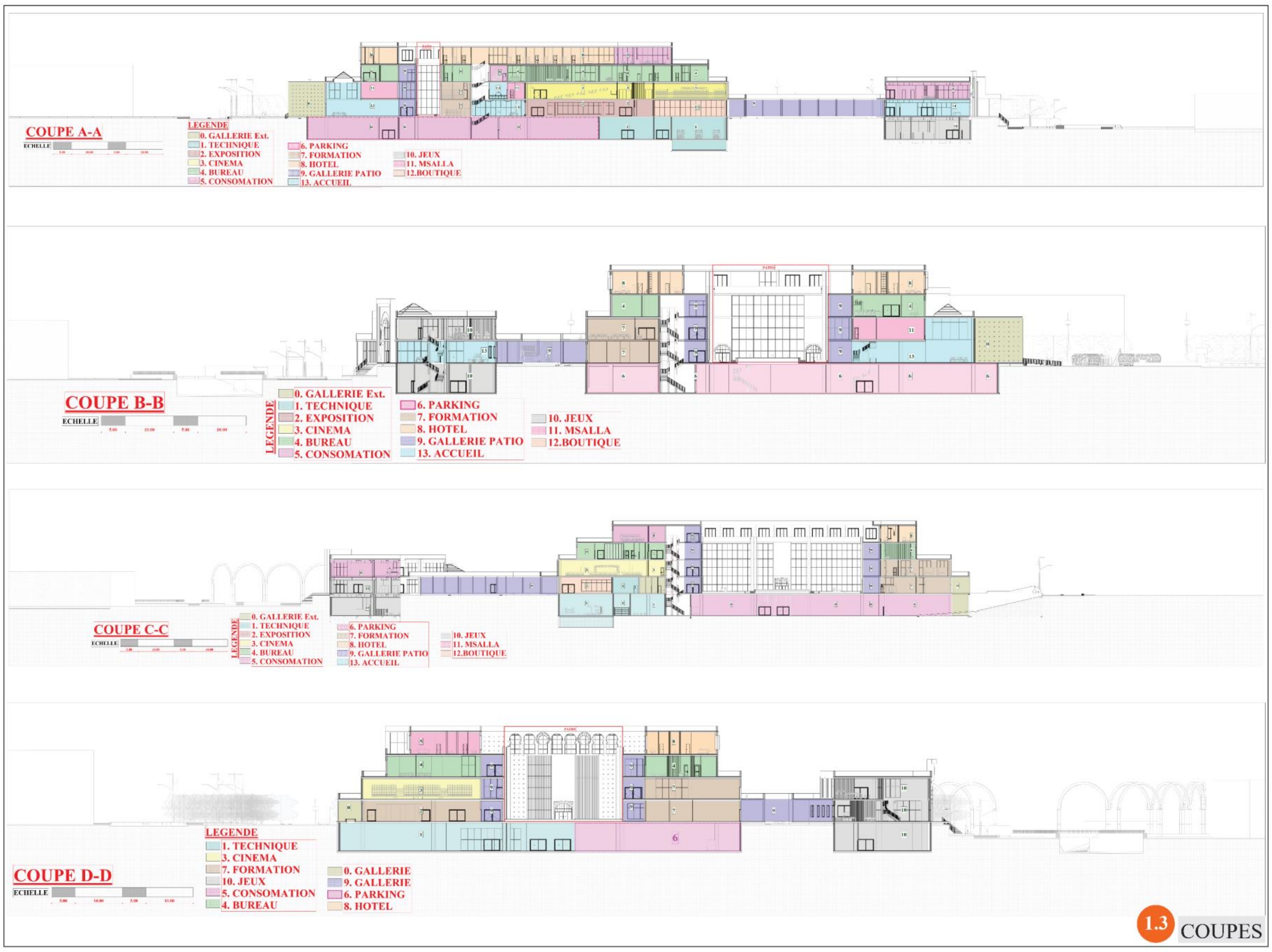
BLOCK C
BLOCK B
ACCESS SECONDAIRE
1.2
FACADE


COUPE A-A
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12.BOUTIQUE
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6. PARKING
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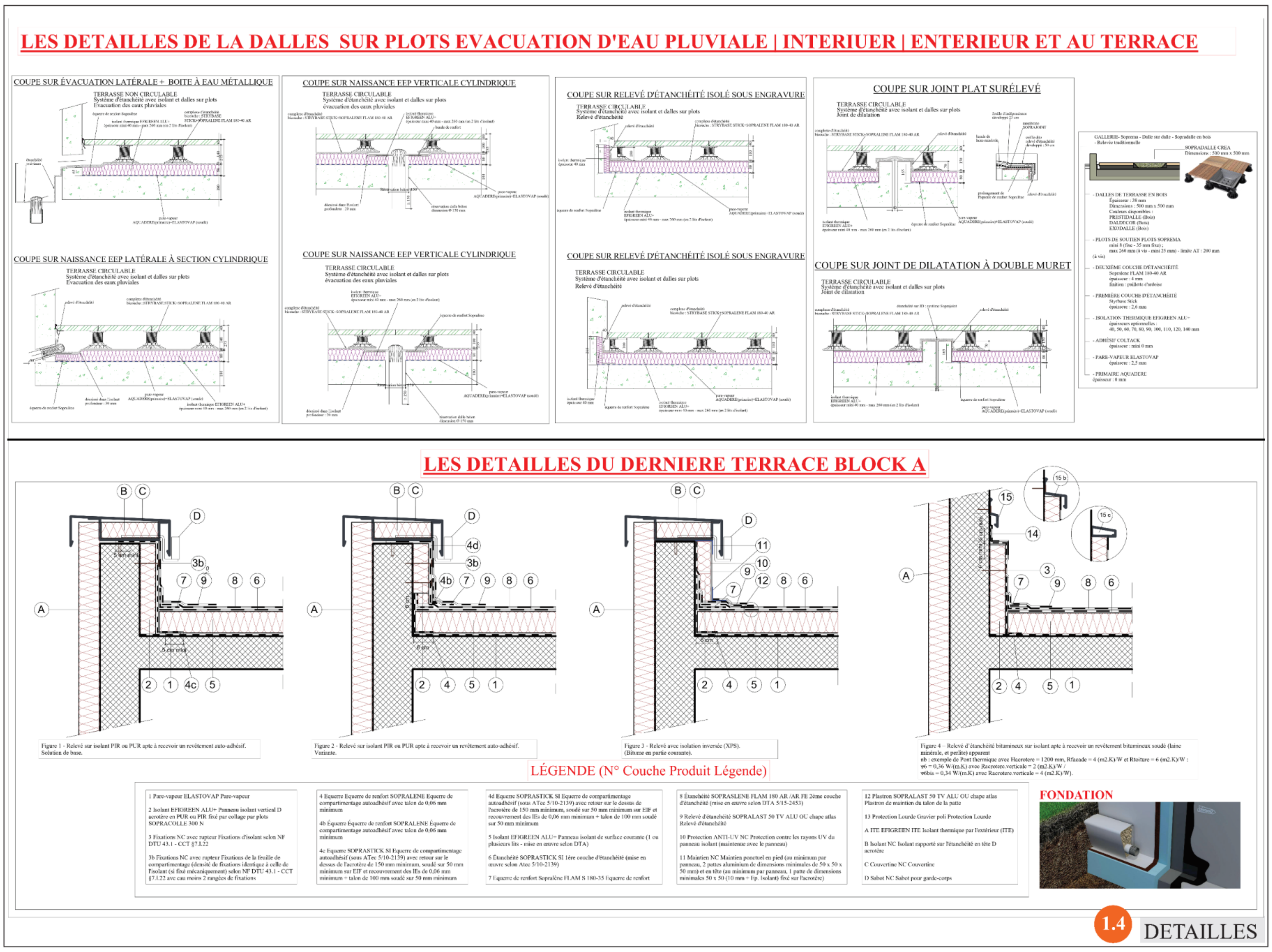
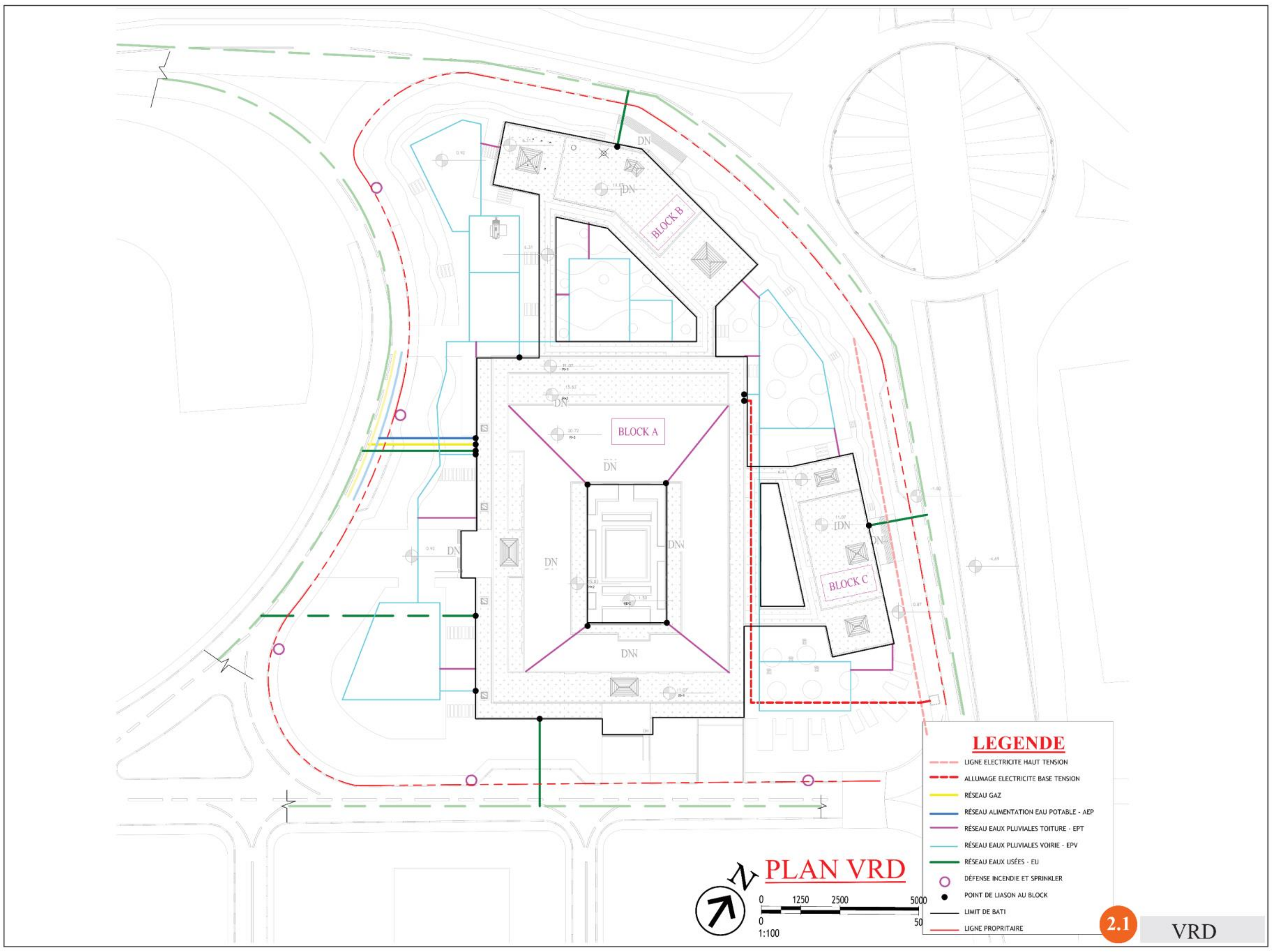
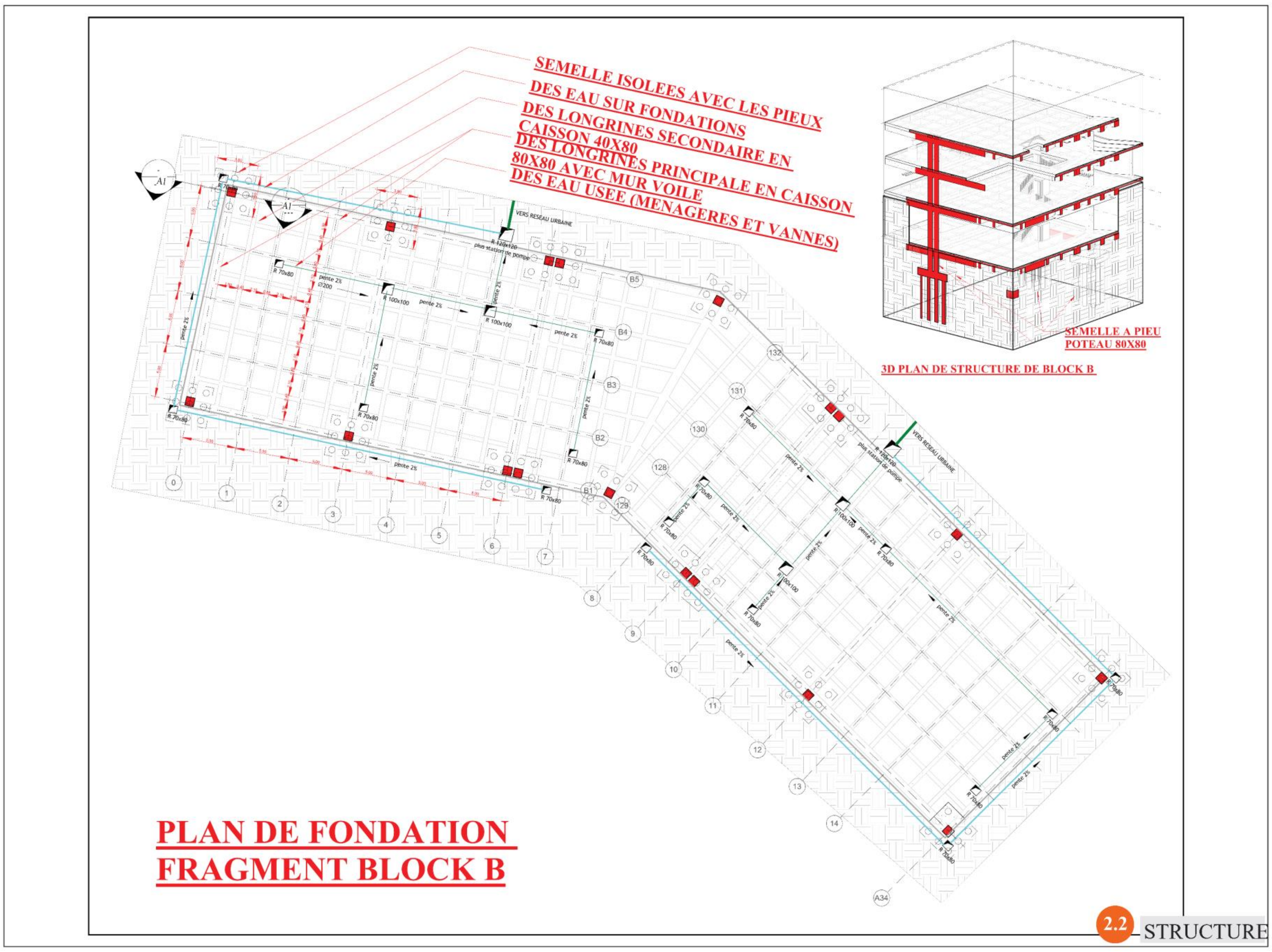
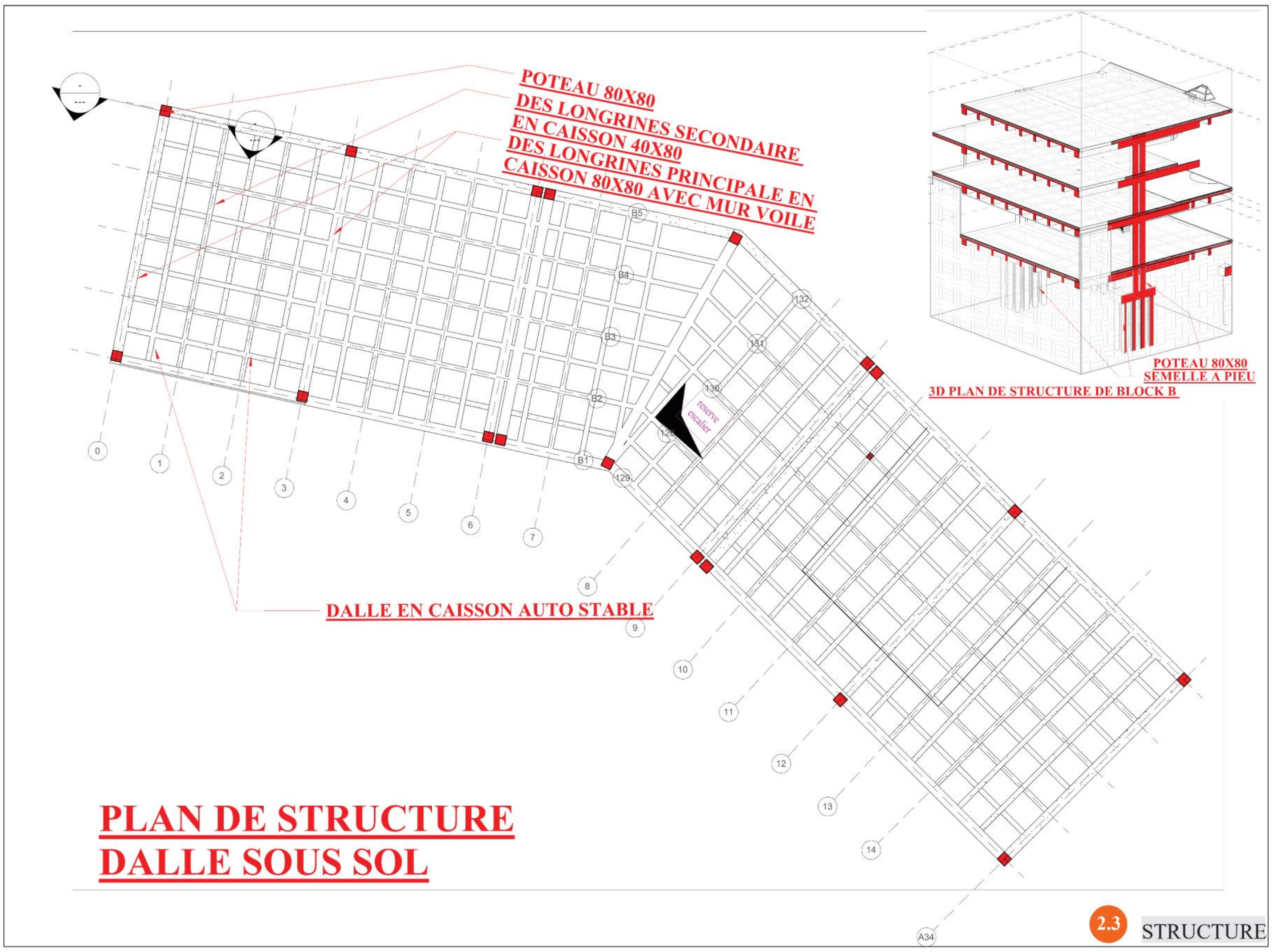

LES DETAILLES DE LA DALLES SUR PLOTS EVACUATION D'EAU PLUVIALE | INTERIUER | ENTERIEUR ET AU TERRACE
COUPE SUR ÉVACUATION LATÉRALE + BOITE À EAU MÉTALLIQUE
COUPE SUR NAISSANCE EEP VERTICALE CYLINDRIQUE
COUPE SUR RELEVÉ D'ÉTANCHÉITÉ ISOLÉ SOUS ENGRAVURE
COUPE SUR JOINT PLAT SURÉLEVÉ
COUPE SUR NAISSANCE EEP LATÉRALE À SECTION CYLINDRIQUE
COUPE SUR NAISSANCE EEP VERTICALE CYLINDRIQUE
COUPE SUR RELEVÉ D'ÉTANCHÉITÉ ISOLÉ SOUS ENGRAVURE
COUPE SUR JOINT DE DILATATION À DOUBLE MURET
LES DETAILLES DU DERNIERE TERRACE BLOCK A
LÉGENDE (N° Couche Produit Légende)
FONDATION
1.4
DETAILLES

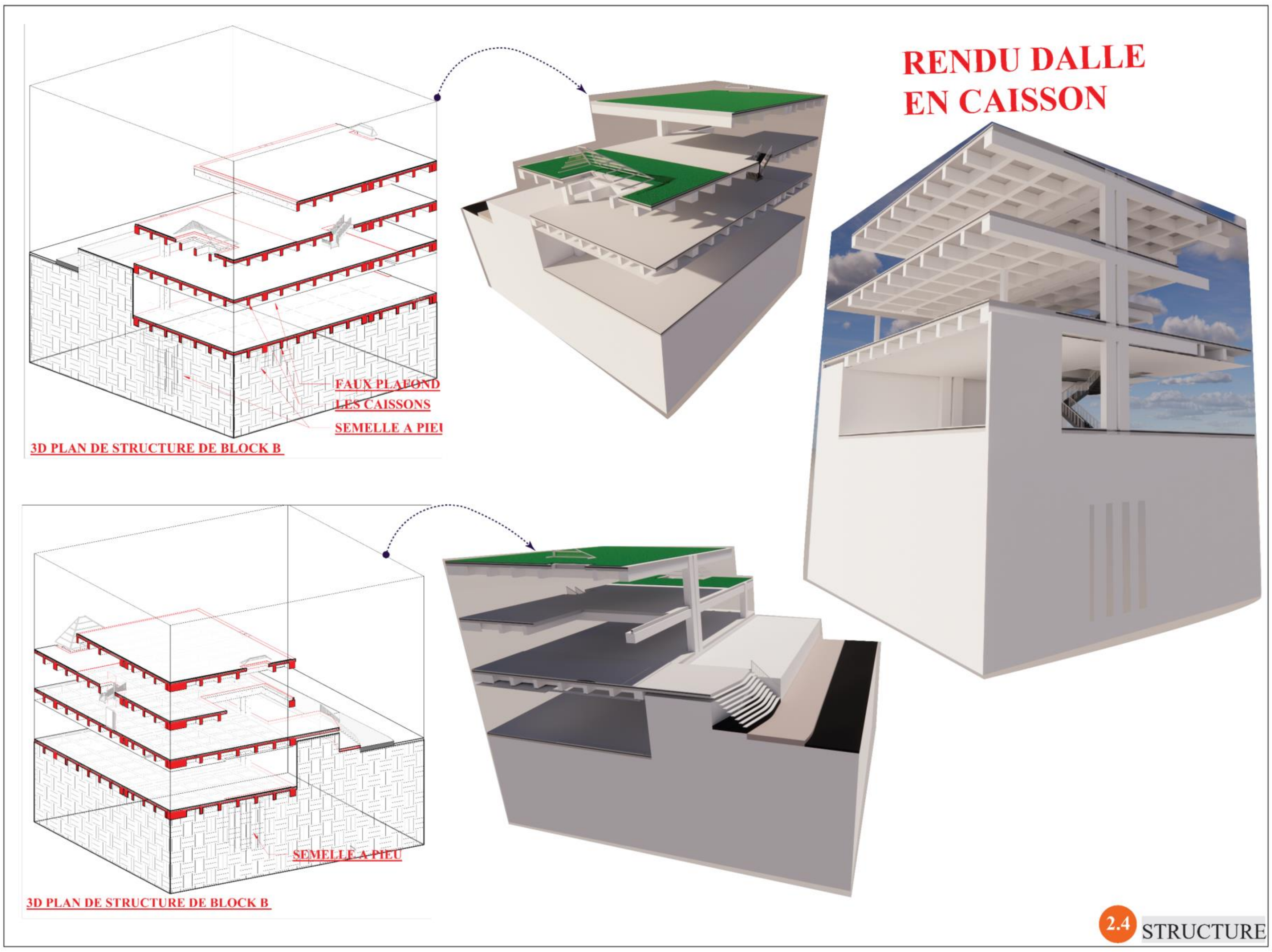
TERRASSE VERTE
DÉTAILS DU SYSTÈME DE TOITURE VÉGÉTALISÉE SUR SUBSTRAT EN BÉTON BLOCK DE LIASON ENTRE A,B & C
Toitures végétalisées extensives (sedum/drainage)
Protan SE Titane +
Fixations approuvées Protan
Laine minérale (MW) - peut être de type verre ou pierre
couche de contrôle de la vapeur
Substrat en béton
Toitures végétalisées extensives (sedum/drainage)
Protan SE Titane +
Fixations approuvées Protan
Polyisocyanurate (PIR) - feuille de revêtement
couche de contrôle de la vapeur
Substrat en béton
Toitures végétalisées extensives (sedum/drainage)
Protan SE Titane +
Fixations approuvées Protan
Combination EPS - MW
couche de contrôle de la vapeur
Substrat en béton
MEMBRANE PROTAINE SE TITANIUM +
• La membrane Protan SE Titanium + est une membrane PVC anti-racines avec armature en polyester, conçue pour les toitures de sedums extensifs. Cette armature en polyester permet une fixation mécanique optimale si nécessaire. Ce produit offre une protection optimale contre les rayons UV, les variations de température et les micro-organismes.
• Les sedums étant installés uniquement en été, il est important d'utiliser une membrane à la fois mécaniquement fixable et coupe-feu. La membrane Protan SE Titanium + est classée au feu Broof (t1) et Broof (t2).
MÉTHODE D'INSTALLATION DU SYSTÈME :
• Système Protan à chevauchement standard
• Système Protan à plaques préfabriquées
• Système Protan à fixation invisible
COULEURS STANDARD AVEC LES CODES RAL LES PLUS PROCHES
ÉTANCHÉITÉ DES TOITURES VÉGÉTALISÉES AVEC MEMBRANE D'ÉTANCHÉITÉ LIQUIDE POLYURÉTHANE-BITUMINEUSE ISOFLEX-PU 560 BT
ISOFLEX-PU 560 BT est une membrane d'étanchéité liquide bicomposante polyuréthane-bitumineuse. Marquée CE selon la norme EN 1504-2, elle est certifiée anti-racines. Consommation : environ 1,2 à 2,0 l/m² en 2 à 3 couches, selon le support.
DELTA-FLORAXX TOP est une membrane drainante en polyéthylène haute densité, avec des alvéoles octogonales de 20 mm de hauteur et un géotextile en polypropylène collé sur une face.
1 - SUPPORT
2 - PRIMAIRE PU 100 Épaisseur minimale
3 - ISOFLEX-PU 560 BT 2 couches de 0,7 mm chacune
4 - GÉOTEXTILE 130 g/m² 1 mm
5 - DELTA-FLORAXX TOP 21 mm
6 - Plantation
COUCHE DES MUR (FLEX 4.0) ET TYPE DE VITRE
Assemblages de murs structurels approuvés
Goujon en acier
Montant en bois
Béton
CMU rempli
Composants clés
Barrière contre l'air et l'humidité
Le premier composant du système StoTherm® ci est StoGuard®. Il s'agit d'une barrière pare-air et pare-humidité (BPA) appliquée par fluide, conçue pour servir de première ligne de protection de l'enveloppe murale. Elle assure un contrôle optimal de l'infiltration d'humidité et des fuites d'air, améliorant ainsi les performances du bâtiment et le confort des occupants.
Adhérence et drainage de l'isolant
Le deuxième composant du système est constitué de rubans adhésifs Sto. Ces rubans assurent l'adhérence des panneaux d'isolation thermique et agissent comme des canaux permettant à l'humidité, éventuellement présente derrière la couche d'isolation, de migrer vers la surface du mur et de l'évacuer par le bas.
Isolation thermique
Le troisième composant est un panneau isolant en polystyrène expansé (PSE) conforme aux normes ASTM E2430 et ASTM C578 Type I, ou l'utilisation de panneaux isolants en polystyrène extrudé (XPS) Foamular® CI-C ou Dow STYROFOAM™ Panel Core 20. Ces couches de contrôle thermique offrent des performances optimales qui respectent ou dépassent la norme de conception ASHRAE 90.1-2019, le code énergétique IECC 2018 et sont conformes aux normes NFPA 285 et NFPA 268.
Finition architecturale
Le dernier composant de notre système StoTherm® ci est la finition architecturale Sto, utilisant Stolit® Lotusan® et la technologie Lotus-Effect®. Stolit Lotusan est une finition extrêmement polyvalente qui imite les propriétés autonettoyantes de la feuille de lotus et offre des possibilités infinies de textures riches et de finitions décoratives pour sublimer l'esthétique et l'expression artistique de votre projet jusque dans les moindres détails.
Finition de placage de maçonnerie collée
Le composant final du StoTherm® ci MVES est le placage de maçonnerie collé (AMV). Choisissez parmi une vaste gamme de matériaux esthétiques conformes aux normes, tels que la brique mince, la pierre naturelle, la pierre de culture ou le carrelage en céramique. Après la pose initiale, les placages de maçonnerie sont recouverts d'un coulis ou d'un mortier de jointoiement conforme à la norme ANSI 118.7.
Assemblage mural
1. Assemblage de murs structurels
2. Barrière contre l'air et l'humidité
3. Adhesive
4. EPS/XPS Panneau isolant
5. Maillage
6. Basecoat
7. Primer
8. Finition architecturale
PORTE VITRÉE AU BLOCK A DANS LES BUREAU
7 Porte vitrée double à deux vitres latérales
6 Porte vitrée simple avec deux vitres latérales
MUR FLEXIBLE (RDC-EXPOSITION)
1.4
DETAILLES

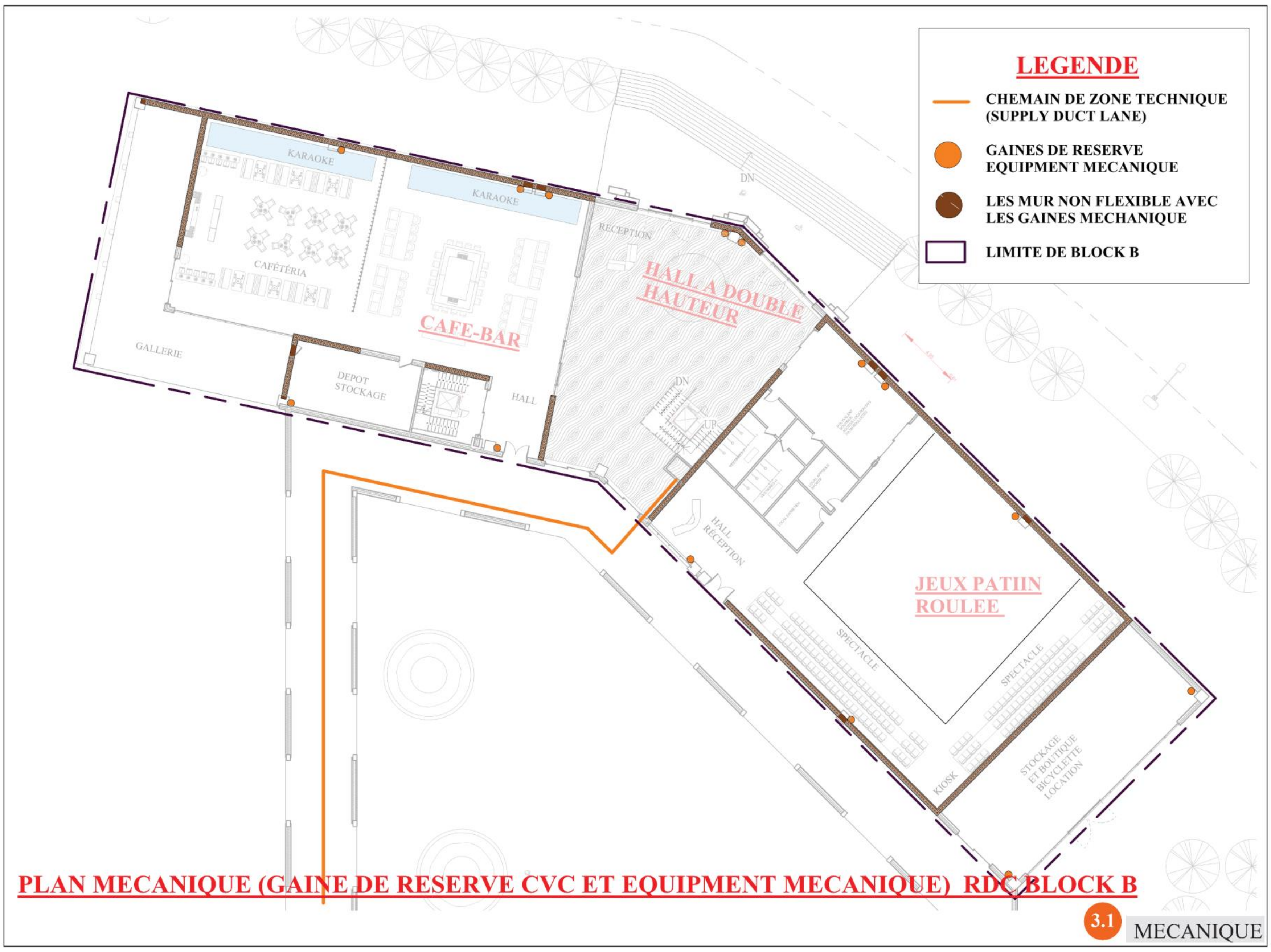


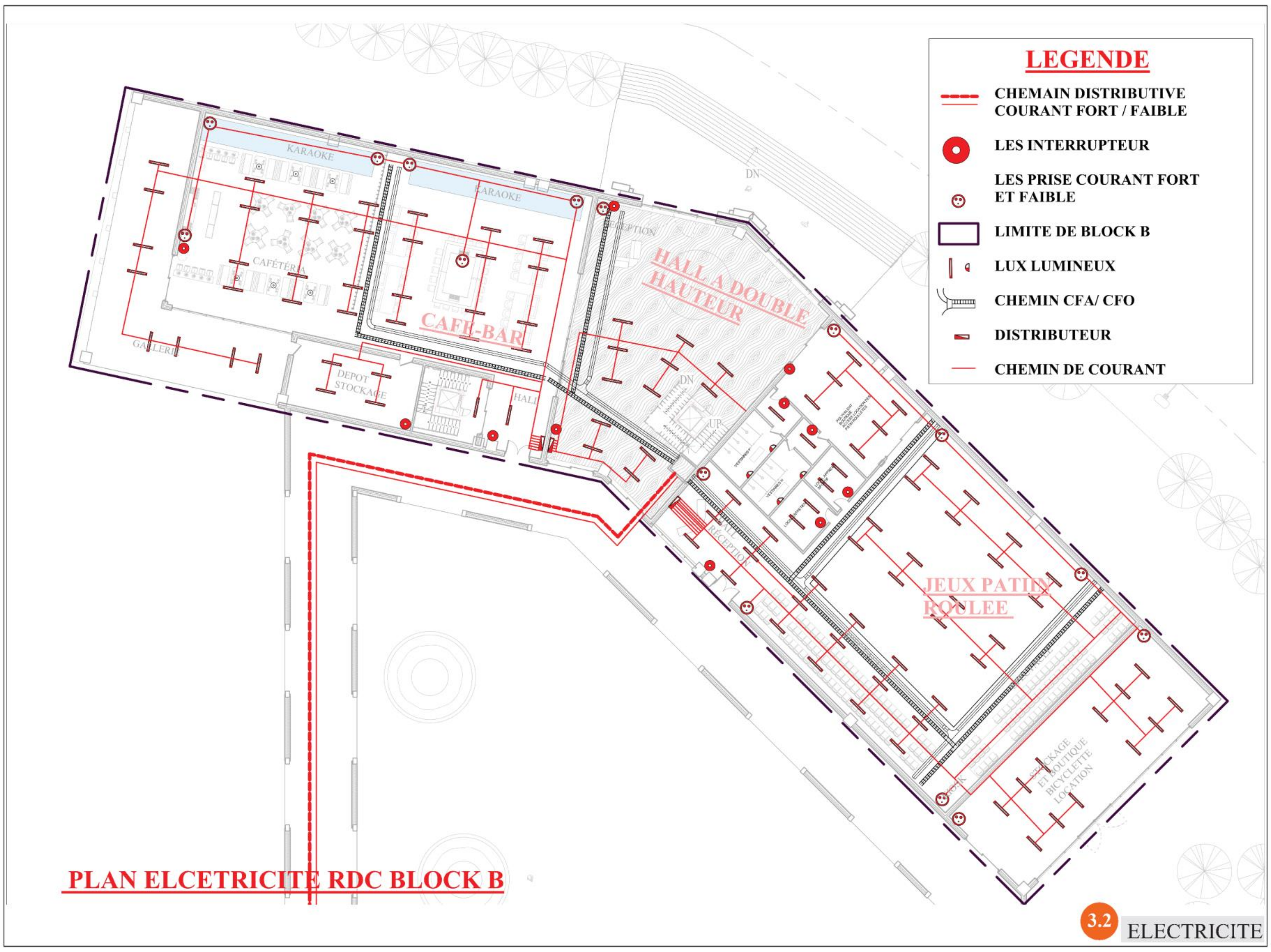
BLOCK B
BLOCK A
BLOCK C
DN
LEGENDE
LIGNE ELECTRICITE HAUT TENSION
ALLUMAGE ELECTRICITE BASE TENSION
RÉSEAU GAZ
RÉSEAU ALIMENTATION EAU POTABLE - AEP
RÉSEAU EAUX PLUVIALES TOITURE - EPT
RÉSEAU EAUX PLUVIALES VOIRIE - EPV
RÉSEAU EAUX USÉES - EU
DÉFENSE INCENDIE ET SPRINKLER
POINT DE LIASON AU BLOCK
LIMIT DE BATI
LIGNE PROPRITAIRE
PLAN VRD
0 1250 2500 5000
1:100
2.1
VRD

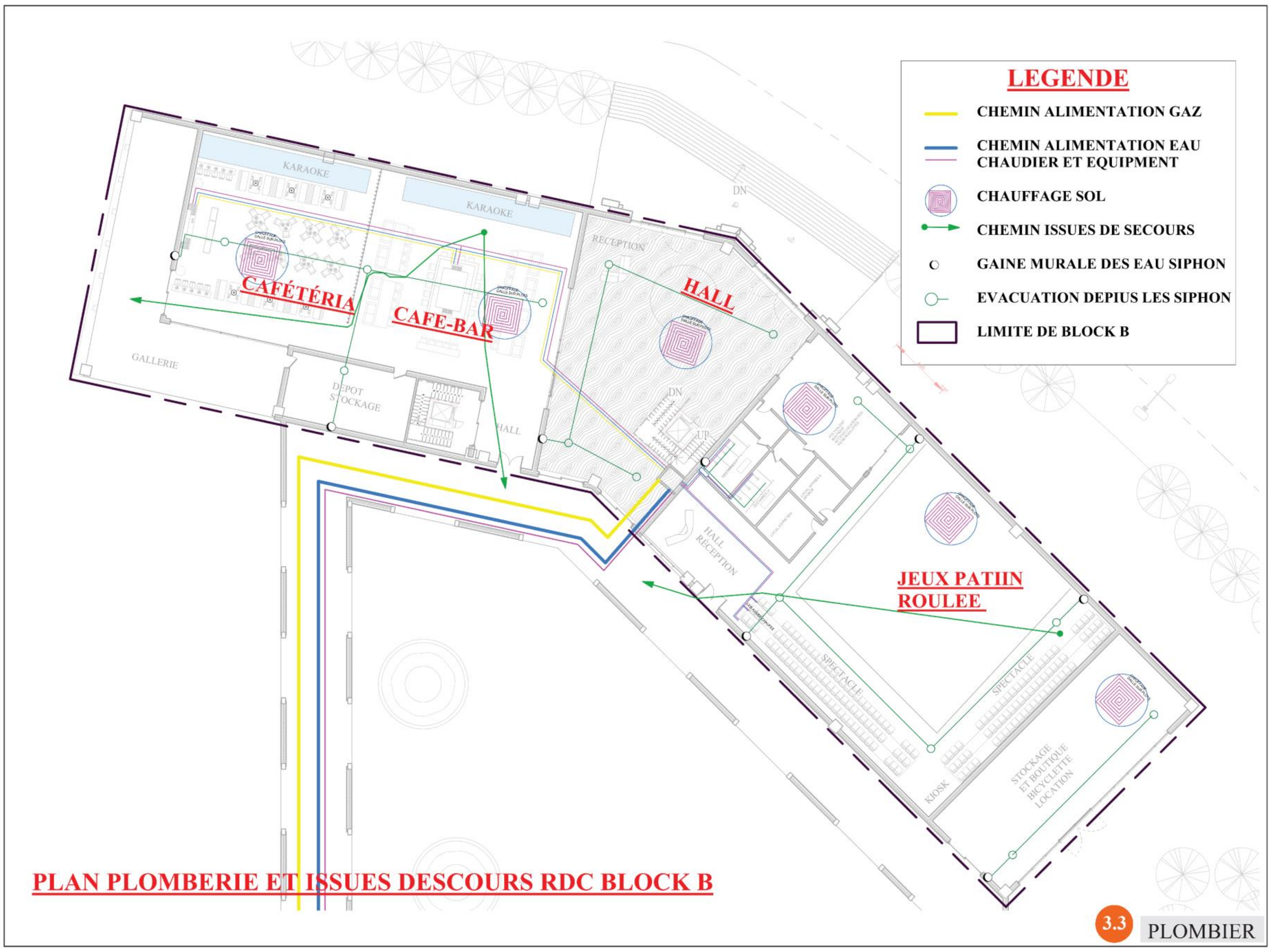

SEMELLE ISOLEES AVEC LES PIEUX
DES EAU SUR FONDATIONS
DES LONGRINES SECONDAIRE EN CAISSON 40X80
DES LONGRINES PRINCIPALE EN CAISSON 80X80 AVEC MUR VOILE
DES EAU USEE (MENAGERES ET VANNES)
SEMELLE A PIEU
POTEAU 80X80
3D PLAN DE STRUCTURE DE BLOCK B
PLAN DE FONDATION
FRAGMENT BLOCK B
2.2 STRUCTURE

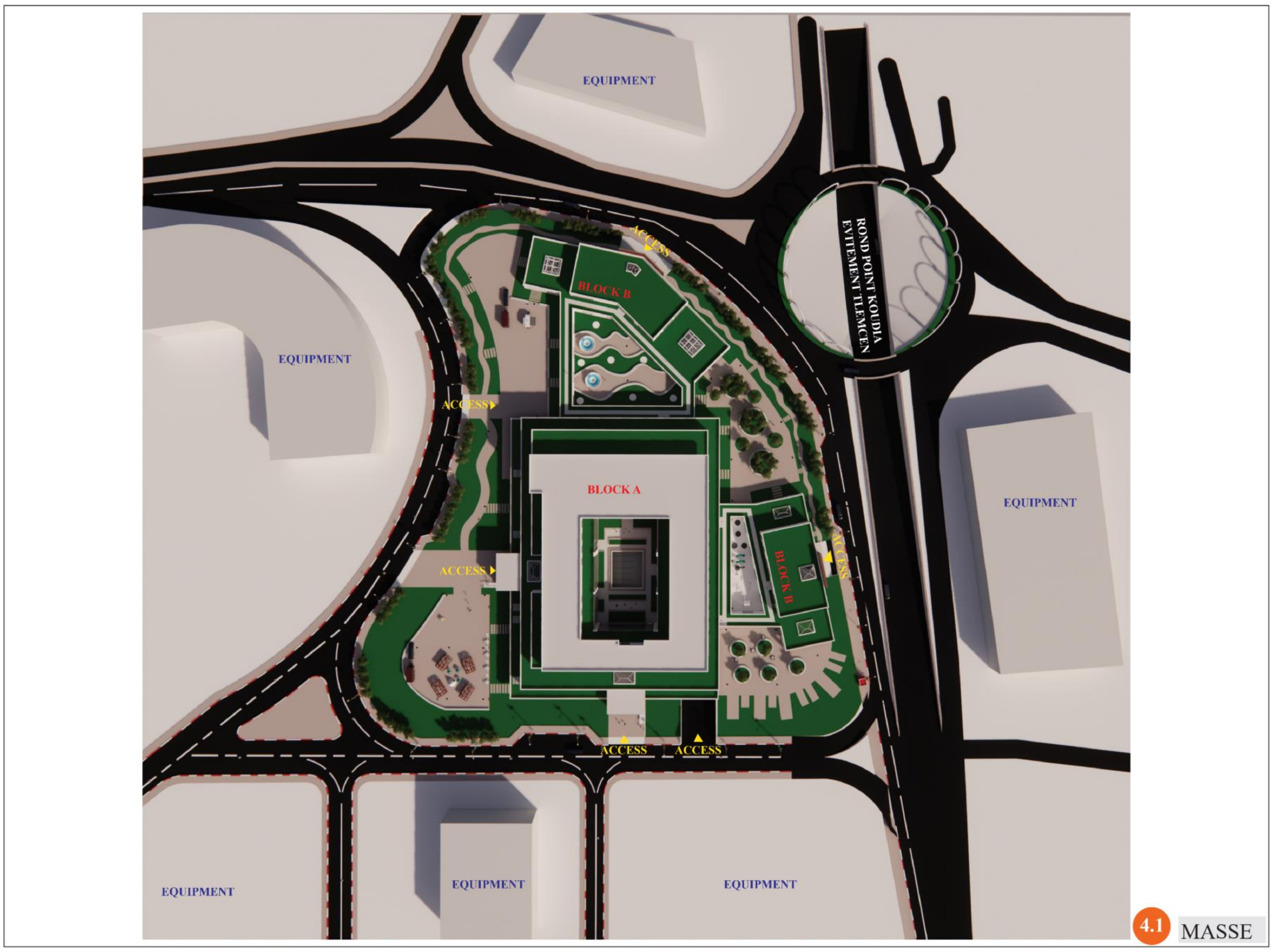

POTEAU 80X80
DES LONGRINES SECONDAIRE EN CAISSON 40X80
DES LONGRINES PRINCIPALE EN CAISSON 80X80 AVEC MUR VOILE
POTEAU 80X80
SEMELLE A PIEU
3D PLAN DE STRUCTURE DE BLOCK B
reserve escalier
DALLE EN CAISSON AUTO STABLE
PLAN DE STRUCTURE
DALLE SOUS SOL
2.3 STRUCTURE


RENDU DALLE
EN CAISSON
FAUX PLAFOND
LES CAISSONS
SEMELLE A PIEI
3D PLAN DE STRUCTURE DE BLOCK B
SEMELLE A PIEU
3D PLAN DE STRUCTURE DE BLOCK B
2.4
STRUCTURE


LEGENDE
CHEMAIN DE ZONE TECHNIQUE (SUPPLY DUCT LANE)
GAINES DE RESERVE EQUIPMENT MECANIQUE
LES MUR NON FLEXIBLE AVEC LES GAINES MECHANIQUE
LIMITE DE BLOCK B
KARAOKE
KARAOKE
CAFÉTÉRIA
CAFE-BAR
GALLERIE
DEPOT STOCKAGE
HALL
RECEPTION
HALL A DOUBLE HAUTEUR
HALL RECEPTION
JEUX PATIIN ROULEE
SPECTACLE
SPECTACLE
KIOSK
STOCKAGE ET BOUTIQUE BICYCLETTE LOCATION
PLAN MECANIQUE (GAINE DE RESERVE CVC ET EQUIPMENT MECANIQUE) RDC BLOCK B
3.1
MECANIQUE


LEGENDE
CHEMAIN DISTRIBUTIVE COURANT FORT / FAIBLE
LES INTERRUPTEUR
LES PRISE COURANT FORT ET FAIBLE
LIMITE DE BLOCK B
LUX LUMINEUX
CHEMIN CFA/ CFO
DISTRIBUTEUR
CHEMIN DE COURANT
HALL A DOUBLE HAUTEUR
CAFE-BAR
JEUX PATIIN ROULEE
PLAN ELCETRICITE RDC BLOCK B
3.2
ELECTRICITE


LEGENDE
CHEMIN ALIMENTATION GAZ
CHEMIN ALIMENTATION EAU CHAUDIER ET EQUIPMENT
CHAUFFAGE SOL
CHEMIN ISSUES DE SECOURS
GAINE MURALE DES EAU SIPHON
EVACUATION DEPIUS LES SIPHON
LIMITE DE BLOCK B
CAFÉTÉRIA
CAFE-BAR
HALL
JEUX PATIIN ROULEE
PLAN PLOMBERIE ET ISSUES DESCOURS RDC BLOCK B
3.3
PLOMBIER


EQUIPMENT
EQUIPMENT
ACCESS
BLOCK B
ROND POINT KOUDIA
EVITEMENT TLEMCEN
ACCESS
BLOCK A
EQUIPMENT
BLOCK B
ACCESS
ACCESS
ACCESS
ACCESS
EQUIPMENT
EQUIPMENT
EQUIPMENT
4.1
MASSE


VIEW D'ENSEMBLE COTE SUD
FACADE PRINCIPALE 1.
FACADE SUD DE PATIO
FACADE PRINCIPALE 1.
VIEW PROCHE
VIEW D'ENSEMBLE COTE NORD
FACADE BLOCK B
VIEW PROCHE
FACADE BLOCK B
VIEW PROCHE
4.2
FACADES

SCAN ME: LA PRESENTATION

SCAN ME: LE DOSSIER GRAPHIC

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