The Urban Lab of Europe!

JOURNAL

PROJECT

Earth Cycle - On-site recycling process of extracted soil from the subway work in SEVRAN and its impact on the circular economy

Sevran, France

TOPIC

Circular economy

EDIT 05 NOVEMBER 2021
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Journal 3 Earth Cycle

See on UIA website

In this third journal, we will present a questioning about the replication and upscaling of the Earth Cycle model in the Parisian Region by placing it in the perspective of a circular economy approach. This issue is a major political task in Europe and on the scale of the Parisian region.

Executive summary

The Cycle Terre: Earth Cycle project, supported by Urban Innovative Actions, is in its final stage of implementation. The factory and the building housing dedicated to this important production process are completed and their inauguration will take place officially before the end of 2021. A cooperative company for the development of this process is also created. Earth Cycle seeks to foster a new urban planning development model based on the use of excavated soil from major construction sites to produce construction materials.

In this third journal, we will present a questioning about the replication and upscaling of the Earth Cycle model in the Parisian Region by placing it in the perspective of a circular economy approach. This issue is a major political task in Europe and on the scale of the Parisian region.

As the project is a success achievement as an innovative pilot, the fundamental question is how to ensure the sustainability of the innovation and the development of a praised process. This reflection will offer an easier integration of this process in the management of excavated earth in the Parisian region.

The journal presents the territorial and project context in the first part. The second part presents briefly the project and the key elements related to its sustainability. The assessment of the challenges is discussed in the third part. This analysis allows demonstrating that the development potential of Earth Cycle is important and the next stage of development without the UIA support is very sensitive for the future.

In the fourth part a theoretical reflection on this urban innovation is discussed. In the fifth part, the analysis of the duplication and upscaling issues of Earth Cycle is presented.

This journal presents the evolution of the situation of Earth Cycle at the end of the pilot development phase. It opens the discussions on the way to make it essential in the process of managing excavated soil Paris region.

The territorial context

In Journal 2 of the Earth Cycle project, we insisted on the fact that Paris Region produces around 30 million tons of DCW (Demolition and Construction Waste) per year, including 25 million tons of inert waste, **including around 18 million tons of excavated earth per year**. The creation of the infrastructures of the Grand Paris Express (GPE) and the town planning operations linked to it will generate even greater production in the coming years: it is expected that 60 million tons will be generated by the Société du Grand Paris (SGP) by 2030. These volumes demonstrate the need for the development of research and innovation actions on a regional scale but also implementation strategies on large scales have to be discussed and elaborated.

This important volume of earth (i.e. four Pyramids of Khufu), must be extracted, transported and valued in a smart and sustainable way. This topic seems to have been completely neglected in urban planning and urban development for the past 30 years, with some exceptions, while it used to be a part of the spontaneous regeneration of urban spaces in the previous periods, as mentioned before. Earth Cycle is an active contributor in an attempt to implement circular economy logic in urban planning. The actors mobilized around this action offer this possibility.

The objective of this journal is to discuss Earth cycle duplication and scaling up strategies in an attempt to address the problems regarding excavated earth management in the Paris Region. Developing an approach to use these soils as a construction material is a large contribution in the development of circular economy in the Parisian region. The duplication of the pilot proposed and implemented by the Urban Innovation Action's project in Sevran is a major issue for the coming period. Scaling up a pilot is an important element of the success of the UIA project.

The choice to deal with this theme was naturally necessary because the UIA Earth Cycle ends on 10/30/2021 and one of the perspectives to be implemented would be the duplication of the pilot in other territories. This journal analyzes this perspective and the strategy proposed through actions of promotion, communication, dissemination of knowledge but above all the development of the factory and the cooperative society.

Earth Cycle proposes to reuse and to valorize the excavated earth to produce building materials with low environmental impact. A raw earth materials factory located in Sevran was designed and built. This factory will produce from autumn 2021 blocks of compressed earth, mortars and coating.

During the UIA project, many initiatives to organize the earth construction sector have been revealed necessary in parallel with the construction of the factory, so that the pilot finds its place in a local ecosystem first then towards a regional scale. These actions relate to three major categories:

- Technical Certification of materials' performance.
- Calculation of their ecological footprint for integration in a Life Cycle Assessment. Three documents of an Environmental and Health Declarations for masonry walls and coating were elaborated.
- The training of architectural professionals and the building sector to the use of materials.

The creation of the Sevran pilot factory is only a first step. The purpose of the UIA project is to test an innovative solution, by creating a knowledge base and skills, in order to then be able to generalize it. The figure 1 proposed by the Earth Cycle team, demonstrates the need of 30 production sites on the scale of the Parisian region. This estimation is based on two criteria; the potential estimated by local authorities and urban developers from one side the availability of construction materials. In this journal, we discuss these models and options.

The figure shows the map of the Parisian region and an estimation of the market potential for earth construction.

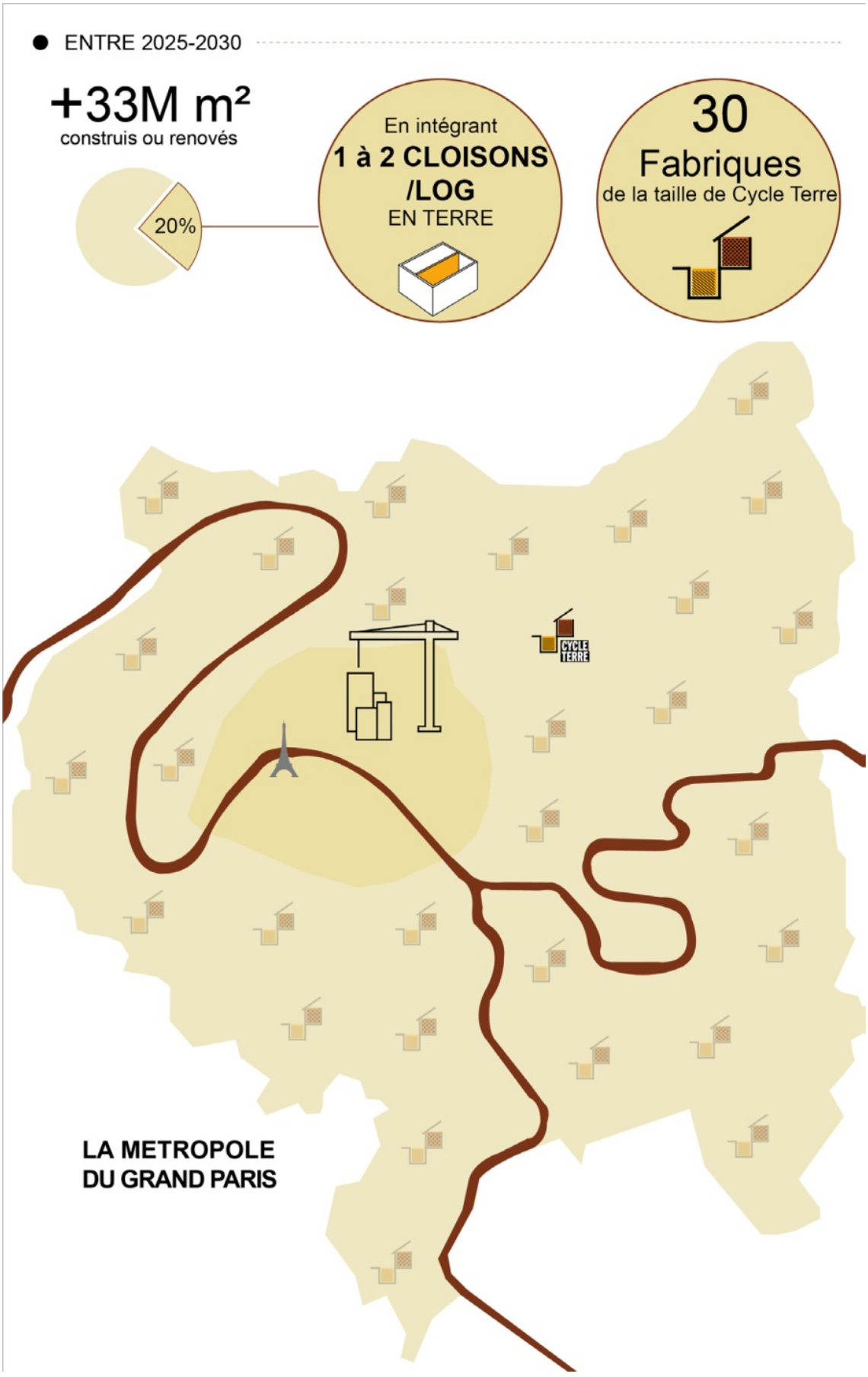

Figure 1: How many production sites are needed on the scale of the Paris Region

The project

The current dynamic of the construction sector for circular economy in the Parisian region, marked by an increasing number of local initiatives, support from the metropolitan authority Grand Paris and the Region Ile de France, requests from developers and the development of production chains, will allow major progress in the years to come. This is a very positive context for a UIA project like Earth Cycle.

In fact, the Sevran project is achieved and the factory is realized and the business and governance model, is established through the creation of a cooperative company. Earth Cycle has succeeded in setting up an ecosystem around earth construction, which will have to be developed. The choice was made to be in a cooperative and not in a competitive process!

Even if the valorization as construction materials will not concern all the excavated earth in the Parisian region, the intelligence lies in the multiplication of valorization solutions both in construction but also in landscaping, in infrastructure, etc.

It is essential to seize this resource opportunity to rethink our building production methods. History shows us that it is possible. This issue was discussed during a conference in June 2021 entitled Urban soils a positive value for the cities of tomorrow. The two co-managers of Earth Cycle presented the project achievement and also the integration of the earth as a construction material in a larger scale of valorization (https://youtu.be/PPUw2aaUHZ4).

To strengthen this dynamic, it is necessary to:

- Rely on the existing earth excavation management channel, which has considerable potential for extraction, transport and sorting capacity;
- disseminate and use the knowledge of earth construction architecture by teaching it even better in engineering schools in order to facilitate the integration of this material in projects;
- continue research into production processes;
- fund research on designs adapted to the constraints of the material, but also to deconstruct prejudices and remove regulatory obstacles on the use of earth construction.

Implementation and perpetuity challenges

An overview of the basic UIA challenges as well as project specific challenges is presented in Table 1. Besides the established UIA challenges, three more challenges are identified for the Earth Cycle project: Financial sustainability, Technical readiness, and Legislative readiness.

These three challenges are crucial for the success of the project due to the high level of technology and service innovation in the project. This analysis of the challenges is realized at the end of the UIA and takes into account the issues related to the development of the cooperative company and to the sustainability of the action once the UIA-funded period is over.

Earth Cycle project is piloting a new technology for a new urban service with new business models and partnerships. As this journal is realized at the end of the project, the indicated levels are reliable and based on the iterative process of the project evolution and on precise observations of the different stakeholders roles especially private partners and local authorities.

For example, the involvement of the city of Sevran and the Region Ile de France was very important in this final stage of the project. The flexibility and the high level involvement of the private urban developer is a very positive signal for the project sustainability and perpetuity. In addition, the mobilization of the researchers in the different fields of the project was also very important. Specialized teams in soil identification, earth construction and urban metabolism were involved and the achievements are innovative in the field of circular economy. The analysis and assessment of these challenges seem to be realistic and reliable as it is arriving at the end of the action and with hindsight on the actions carried out and the encountered difficulties.

In the table (1) the levels are discussed and classified as follows:

- High: important issues that are necessary for the project to focus on during the coming s twelve months. If not resolved, they may impact the project. As the project is finished, the next period is important to ensure he mid and long terms sustainability

- Medium: the project has a plan or they are potential showstoppers later for the project achievement.

- Low: the project had a plan or solution to mitigate or to face future difficulties.

For Earth Cycle, at this stage of achievement no challenge is considered with a risky profile. The duplication and scaling up process on the regional, and probably the national scale are undergoing. Probably the process is long but many indicators and positive political and operational signals discussed and evaluated during the last Steering committee of the project on October 21 2021 in Sevran, are encouraging.

Another assessment of the challenges will be realized in the next journal. It integrates this new context and the reality of the implementation of this potential development. The strategies of duplication and scaling up are discussed in the second part of the journal.

Challenge	Observation
Leadership for innovation Challenge level ●	The project has aroused major interest in the Paris region. The Ile de France region was associated to the project. A financial contribution of 200 000 Euro was proposed and the communication of the Region demonstrates a will to continue the support to the project. We believe that these political investments will ensure the project development. The municipality and the Mayor facilitated the administrative procedures for the project to come out by accelerating the process for urban planning and construction permit for the new implementation site. This simplification of the procedures has allowed to respect the UIA schedule. The Mayor of Sevran participated in the last steering Committee (21/10/2021) and he insisted in the fact that Sevran would be the regional leader for earthen construction and that it would allocate a lot of resources for development. The collective spirit characterizes the project and its partnership. The creation of the cooperative company is very promising for the commercial development and the sale of the factory products. A show room is also proposed by the Urban Developer. The partnership is mobilizing new actors and a two-day conference about earth construction is scheduled in Sevran in January 2022. Sevran is now the heart of Earth Construction in Paris Region.
Public Procurement Challenge level ●	As for the factory operation and the sale of products, public procurement might be an obstacle as public entities that would like to encourage the use of locally-produced geo-resourced materials will still have to guarantee market competition. The prices of the materials will probably be slightly higher than heavily industrialized, less environmental-friendly processes. In the same time, the French government is interested by developing this new environmental-friendly material by granting assistance and financial aids to potential project developers. Criteria of carbon and ecological footprint must be taken into consideration, for our materials to become competitive. Regarding the duplication in other local authorities, the public procurement or the private involvement has to be defined. The advantage is that the SCIC (Cooperative Society of Collective Interest), the operating company of the factory has already proven its worth, but other models stemming from the Circular Economy could be proposed

Integrated cross departmental working

Challenge level

Earth Cycle has taken the role of uniting many actors of earth management in the Parisian Region and even France. This integrated approach allowed an involvement of all the departments in the city and even the Region Ile de France. The project is offering a shared vision.

The department of sustainable development, infrastructures, public command and the urban development are involved in the consultation and decision process and the project is highly supported by the Mayor and his team. This interdepartmental involvement accelerates the rhythm of the project modifications and will facilitate the factory construction.

Regarding the future, this interdisciplinary approach is crucial for the implementation of future factories in Paris region.

During the last steering committee, the chief of staff and the director for technical affairs in Sevran insisted on the fact that the project created this interdisciplinary approach inside the city. It was also mentioned by the representative of the Region Ile de France that Circular economy was a priority (https://www.iledefrance.fr/zero-dechet-et-economie-circulaire)

The interdisciplinary method is proven and can be duplicated to raise awareness of all stakeholders, funders and decision-makers.

The coordination mechanisms for the co-implementation of the project performed very well. Two project managers with a high level of knowledge and involvement allow facilitating the communication and the exchanges between the project partners. This coordination is a strong point of the project.

Adopting participative approach

Challenge level

The Sevran pilot project is very close to the city center and the inhabitants were fairly motivated for the project as it is going to increase jobs opportunities. This was confirmed during the last steering committee by Mr Posmorgeur (Compétences Emploi) who showed in his presentation of WP6 of the project, the significant success in terms of local job creation and ownership of the project by young people.

Innovative governance is proposed for the factory by creating the SCIC. The company's charter allows anticipating the management of an Earth Cycle plant. The SCIC promotes collective values and has a double objective: economic efficiency and a social and democratic dimension. This approach can be applied to other local authorities if needed. The Chairman of the SCIC is insisting on this aspect in the presentation of the main targets of the project.

Sevran factory is attracting many visitors who are involved in the circular economy. We can quote the CAUE93 which is a professional regional association in charge of the sensitization of architects. They visit the site and are willing to promote this construction technique. During the last steering committee many civil servants and representatives of local associations participated.

Also, Earth Cycle location is an industrial zone: the project is expected to improve its image of the area and the job creation generated by Earth Cycle is highly appreciated by the population. The building design is open to the public space and will allow an important integration in the surrounding environment.

Monitoring and evaluation

Challenge level

After the evolution and the modification of the project (cf Journal 2: site choice and size of the factory), the new objectives, targets and associated indicators for the new factory were approved by the UIA managing authorities. This concerns the cost, the production rhythm, the quantity of treated earth, the environmental balance, the technical performance, etc. The follow up and the evaluation is very reliable and the targets are respected. The data collection process is well established and managed by Sevran with a very precise reporting for each partner and stakeholder.

The architect and the technical team are in charge of the earth material quality and performance. This issue concerns the entire production chain from soils collection and characterization, transport, drying, manufacturing and distribution.

No specific problem is encountered except the realization delay related to COVID-19. The inauguration of the factory by the President of the Region Ile de France is scheduled for 29 November 2021.

It is important also to mention that the education and trainings are very positive and new center for continuing education will be created in Sevran.

Communication with target beneficiaries

Challenge level

Earth Cycle is having high expectations from all the stakeholders and even on a large number of stakeholders not directly involved. It is one of the major urban innovations in the Parisian region. The integrated circular economy system developed via Earth Cycle is presented regularly as one of the top innovation in Parisian region.

Also the team is active on social media (LinkedIn, instagram...) and important number of webinars were realized during the Covid period.

A steering committee is organized every 6 weeks and all the stakeholders are participating. Also, specific meetings are organized by the local authority to sensitize the target beneficiaries on the importance of the project. The last steering committee took place on the 21st of October 2021. Then a visit of the factory was proposed. The atmosphere was very positive.

National and regional media (press, television, etc.) regularly cover Earth Cycle news. For example, in November a report on the first French national channel will be proposed in 8:00 pm journal. One of the candidates for the presidential elections, Yannick Jadot, has cited Earth Cycle as an inspirational project during two TV debates among candidates.

Upscaling

Challenge level

Discussed in detail in the second part of the journal.

Project specific challenges

Challenge	Observation

Financial sustainability

Challenge level

The project has planned to identify more immediate potential clients and more use cases, the operational costs and how to integrate this new concept in urban projects from the early stages of the design is a major issue. Earth Cycle is a demand driven project.

This identification of new clients will be realized by the SCIC to create a sustainable market for the project products'.

One aspect that might have an impact on financial sustainability is the cost of sourcing excavated soil. The technical constraints enforced by the certification authority (CSTB) imply that only one geological formation can be used at the moment, until new (costly) tests are performed and validated. For this reason, while the volumes of excavated soil are huge, only a small fraction can currently be accepted for transformation by Earth Cycle. The possibility of not having access to excavated soil does not seem likely, but the partners might have to lower the price for collecting the soil in order to ensure sufficient volumes of the right type in the years to come.

The first year of the project without UIA support will allow a more in-depth analysis of the situation. This challenge is important for the future of earth construction.

Technical readiness

Challenge level

The technical process for compressed bricks and coating is mastered. The produced construction materials will be easily used by construction companies.

The business plan for the factory and the management team is very performant and the production rhythm is realistic.

From the environmental point of view, the evaluation and the integration in the green buildings challenges like LCA (Life Cycle Analysis) analysis and metabolism approach will allow an important technical readiness of the products.

Legislative readiness

Challenge level

The legal status of collected earth is waste. An implicit exit procedure approved by the French Ministry of Environment in July 2021, the produced construction material isn't being considered as waste. Changing this status will impact positively the valorization approach related to the project.

The economic stakes are important and the earth construction process is now considered friendly green with like a material of an acceptable quality via approved environmental sheets (FDES) integrated in the national construction material data basis (Inies);

The legislative context and the legal issues are very favorable to Earth Cycle.

An urban pilot in a systemic view: a theoretical / academic feedback

There are good reasons to study urban innovation and pilot implementation from a systemic perspective. A key finding in innovation research and social sciences is that organizations rarely innovate in isolation, but in interaction with clients, competitors, suppliers, and other organizations. This relation between the Parisian ecosystem of earth management is one of the major achievements of the Sevran pilot project. Indeed, there is a serious will to develop the pilot and working together for a systemic approach for earth management and earth construction.

This system perspective was useful in understanding and analyzing these interactions. The urban innovation system approach elaborated during Earth Cycle conceptualizes the city or urban region as a context in which innovations emerge from complex interactions between urban actors — firms, citizens, local authorities, universities and research institutes — in a particular institutional setting.

Innovation processes are much more complex and diverse, influenced by multiple actors that interact in networks with feedback loops, and involving many types of knowledge beyond scientific knowledge. Studies on urban innovation systems seek to explain how innovations emerge in an urban context, why urban regions differ in their innovative performance, and also address questions on the governance and management of such systems. Studies in this field draw from a variety of disciplines including economic geography, urban and regional economic, political sciences, innovation studies, social sciences, and urban planning.

Reconciling needs, demands and supply is an important issue in developing the implementation of an innovative system like Earth Cycle and it is a fundamental element for the success of an innovation. Creating the market and demonstrating that innovation fits into it is the crucial element towards duplication and scaling up.

According to a recent study by the Paris Urban Agency, 33 million square meters will be built or rehabilitated over the period 2025-2030 in the Greater Paris area. To start integrating the raw earth in urban construction, a first strong initiative would be to integrate 0.025m3 of earth materials per m² of floor area. On average, this represents approximately one to two partitions per apartment. By applying this realistic ratio, for example, for housing, one to two partitions per dwelling, at 20% of these constructions, then 30 production sites of the size Earth Cycle would be needed. This very summary and preliminary analysis shows the need for about 30 similar Earth Cycle factories in the Paris region. This number is indicated on the top of figure 1.

A strategy for duplication and scaling up

In order to facilitate the realization of new factories in other territories, the following elements must be considered so that the concerned cities and territories join this approach and will participate in the development of Earth Cycle. The sensitization on these elements will facilitate the duplication.

- Job creation and training: The implementation and realization of a mechanized production allows job creation on site but also off-site for the stakeholders involved in the earth construction sector (installation, implementation...).

- Improving of urban local metabolism: By managing locally their excavations, constructions and their local processing, soils and earth materials contribute to the decrease in urban flows especially those dedicated to transportation.

- Local circular economy strategy for material management: Soils and excavation management are a part of a local circular economy project especially in new towns and suburbs having an important rhythm of urban development projects. The used materials are coming from excavation in construction sites. They are then transformed into materials then used in the building construction. It is important to know that this process is from cradle to cradle as for construction by using earth, no adjuvant is necessary.

- Green building: Earth materials are a good regulator hydric and have qualities thermal inertia allowing reducing the energy consumption. In addition they do not release organic volatiles compounds (VOCs) and participate therefore to the quality of indoor air. Figure 2 shows the certified materials proposed by the Sevran factory.

Figure 2: the certificate of technical materials produced by the Sevran factory

- Local Economic Development (LED): The excavated earth is transformed to a construction material and used on a limited territory. This approach creates local economic development. The territory is in fact a key link between development actors like investors and developers of the sector and socio-ecosystem coordinator.

5 major criteria to ensure the success of the replication is proposed by Earth Cycle:

The raw material: Use embankment land, and not quarry lands, to maximize environmental benefits, by selecting suitable earth to use as a construction material on the basis of environmental criteria and mechanical criteria.

The classic soil studies will be enriched with some parameters. Investigation and core samples will be updated provision of an earth expert to perform tests. It is important to push aside any suspicion of pollution.

To keep it simple or an easier scaling up in the Parisian region, the used earth in Sevran is the silt. This category of soil is available in many areas of the Parisian agglomeration. Starting from the same resource will make possible to achieve important savings in terms of material certification and assessment. This element is very important for the duplication.

A place of storage, drying and preparation of Earth The homogeneity of the resource is essential for control production quality and validity of certifications obtained especially if the used silt is from the same category as Sevran. This issue requires building up important substantial stocks to avoid testing frequently new formulations.

The current process for Earth Cycle in Sevran plans for a stock of excavated earth to be done once a year, at the end of summer. This imposes a capacity to earth storage. In addition, the natural drying chosen by Earth Cycle involves storing the earth under a covered building for several months before use.

Whether or not it is linked to the site of production, a storage site of at least 5000m² must therefore be planned. This place will also be used for carry out preparation operations soil (crushing, sifting, generating nuisances during preparations (1 to 2 sessions of a few days per year).

Another possible option for the drying would be to implement the storage site next to a production unit which releases fatal heat which will be reused for heating. This will give meaning to an integrated urban planning through a Nexus-type approach proposed in our first journal.

A production and sale place: Based on the Sevran experience, these two functions can be easily be integrated into urban areas in comparison with the storage and preparation part. The production site, based on the experience of Sevran factory, must be at least 2800m.

As in Sevran, it can be located near other buildings by respecting the level of noise, which may involve acoustic treatment of the building. The architectural and its integration into the landscape are also key elements of

acceptance of this site by the inhabitants.

Another option could be explored in future development, it is related to a potential implementation of mobile lines that take smaller places but probably need more technological development. Figure 3 shows the integration of the Earth Cycle factory in Sevran.

Figure (3): The Landscape integration of Sevan production pilot project

Products and constructive systems: A consistent choice of products with the available earth resource, production methods and storage is necessary. Thinking products according to their potential implementation and use is also an important criterion. The factory can propose small precast elements, poured earth, etc. Earth Cycle in Sevran produces compressed earth blocks, plasters and later on panels in extruded earth. These three different construction systems are already certified by French national certification agency.

The business model and the local context in Sevran, the partners of the project decided to create a cooperative company but other models could be possible if the local authority is willing to have a direct management of the project or a Public Private Partnership system. These elements are important and the pilot of Sevran supported by UIA opened many potential options. These options will be discussed in the next journal.

Discussion

At each stage of the project, the Earth Cycle team made choices: on materials, drying and land preparation and material production. At each of these stages, other choices could have been made. Also in the context of duplication, it is advisable to ask at each step, what the best choice is that suits to the local context. The figure 4 resumes the different steps of the pilot implantation and functioning in Sevran. The steps : 1- Extraction of soils, 2- Storage and Earth preparation, 3- Construction process (the fabric), 4- Use of Earth Cycle Production in a building project.

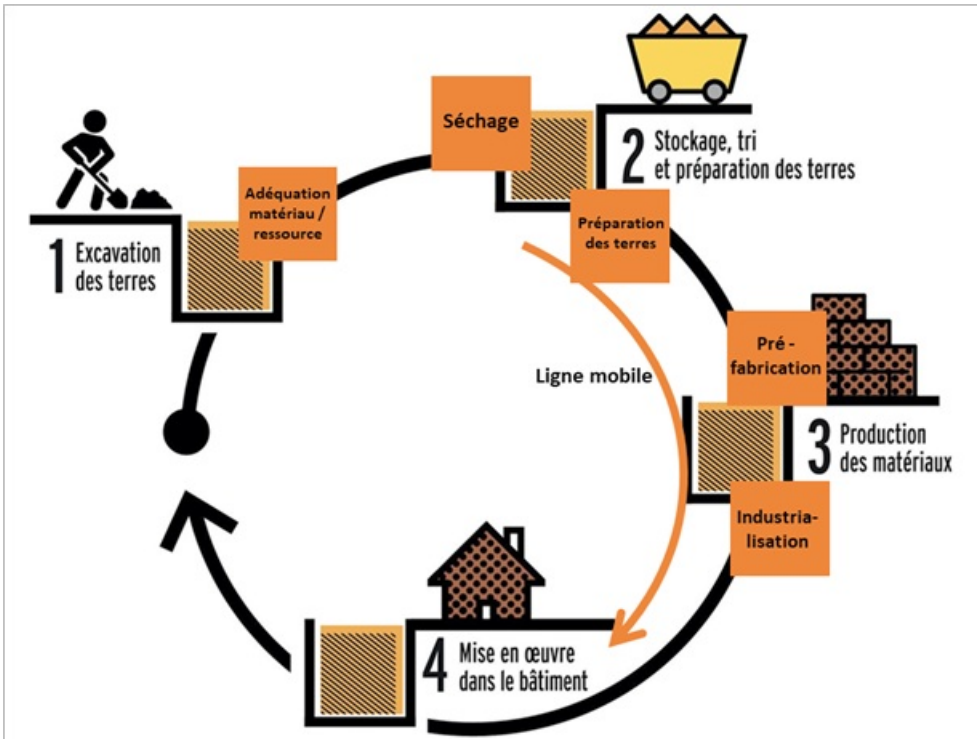

Figure 4: The 5 steps of Earth Cycle in Sevran

Conclusion

A shift towards a more Circular Economy in the construction sector is crucial to achieve a more sustainable and inclusive built environment that meets future demands. Circular Economy is a promising concept for industry and society. If implemented well, Circular Economy can deliver environmental benefits and economic advantages for which innovation is essential.

The management of earth excavation is often a forgotten topic in the territorial circular economy approach. To achieve a resource-efficient built environment, Circular Economy principles should be developed and implemented systemically and on large scale, going beyond cities. This is the topic of this journal dealing with duplication and upscaling of the UIA Earth Cycle.

To realize this, local authorities, citizens, and other stakeholders need a collaborative and science-informed decision environment that allows for developing different waste and resource management options, and assessing their impacts on the environment, spatial quality and quality of life.

Earth Cycle is a very successful initiative as the different analyses presented in this journal show. In fact this pilot has an important potential of development. It is integrated in a strategy for an integrated earth management on the regional scale and also the duplication potential is very important and the key for success are under control as the local authorities are interested, the urban developers are motivated and the research to improve the technical elements is still continuing through a high level of research and development.

Earth Cycle delivers solutions and strategies for a circular economy in urban planning throughout Europe, focusing on sub-urban locations. This pilot in Sevran introduces a methodology to create strategies with local stakeholders for earth valorization. In the next steps focusing on governance for the shift towards Circular Economy on regional level is important. In fact transferring circular strategies and solutions from one location to another is very sensitive issue.

Circular economy

See on UIA website