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Improving biodiversity in the built environment: A study investigating façade solutions and their impact on local biodiversity

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Abstract: The introduction of the 10% Biodiversity Net Gains legislation in 2023 marks a start towards committing to a broader environmental engagement. In this research, biodiversity-friendly façade solutions within a typical housing planning in Nottingham are explored. The study involved interviews and parametric study to evaluate the impact of green wall and biodiversity bricks on local biodiversity and envelope performance using DEFRA's Biodiversity Metric 4.0 and IESVE. The results suggested that around half of the new-built terraced homes of a project would require two green walls to achieve the necessary 10% net gains. Approximatively 60% of typical detached homes would need biodiversity-friendly bricks to replace regular bricks on two rows at the bottom of all walls to achieve the 10% target. Biodiversity-friendly façades solutions have been proven to be effective design strategies for housing in urban areas, by reducing the risk of summer overheating while enhancing local biodiversity.
Keywords: Biodiversity loss, Biodiversity-friendly façade solutions, Green walls, Biodiversity Net Gains, Urban areas

1. Introduction

Biodiversity loss and the built environment are intricately linked, and the impact of human development on natural ecosystems cannot be underestimated. In the face of escalating environmental concerns, urban areas are experiencing rapid transformation, leading to the decline of natural ecosystems and the depletion of local biodiversity. The threats emerging from the infrastructure and the built environment system together impact 29% of the IUCN's (International Union for Conservation of Nature) list of threatened and near-threatened species (World Economic Forum, 2020, p.12). The built sector emerges as a key factor in the loss of biodiversity (World Economic Forum, 2020) and therefore, should have an important role in creating a sustainable world where ecological values are prioritized. As a response to these challenges, the integration of biodiversity-friendly façades in building design could emerge as a promising solution to mitigate the detrimental effects of urbanization on local ecosystems.

2. Methodology

The main goal of this research was to organise design advice and recommendations for the application of facade-bound green walls and biodiversity bricks. Therefore, the research undertaken in this work utilised three main methods, interviews, case study including a parametric investigation and simulations. The first method comprised of narrative analysis of interviews with designers of biodiversity bricks and green walls, to understand the perspectives on these strategies, the limitations and challenges preventing people to make biodiversity-friendly design choices as well as potential of their applications. The design of the interviews consisted of 17 open questions about biodiversity, design development & product requirements, measuring improvements in the ecosystem, application & use and future recommendations. The second method covered parametric investigations of the impact on local biodiversity of those two façades solutions, to measure and compare biodiversity bricks and green walls in terms of Biodiversity Net Gains using DEFRA's Biodiversity Metric 4.0. It is important to note that the predictions and scoring from DEFRA's Biodiversity Metric 4.0 can't be taken as the real impact of biodiversity bricks on local ecosystems as it doesn't take into consideration orientation and closeness to other habitat, showing the limitations of the metric and the new regulation. Additionally, the simulated applications of green walls and biodiversity bricks on buildings instead of typical brick wall was assessed using IESVE software, to verify the solutions' impact on envelope performance in term of thermal and daylighting comfort.

3. Biodiversity Net Gain policy

Biodiversity Net Gain (BNG) is one of the key biodiversity policies proposed in the Environment Bill (Environmental Audit Committee, 2022). The policy involves a requirement for all new building developments to include a 10% net increase from the pre-development biodiversity value as part of the development process. Biodiversity net gains will be mandatory through becoming a condition of planning permission and will be required to be maintained for at least 30 years (Local Government Association, 2023). The new regulation will come into force in November 2023 and will be compulsory for small sites from April 2024. BNG will be measured using the Biodiversity Metric 4.0 that has been developed by DEFRA. Biodiversity Metric 4.0 allows developers to quantify the biodiversity value of a site before and after development (Environment Act, 2021). The metric gives a subjective score to each habitats, considering the area of land affected (in hectares or kilometres), the type of habitat (definitions derived from multiple sources, including the UK Habitat Classification), its condition (N/A, Poor, Fairly Poor, Moderate, Fairly Good or Good) and its distinctiveness (Very Low, Low, Medium, High or Very High) (Natural England, 2023). Incorporating BNG regulations and DEFRA's Biodiversity Metric 4.0 into the planning process are concrete ways to ensuring that development activities leave the environment in a better state than before.

4. Case study

A housing development in Nottingham was considered as the starting point in this investigation. The Old Mill Farm is a housing development of 115 energy efficient homes in Brinsley, in Nottinghamshire countryside. The project consisted of a range of housing typologies accounted as a baseline representation of typical detached and terraced homes. The typical residential project has a Biodiversity Net Gain calculation report (Crestwood Environmental Ltd., 2020) and hence was selected for the simulations.

Figure 1: Old Mill Farm Housing Planning , UK

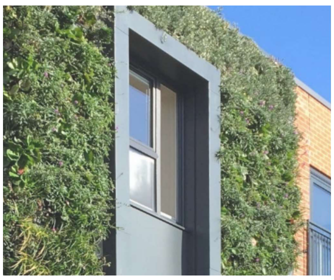

Figure 2: Green Wall on Fordham House, UK

Figure 3: Biodiversity Bricks by Artecology

The parametric study consisted of testing different sizes of green walls and biodiversity bricks using three different typical home typologies from the case study. Green walls are vegetated surfaces installed on building façades providing new habitats for plants and associated wildlife. Biodiversity bricks, a relatively new innovation, are modular units designed to support diverse plant species and wildlife (e.g., bees, insects, invertebrates) within compact urban spaces. These textured bricks replace typical construction red bricks and allows different plant and insects species to grow on their surface, find shelter and breed.

5. Interviews

Interviews were conducted in order to collect qualitative data from businesses who design prefabricated wall solutions for supporting biodiversity. The key learnings from the interviews were a) biodiversity bricks are most useful embedded in walls, pathways, or in gardens near existing habitats, b) the abundance of plant species used on green walls was seen as a key factor in their ecological impact, c) south and west are described as the most efficient orientations for plant's growth on green walls, d) the interviewees recognized the importance of education, engagement, and policy changes to address biodiversity loss and create a more sustainable built environment and e) collaboration with experts, ecologists and biologists is also recommended to ensure that the strategies planned aligns with the specific needs of local biodiversity. Insights learned during this process served to direct the pursuit of deeper understandings of green walls and biodiversity bricks in the following parametric study.

6. Biodiversity net gains assessment

The objectives of evaluating BNG through DEFRA's Biodiversity Metric 4.0 were to determine the strategies' relative ecological benefits and best practices for maximizing biodiversity gains, to better inform architects and developers. The parametric study consisted of testing different sizes of green walls and biodiversity bricks added to the post intervention habitat list using three different typical home typologies, following the metric user guide and classifications (Natural England, UKHab Ltd., 2023). Seven iterations were tested, 1) one green wall, 2) two green walls, 3) four green walls, 4) one green wall + biodiversity bricks on one wall, 5) biodiversity bricks on one wall, 6) biodiversity bricks on two walls and 7) biodiversity bricks on four walls.

Table 1: Biodiversity Net Gains of typical detached 130sqm home per level of strategy

Biodiversity iterations	1 Green wall	2 Green wall	4 Green walls	1 Green wall + Biodiversity bricks	Biodiversity bricks on 1 wall	Biodiversity bricks on 2 walls	Biodiversity bricks on 4 walls
Habitats Units Change	0.02	0.03	0.07	0.03	0.01	0.01	0.03
% Net Gain in Case Study	0.13%	0.26%	0.51%	0.17%	0.04%	0.09%	0.17%
10% Net Gain Target for Case Study	77/115 homes	38/115 homes	19/115 homes	59/115 homes	250/115 homes	111/115 homes	59/115 homes

Installing green walls, even just one, resulted in a notable increase in habitat units (0.01 to 0.02) compared to the baseline typical house. The impact became more significant with two or four green walls (0.03 to 0.07). Four green walls were identified as the most ecological impactful strategy was green walls applied to the four façades of one detached home of the case study, showing a 0.51% net gain. Considering a typical detached house typology, simulations of 2 rows of biodiversity bricks replacing typical red bricks on one wall were evaluated to impact BNG from baseline to 0.01 unit change and to only 0.04% net gain. Biodiversity bricks alone had a relatively small impact on habitat units compared to green walls due to the difference of the created habitats size (e.g., on the same typology, biodiversity bricks on four walls resulted in a 0.17% net gain). This shows clearly how biodiversity bricks in small batch are not sufficient as the only BNG strategy and need to be complimented by other solutions (e.g., green walls, or creation of urban habitats like ponds, new trees, etc.).

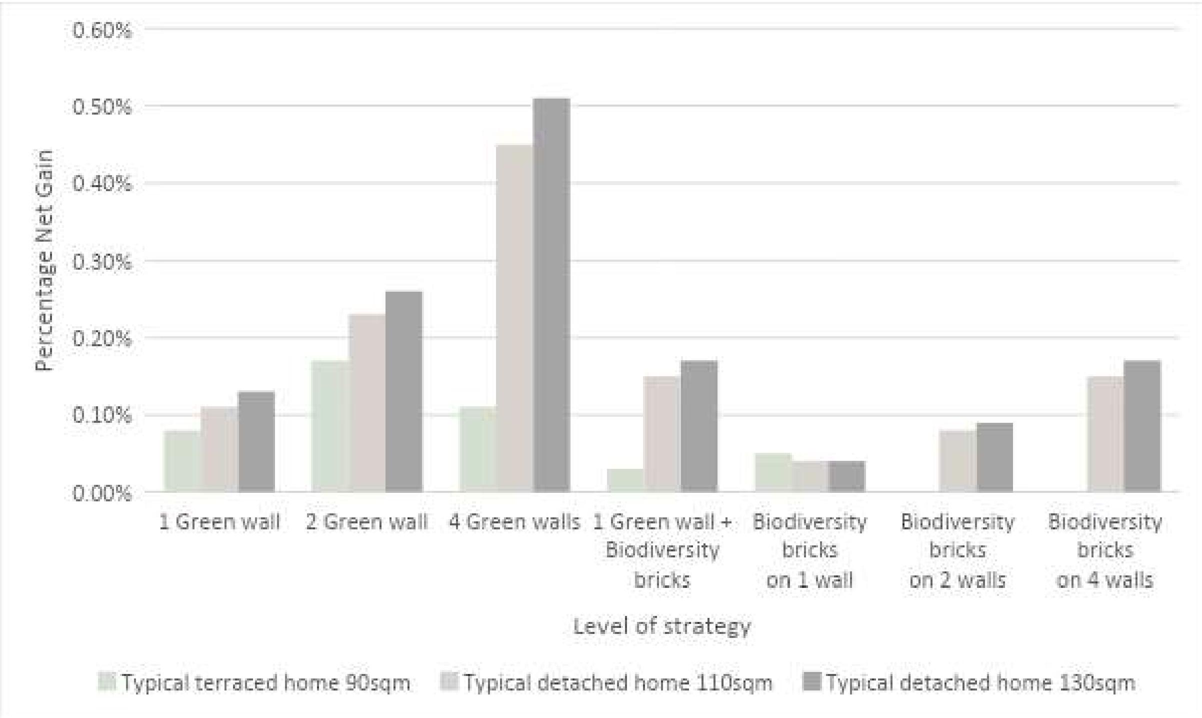

Figure 4: Percentage net gain per housing typology and level of strategy

On typical terraced home, green wall incorporated on the two available façades of around 50% of the project's homes would be sufficient to achieve the 10% biodiversity net gain requirement. Considering a 130 sqm typical detached home typology, around 65% of a project's houses need one green wall for the BNG targets. Through quantification of biodiversity outcomes, this study has demonstrated that fulfilling Biodiversity Net Gain (BNG) targets of 10% solely with façade solutions is both feasible and achievable.

7. Environmental performance evaluation

Green walls were proved to contribute to local biodiversity. However, their impact on the façade performance must be either minor, non-existent or positive to show pertinent applicability. The 'Green Room' methodology (Laparé, F., 2013) was applied to simulate green wall on IESVE software on 7 different iterations, 1) one green wall oriented north, 2) one green wall oriented south, 3) one green wall oriented east, 4) one green wall oriented west, 5) two green walls oriented north-south, 6) two green walls oriented east-west and 7) four green walls on all façades. Biodiversity bricks were assessed to have no relevant impact on the overall building envelope performance, neither on thermal nor daylight performance due to low changes of material's density and lack of created shading and therefore were not simulated.

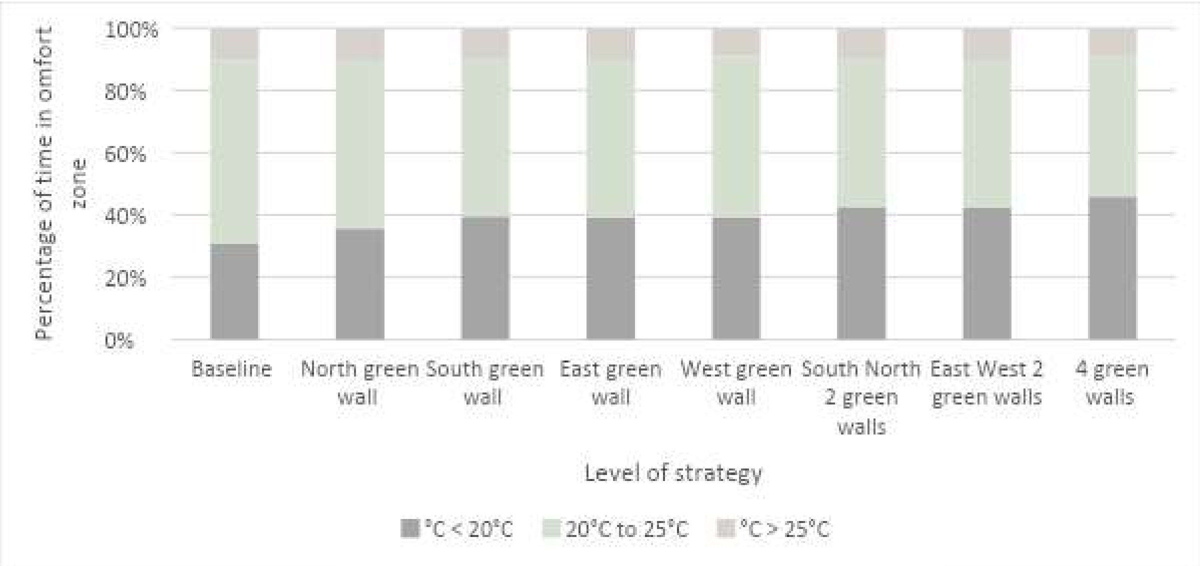

Figure 5: Comfort temperature percentage of typical detached 130sqm home per level of strategy

The improvement of the summer overheating risk is significant for west and south green walls, with temperatures above the comfort zone (ASHRAE 20°-25°C) going from 10.30% (baseline) to 9.10% (west) and 10.00% (south) in summer. The order of efficacy by iterations with green wall's orientation, from most effective to least is west orientation, south, east and west, north and south, 4 green walls, east and north.

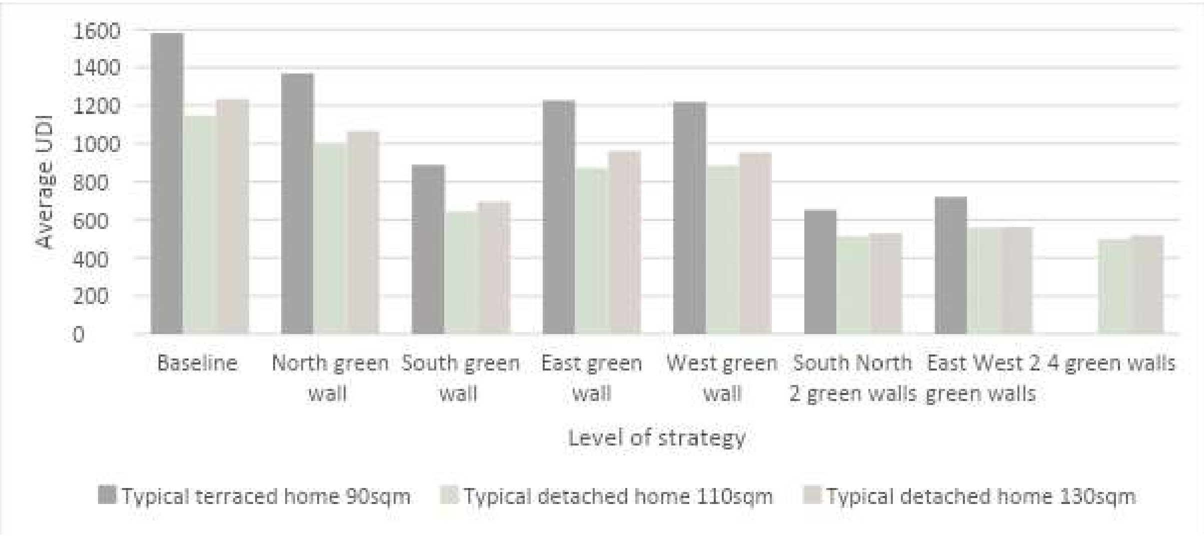

Figure 6: Useful Daylight Indicator average per housing typology and level of strategy

The additional shading on the windows caused by the green walls' plants obstructed natural light entering the houses, resulting in lower Daylight Factor (DF > 2%, benchmark SSL LG9, LG10) and Useful Daylight Indicator (UDI > 200 lux benchmark SSL LG10). South-facing green walls resulted in significant lower DF and UDIs (e.g., around 60% reduction of lux compared to baseline average UDIs), while north-facing green walls had a minor impact on daylighting comfort measurements.

8. Conclusion

The impacts of all the different iterations are not aligned between each important decisions factors (i.e., biodiversity performance, thermal performance and daylighting performance). However, the strongest design recommendation is to place green walls and biodiversity bricks on the façade near any green space (i.e., garden for housing or any public green space). Applying as many green walls and biodiversity bricks as possible to a project design will of course be very impactful in terms of biodiversity net gains. However, considering developers, management and economics, it is most likely more feasible to project incorporating green wall on one façade and biodiversity bricks in small batches.

Therefore, considering the investigated scenarios, green walls are recommended in the west and south orientation a) because of great impact on local biodiversity (i.e., simulations of BNG going baseline to 0.13% net gain for one green wall, meaning that 91 on 115 houses of the case study need one green wall to attain 10% BNG target with only this strategy), b) because of highest impact on reducing summer overheating risk by (i.e., simulations of summer overheating risk going from 10.30% in baseline, to 9.10% for west orientation and 10.00% for south orientation), c) because of small impact on daylighting factor (i.e., simulations of DF going from 20% in baseline, to 19% for west and south orientation) and d) because of better plants growth in sunny environments.

As for biodiversity bricks, it is recommended to place biodiversity bricks near the ground. It is advised to place bricks with bigger cavity and with numerous smaller holes on south and west oriented walls to create new insects feeding and breeding habitats. On north and east façades, it is best to set textured bricks that are perfect for species shade tolerant like mosses, lichens and fungi. Biodiversity bricks placed on the four walls of the house shows great impact on BNG (from baseline to 0.03 unit change, to 0.17% net gain for bricks change on four walls). This strategy if used by itself, need application on 50% of the houses of the case study to achieve the 10% BNG target, which might be an interesting solution.

With the demonstrated feasibility and ecological benefits, it becomes evident that convincing even a small percentage of urban developers, architects, and policymakers to integrate these solutions into their projects could have a substantial positive impact on biodiversity conservation. While the focus of this study has been on biodiversity conservation, green walls and biodiversity bricks offer multiple co-benefits that enhance the overall urban environment. The integration of nature into the built environment not only supports biodiversity but also contributes to more liveable, healthy, and resilient cities.

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