



# Is the retrofitting of living wall systems on existing building stock a cost-effective way to prevent pluvial localized flooding in UK cities?

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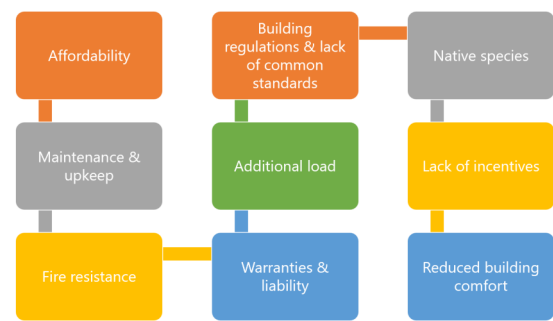
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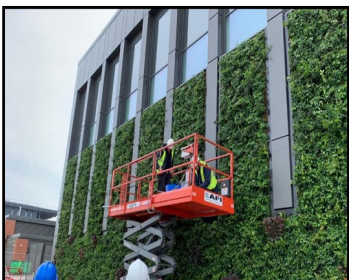
## Introduction

There is an intensifying pressure on dense urban areas to employ Sustainable Urban Drainage Systems (SUDS) to mitigate the effects of localised pluvial flooding. Marching toward legitimacy, Modular Living Wall Systems (MLWS's) are gradually being scrutinized. Intricacies interlinked to retrofitting MLWS's include:



Fulfilling these complexities, conquering all these factors, will be indispensable for MLWS's to mature beyond their use as vanity projects and gain acceptance as a forthright SUDS technology by the construction sector.

**Figure 1:** 144m<sup>2</sup> MLWS at Swansea University (Author, 2019).



## Research Objectives

- To recognize the **attitudes** of construction professionals towards the retrofit on MLWS's as a flood remediation technology and to interpret how their expertise **diverge** from construction undergraduates.
- To provide **professional guidelines** to design managers who are required to design and retrofit MLWS's through constructing a **comparative table** showing the difference in performance between retrofitting MLWS's and other flood remediation technologies. The development of a **mathematical formula** to predict how much pluvial rainwater and a retrofitted MLWS can take out of the local environment will help promote this.
- To **evaluate the cost** of MLWS's per m<sup>2</sup> to the alternative technologies currently being installed at the London Tideway Super Sewer and to additionally critically appraise if imposing MLWS's **compulsory** on all new government funded projects would help lower the costs of the system, as well as making a case for **government-backed incentives**.

## Methodology

The scientific and psychosomatic paradigms of MLWS benefits and the entrenched objections to the technology being a flood remediation mecha-

nism was surveyed through quantitative **questionnaires** and further triangulated by structured qualitative attitudinal **interviews**.

Opting for a non-random purposive sample of UK-based construction undergraduates (CS) and practicing professional's (CP), analytical methodologies were induced upon the resultant data, including:

- Spearman's risk coefficient (p)
- Pearson Chi-square ( $\chi^2$ )
- Thematic Analysis (TA)

## Results & Analysis

**"Should there be a government-backed incentive to retrofit MLWS's?"**

The 0.184 correlation coefficient value obtained by the Statistical Package for Social Sciences (SPSS) when cross-tabulated to the 2-tailed Spearman's Rho Table signifies a small to moderate correlation between the datasets.

| Correlations   |            |                         |            |            |
|----------------|------------|-------------------------|------------|------------|
|                |            |                         | Question_1 | Question_7 |
| Spearman's rho | Question_1 | Correlation Coefficient | 1.000      | .184       |
|                |            | Sig. (2-tailed)         | .          | .330       |
|                |            | N                       | 30         | 30         |
|                | Question_7 | Correlation Coefficient | .184       | 1.000      |
|                |            | Sig. (2-tailed)         | .330       | .          |
|                |            | N                       | 30         | 30         |

**Table 1:** Spearman's SPSS data.

Whilst using a 0.05 level of significance, the 2-tailed value has been observed larger, therefore **rejecting the hypothesis** that no correlation exists between both CP and CS's and their attitudes toward whether there be a government-backed incentive to retrofit MLWS's.

**"Do you agree that all future government-funded buildings (e.g. hospitals, schools) should have compulsory MLWS's installed?"**

Distinguished by the Chi-square test is a resultant 0.791 significance value, whilst testing at the 5% level of significance this figure is exceedingly higher than the tabulated value, meaning this result is **not statistically significant**, where there is not enough of an agree distribution to clarify an assumption that all future public-funded building should have compulsory MLWS's installed.

| Chi-Square Tests             |                    |    |                                   |
|------------------------------|--------------------|----|-----------------------------------|
|                              | Value              | df | Asymptotic Significance (2-sided) |
| Pearson Chi-Square           | 1.701 <sup>a</sup> | 4  | .791                              |
| Likelihood Ratio             | 1.977              | 4  | .740                              |
| Linear-by-Linear Association | .868               | 1  | .352                              |
| N of Valid Cases             | 30                 |    |                                   |

**Table 2:** Chi-square SPSS data.

Academia from the literature offers both support and scepticism to the impacts of this conclusion. Contributions from (Gunnell, 2013) advocates the systems biodiversity benefits, conversely, to add doubt (Baumann, 2015) states that **"it's [compulsory MLWS's] not necessary nowadays with alternative technologies available"**.

## Conclusions

Data obtained by the researcher permitted the creation of a comparative table, attempting to equate the most up to date cost of the London Tideway Super Sewer Project (LTSSP) against the projected cost of mass MLWS implementation within Kensington & Chelsea.

| Table 3: Kensington & Chelsea MLWS vs LTSSP cost comparison.                    |                     |
|---------------------------------------------------------------------------------|---------------------|
| Comparatives                                                                    | Associated cost (£) |
| MLWS                                                                            | £9,289,575          |
| London Tideway Super Sewer Project (LTSSP) in the Kensington & Chelsea Borough. | £36,599,625         |

Table 3 unambiguously concludes that the mass-retrofit of MLWS is a **cheaper alternative** to the LTSSP upgrades. Entailing additional exploration, the researcher has successfully begun to construct a one-size-fits-all formula to estimate the quantity of rainwater a MLWS can eliminate from a local area. Delineated below:

$$MLWSm^2 \times H_2O \text{ (Potential Eradicated)} = R1$$

$$Average \frac{\text{rainfall}}{\text{year}} - R1 = \text{Total benefit (m}^3\text{)}$$

It has been proven through extensive literature research that the system has the capacity to prevent localized pluvial flooding, and through further triangulation mathematical calculations have determined a high degree of **cost-effectiveness** against the LTSSP case study.

## References

- Cecil, N. (2020) 'London faces flooding if homeowners keep paving over their gardens, experts warn', *Evening Standard*. Available at: <https://www.standard.co.uk/news/london/london-a31091.html> (Accessed: 7th April 2020).
- Gunnell, K., Murphy, B. and Williams, C. (2013) *Designing for Biodiversity*. 2nd edition: RIBA.

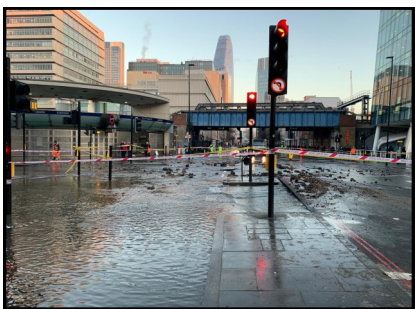


**Figure 2:** Pluvial flooding in Kensington (Cecil, 2020).