

Annex A3

RESEARCH COLLABORATION OPPORTUNITY

Research Collaboration Opportunity Ref No.: RCO-CUGE-2018-03

Project Title: Lightweight systems: Evergreen Roof Greening

1. Key Challenges and Objectives

1.1 Today's urban tropical city densification efforts witness the advent of building-greenery-integration, with green roof as an emerging hybridized option. Major challenges/draw-backs are:

- High design load of elevated landscapes driving up structural-cost;
- Need for irrigation on such elevated landscapes;
- Aesthetically compromised during drought period;
- Dependency on plastic-based (green roof system) under-layers for water-reserve

1.2 We are seeking proposals to develop green roof system to be:

- Lightweight (0.5kN/m^2 to 2.0kN/m^2);
- Drought-tolerant (with sole reliance on rainfall);
- With dense foliage (even during drought period);
- Without use of plastic under-layers (so as to reduce plastic-waste)

1.3 The proposed project should include (but not be limited to):

- (i) Identify and Test suitable drought-tolerant plant species for the system
- (ii) Develop and Document lightweight green roof prototypes and anchorages
- (iii) Demonstrate and Monitor the prototypes' real-world performances

2. Minimum Project Deliverables

The deliverables described here represent the minimum outcomes arising from the proposed project. Additional relevant deliverables that are proposed will be favourably considered during project evaluation.

- (i) **Shortlist and test** the drought tolerance of at least 20 suitable dense ground-cover-species (or equivalent) for shallow extensive rooftop greenery.

(ii) **Develop:**

Developed Lightweight-Greenery-Mats must:

- Be non-plastic.
- Achieve saturated design load limits of 0.5kN/m², 1.0kN/m², 1.5kN/m² and 2.0kN/m².
- Shortlist and test the drought tolerance of at least 20 suitable dense ground-cover-species (or equivalents) for shallow extensive rooftop greening.
- Achieve dense fibrous root network that lends the system its mat-like physical quality.
- Achieve at least 20 Lightweight-Greenery-Mats prototypes (developed and demonstrated).
- Be tested to be safely applicable to solid concrete, metal and composite rooftop surfaces without compromising the surface integrity of these rooftop surfaces, with test-reports.
- Be compared with the current top-five extensive green roof systems in the Singapore market, in the aspects of design loads, drought-tolerance, maintenance, etc.

In total, a minimum of 20 system-prototypes (Lightweight-Greenery-Mat + Anchorage-systems) must be developed and demonstrated.			
Prototypes' Design Loads (when saturated) kN/m ²	Minimum drought tolerance (days) that each prototype must achieve, when at 20 degree roof inclination	Minimum number of system-prototypes	Examples of rooftop surface types
0.5	07	5	Walkway shelters
1.0	14	5	
1.5	21	5	Residential building roofs
2.0	28	5	
Note: <i>The longest recorded drought in Singapore is 27 consecutive days in 2014.</i>			

Developed complementary anchorage-system(s) must be able to:

- Secure all relevant Lightweight-Greenery-Mats onto all relevant rooftop surface type(s) which include solid concrete, metal and composite rooftop surfaces;
- Up to 20-degree roof-inclination;
- Withstand wind speed of up to 144.4kmh when system is saturated and when desiccated, at up to 20-degree roof inclination;
- This performance must be tested at recognised wind-tunnel facility in Singapore with test-reports.

(iii) **Monitor and Document** (in a comprehensive report) the prototypes' performances. The documentation must include:

- Monitored health parameters, of the tested plant species, over the drought-tolerance test duration of no less than 28 days;
- Drought tolerance of at least 20 suitable dense ground-cover-species (or equivalents) as monitored;
- Drought tolerance test method;
- Monitored drought tolerance of the system(s) with and without hydrogels up to 28 days of drought;
- Monitored water loss, per system, over the drought-test duration of up to 28 days;
- Test-Reports on the systems' engineered-effectiveness against maximal expected wind speed/uplift (recorded in Singapore; *recorded at 144.4kmh at Tengah in 1984*) when saturated and when desiccated of up to 20 degrees-inclination;
- Test-reports that the lightweight-greenery-mats (and fibrous roots) do not compromise the surface integrity of rooftop surfaces.
- Specifications of all system-prototypes (Lightweight green roof systems; Anchorage systems; Roof Condition Requirements; etc.). There must be at least 20 system-prototypes (developed, tested, demonstrated), with specifications.
- Comparison of developed system-prototypes with the current top-five extensive green roof systems in the Singapore market, in the aspects of design loads, drought-tolerance, maintenance, etc.

(iv) **Demonstrate and monitor** the prototypes outdoor (in real-world contexts, such as bus stop roofs, HDB carpark roofs, etc.) without irrigation over a year (or more), to build confidence on the developed systems.

- Each demonstration site per prototype must not be less than 3m by 3m in area.
- Plant health parameters (i.e. chlorophyll level, etc.) must be collected fortnightly, over a year (or more).
- Monitored comparative thermal data to ascertain systems' thermal performance.
- Such information from monitoring must be updated into the above report monthly.

3. Budget Limits

3.1 The proposed budget cannot exceed \$100,000. Proposals that exceed this limit will not be considered. Please note that this amount is simply an indication of budget availability, not an estimate of expected project cost.

3.2 The project duration should also not exceed 2 years. Proposals requiring more than 2 years can be considered, but with strong justification.

3.3 Please note that NParks' decision on the funding support to be awarded for the project is final.

4. Submission Instructions

Proposals for the Research Collaboration Opportunity as stated above must be submitted to Mr Poh Choon Hock at poh_choon_hock@nparks.gov.sg by 9th November 2018, 1200 hrs.

5. Enquiries

For transparency, all enquiries and associated clarifications will be published (without details on the identity of the person making the enquiry) on the Research Collaboration Opportunity page on the CUGE website. We regret that phone enquiries will not be entertained.

For enquiries, please contact Mr Poh Choon Hock at poh_choon_hock@nparks.gov.sg.