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EDIBLE GREEN WALLS

Addressing Food Security and Heat Stress in South Africa's Informal Settlements

Shané de Beer; Arthur Baleeta
Dr. Karen Botes; Dr. Jan Hugo

ILASA / IFLA AFRICA CONFERENCE 2025

INTRODUCTION & BACKGROUND

URBAN AGRICULTURE

A powerful tool for enhancing both food security and urban sustainability

NUTRIENT-DENSE, CULTURALLY RELEVANT CROPS

- **LOCALLY ADAPTED**
- **LOCAL PESTS AND DISEASES TOLERANT**
- **HIGH NUTRITIONAL VALUE**
- **CLIMATE STRESS TOLERANCE**

Schreinemachers *et al.,* 2018

Zonneveld, 2020

Maseko *et al.,* 2017

RESEARCH QUESTION & OBJECTIVES

FLEXIBLE FACADES AND ECOSYSTEM SERVICES

How do African vegetables compare to leafy mainstream vegetables in living wall systems to improve urban household food security and mitigate heat stress as a co-benefit within informal settlements in Tshwane, South Africa?

ACTIVITY 1

1. To compare the performance of leafy African Vegetables and leafy Conventional Vegetables grown on a northern versus western aspect in an outdoor modular living wall system in Tshwane, South Africa.

1. To compare the performance of four leafy Traditional African Vegetables and four leafy Conventional Vegetables grown in a modular living wall system for household food security in Tshwane, South Africa.

ACTIVITY 2

1. To assess the thermal performance of soil-based vs hydroponic LWSs with AVs in reducing heat stress in informal dwellings.

2. To determine the efficiency of soil-based and hydroponic LWSs with AVs in contributing to household-scale food security in informal dwellings through measuring plant stress.

INTRODUCTION & BACKGROUND

2.1m households

11.6%

lack adequate and nutritious food

OUTDOOR MODULAR LIVING WALL SYSTEMS PLANTED WITH LEAFY AFRICAN VEGETABLES AS A RESPONSE TO THE URGENT NEED FOR SPACE-EFFICIENT FOOD PRODUCTION STRATEGIES WITHIN SUB-SAHARAN AFRICAN INFORMAL SETTLEMENTS

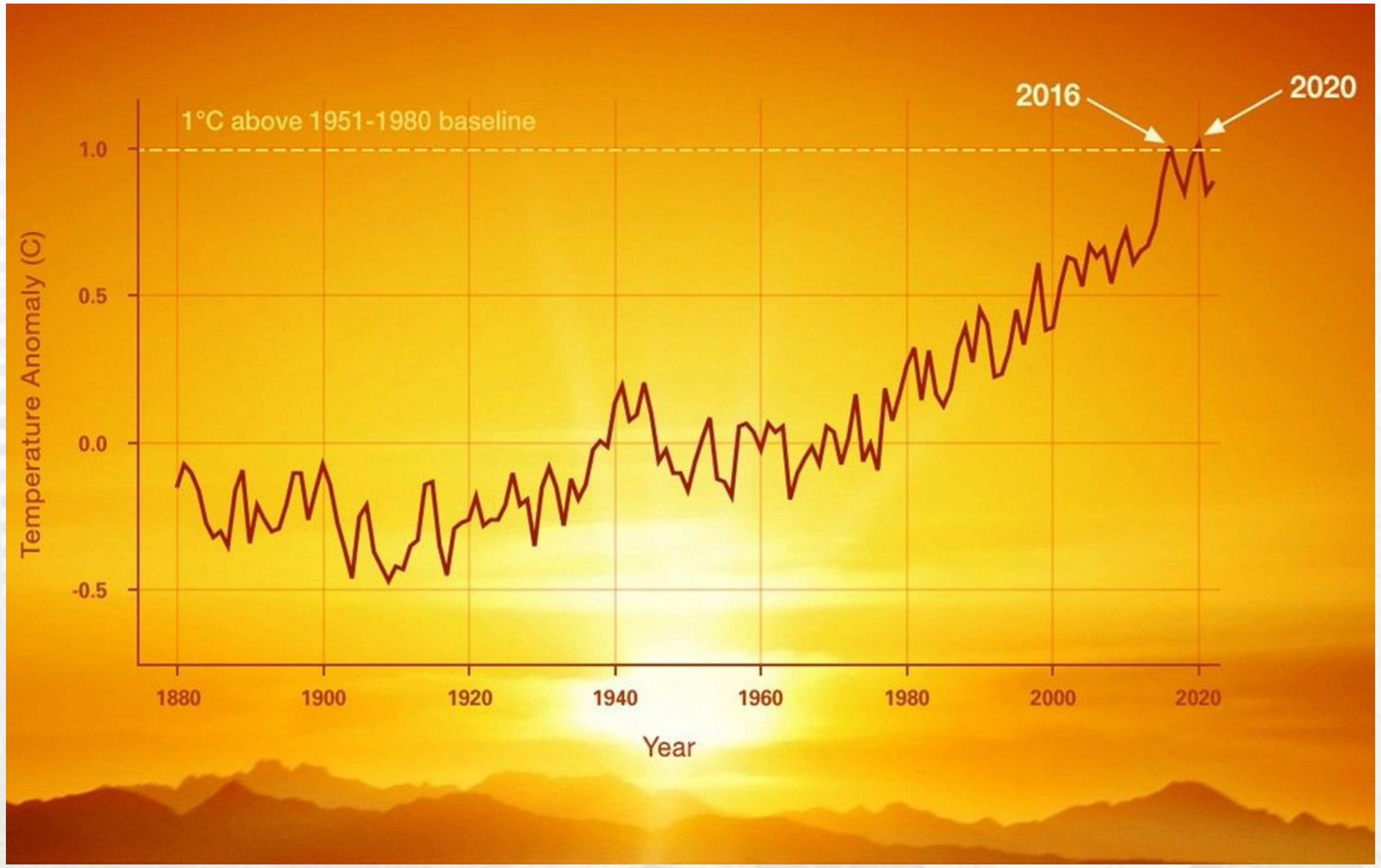
Botes, 2024

Nengovhela, Mokhaukhau & Hlongwane, 2024

Titz & Chiotha, 2019

John, 2024

INTRODUCTION & BACKGROUND



CLIMATE CHANGE INTENSIFICATION AND ITS EMERGING THREAT IN **INFORMAL SETTLEMENTS**

NASA, 2022

Satterthwaite *et al.*, 2020

FAO *et al.*, 2018

Kafle, Hopeward & Myers, 2022

INTRODUCTION & BACKGROUND

VERSUS

CONTROL DWELLING

ADAPTED DWELLING

Zezza & Tasciotti, 2010
Mabhaudhi et al., 2018
Botes & Breed, 2022
Manso & Castro-Gomes, 2014
Collins et al., 2017
Auslander et al., 2003
Dubravka & Ilin, 2022
Specht et al., 2013

INTRODUCTION & BACKGROUND

Thermal benefits of LWSs in reducing Heat Stress

- Shading
- Evapotranspiration
- Insulation

Perini & Rosasco, 2013; Perez et al., 2018

Akinwolemiwa et al., 2018

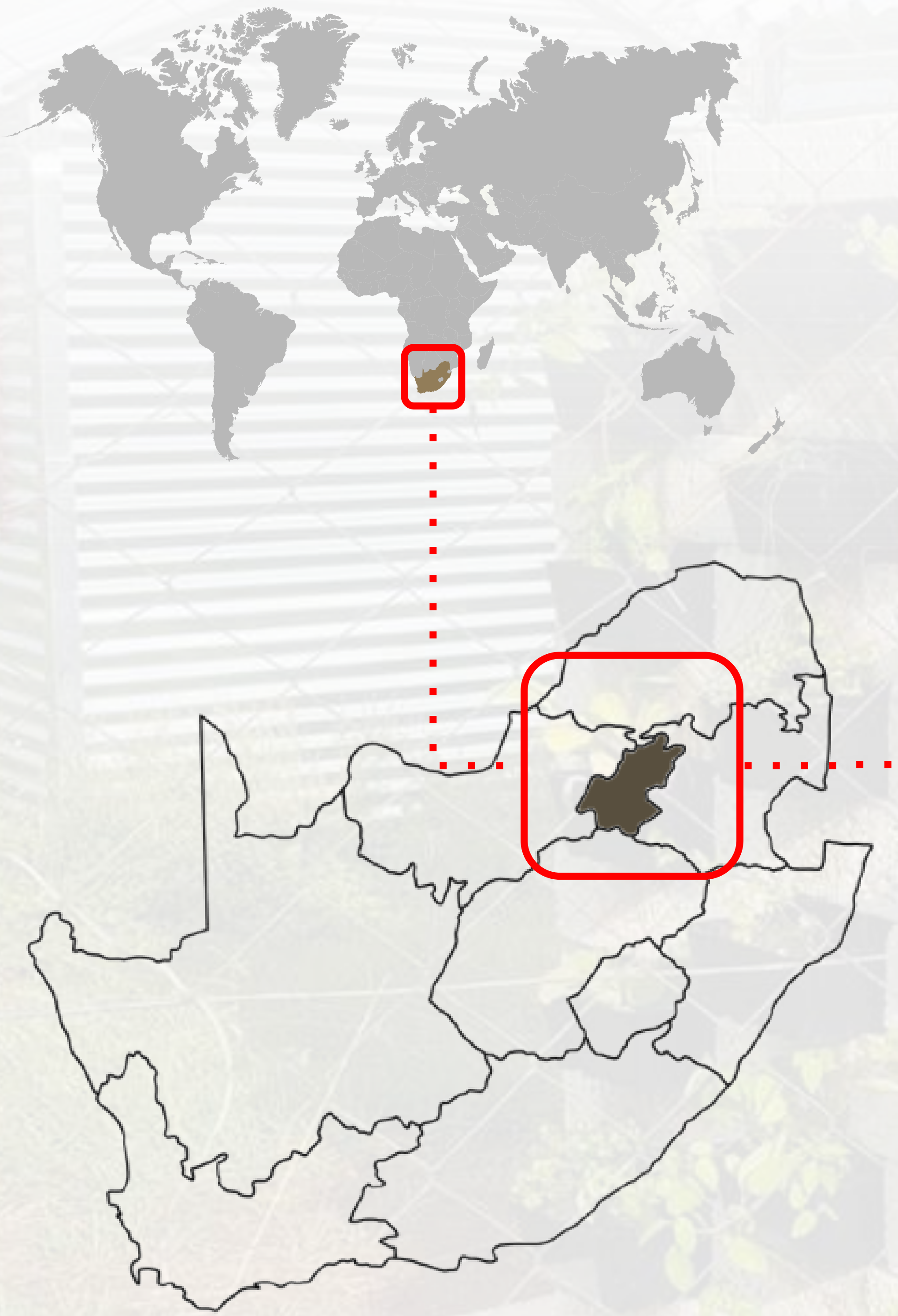
- Plant Density
- Orientation
- Substrate type

Manouchehri et al., 2024

Gouws & Gouws, 2022

RESEARCH METHODOLOGY

University of Pretoria's Experimental Farm



RESEARCH METHODOLOGY

Performance of leafy African Vegetables in outdoor modular living walls

ACTIVITY 1

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Performance of leafy African Vegetables in outdoor modular living walls

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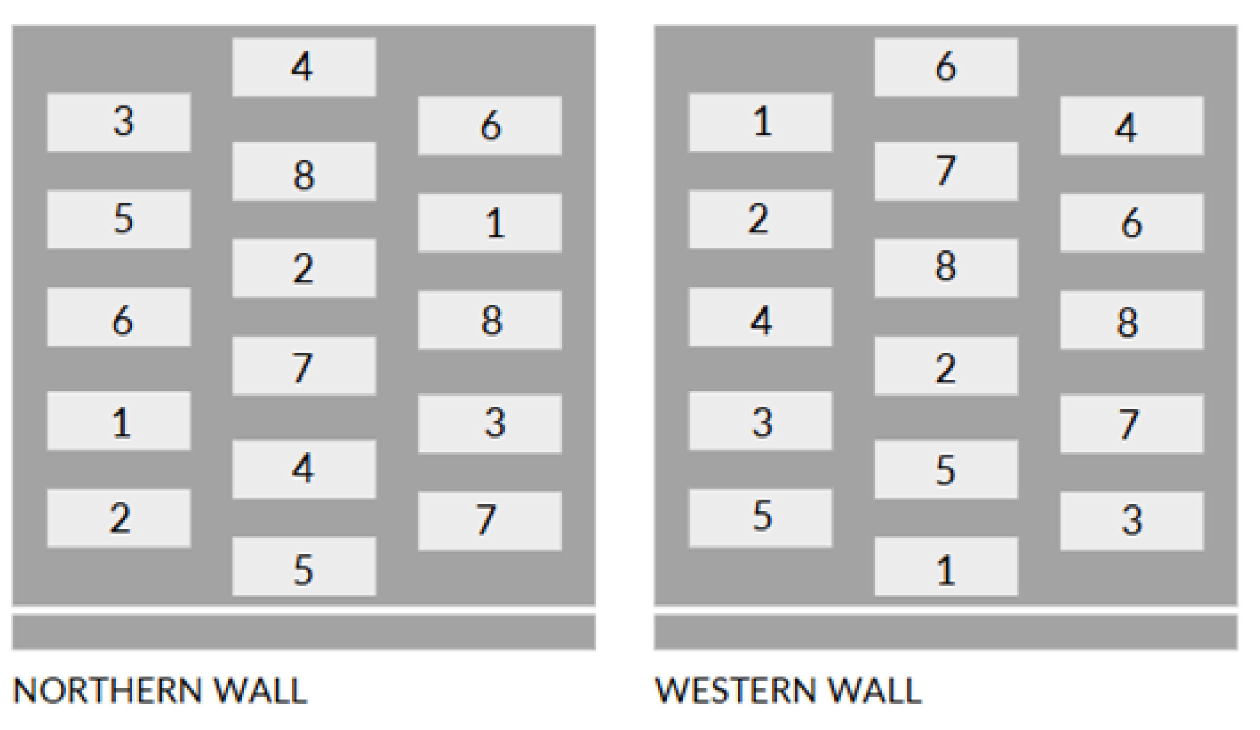
Performance of leafy African Vegetables in outdoor modular living walls

ACTIVITY 1

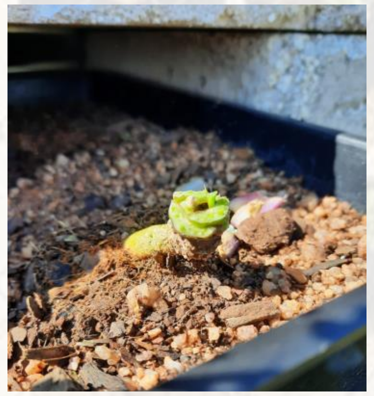


Allocated number	Scientific name	Common name	Family name
Leafy African Vegetables			
1	*Coleus amboinicus*	Indian Borage	Lamiaceae
2	*Portulacaria afra prostrata*	Dwarf elephant's food	Portulacaceae
3	*Portulaca oleracea*	Purslane	Portulacaceae
4	*Asystasia gangetica*	Creeping foxglove	Acanthaceae
Leafy Mainstream Vegetables			
5	*Ocimum basilicum*	Basil	Lamiaceae
6	*Brassica rapa* subsp. *chinensis*	Bok Choy	Brassicaceae
7	*Petroselinum crispum*	Parsley	Apiaceae
8	*Allium schoenoprasum*	Chives	Amaryllidaceae

RESEARCH METHODOLOGY

Performance of leafy African Vegetables in outdoor modular living walls

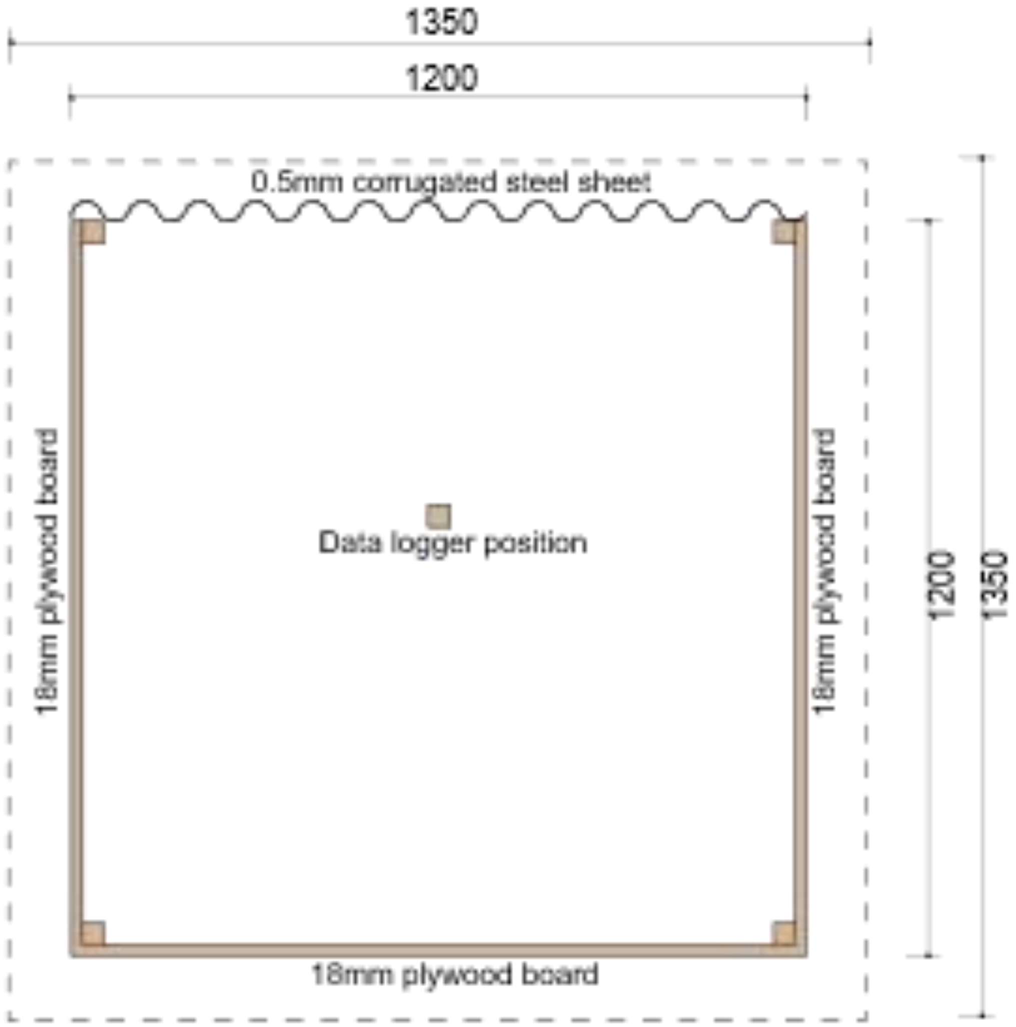
ACTIVITY 1

Data measured	Data collection method, Instrument & unit of measurement		Frequency of measurements	Manual measurements
Plant stress (Chlorophyll Fluorescence)	Experimental: JIP test with Plant Efficiency Analyser (PEA)(Fv/Fm)		Bi-Monthly	3
Crop yield (Fresh biomass)	Experimental: Calibrated digital scale (g)		Bi-Monthly	3
Orientation comparison (North vs. West)	Observations	 	Bi-weekly	24

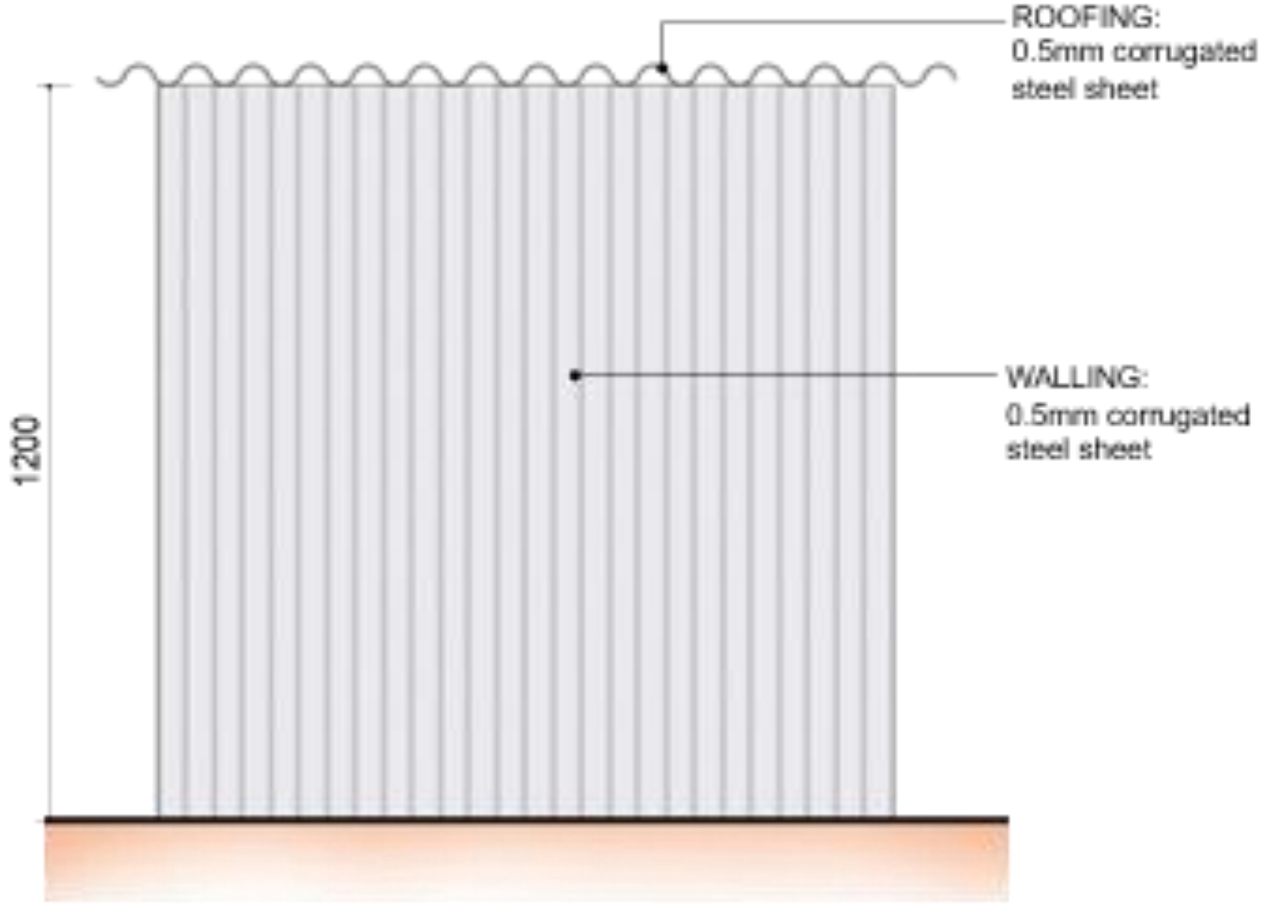
RESEARCH METHODOLOGY

Thermal Performance of Living Wall Systems with leafy African vegetables

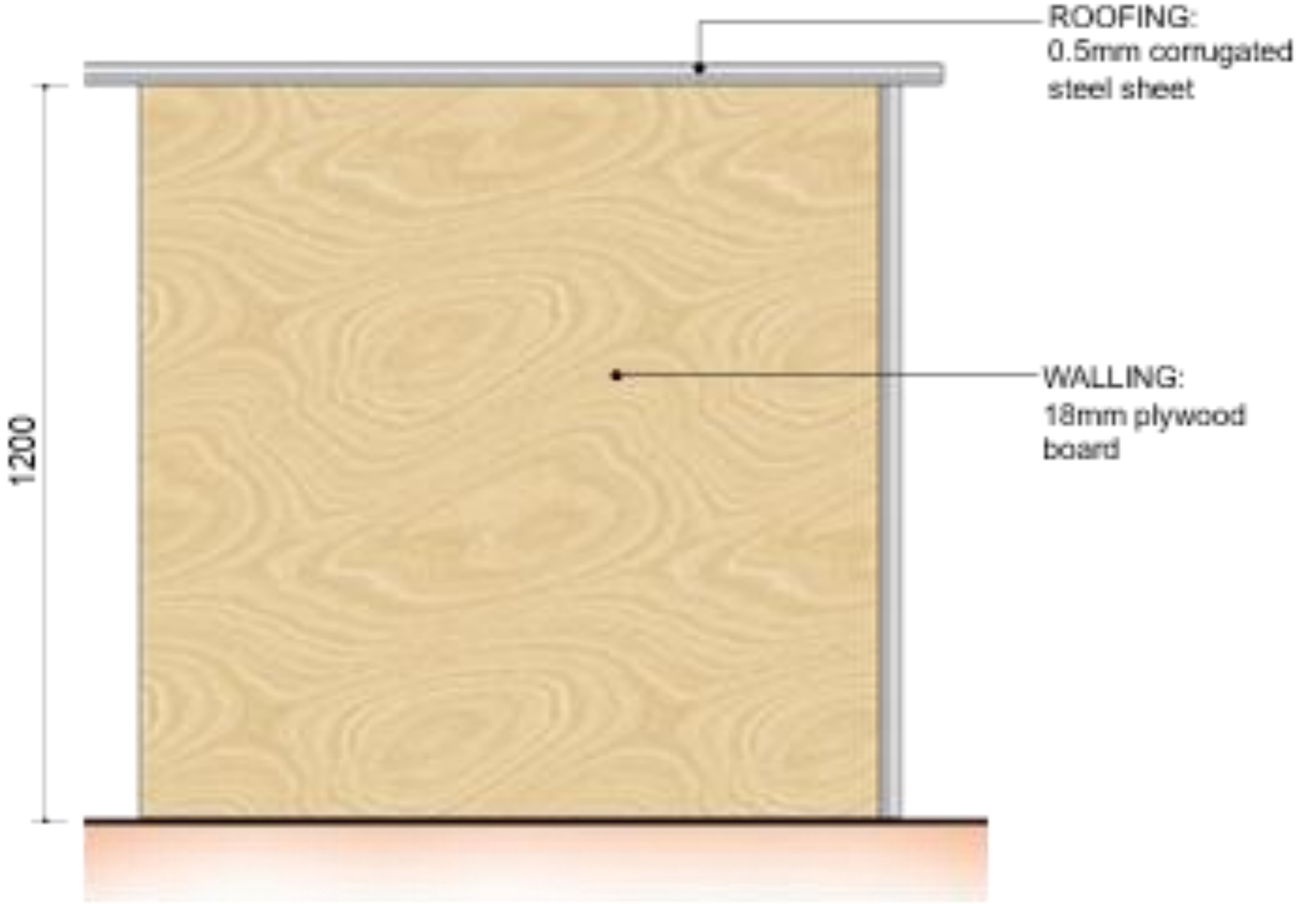
ACTIVITY 2



PLAN



NORTHERN ELEVATION



EASTERN, WESTERN & SOUTHERN ELEVATION

RESEARCH METHODOLOGY

Thermal Performance of Living Wall Systems with leafy African vegetables

ACTIVITY 2

CONTROL UNIT

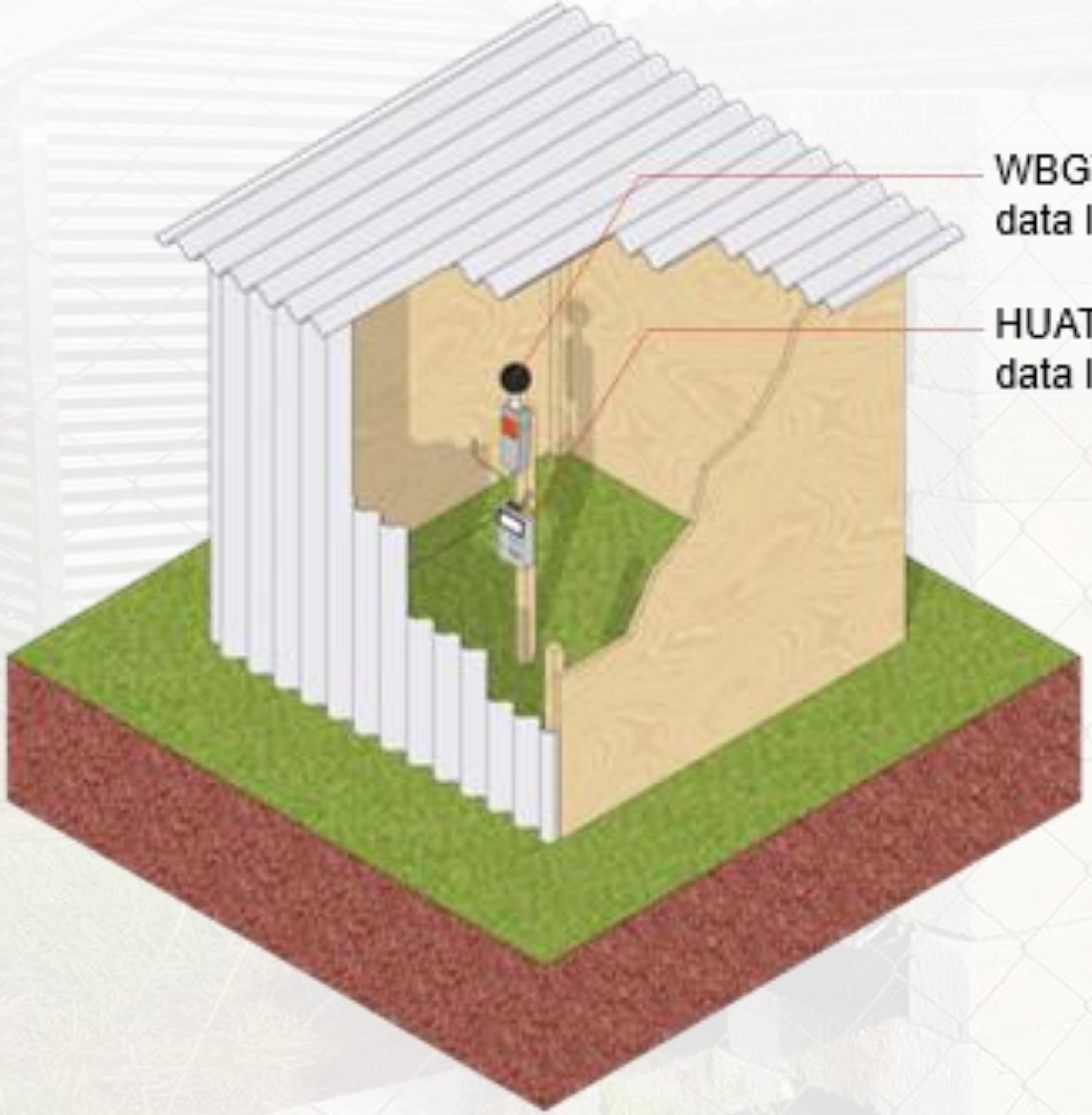
EXPERIMENTAL UNIT 1: **SOIL-BASED LWS**

EXPERIMENTAL UNIT 2: **HYDROPONIC LWS**

RESEARCH METHODOLOGY

Thermal Performance of Living Wall Systems with leafy African vegetables

ACTIVITY 2



WBGT
data logger

HUATO S220-T8
data logger

AMBIENT TEMPERATURE **(Ta)**
SURFACE TEMPERATURE **(Ts)**

AMBIENT TEMPERATURE **(Ta)**
RELATIVE HUMIDITY **(RH)**

Data collection:
7 to 10 days

RESEARCH METHODOLOGY

Thermal Performance of Living Wall Systems with leafy African vegetables

ACTIVITY 2

AMBIENT TEMPERATURE (TA) & RELATIVE HUMIDITY (RH)

AIR & SURFACE TEMPERATURES

AMBIENT TEMPERATURE **(Ta)**

SURFACE TEMPERATURE **(Ts)**

RELATIVE HUMIDITY **(RH)**

HEAT STRESS

COLLECTED THERMAL DATA

VARIABLES

Hugo, 2023

Steadman, 1994

Australian Government Bureau of Meteorology, 2010

RESEARCH METHODOLOGY

Thermal Performance of Living Wall Systems with leafy African vegetables

ACTIVITY 2

AMBIENT TEMPERATURE (TA) &
RELATIVE HUMIDITY (RH)

AIR & SURFACE TEMPERATURES

AMBIENT TEMPERATURE
(Ta)

SURFACE TEMPERATURE
(Ts)

RELATIVE HUMIDITY
(RH)

DIURNAL TEMPERATURE RANGE **(DTR)**
&
APPARENT TEMPERATURE **(AT)**

HEAT STRESS

COLLECTED THERMAL DATA

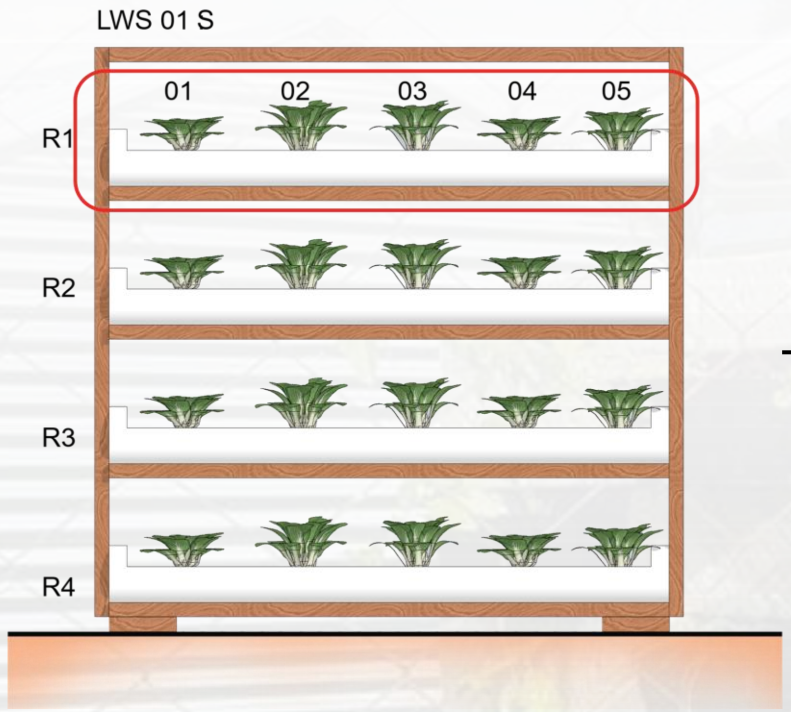
VARIABLES

Hugo, 2023
Steadman, 1994
Australian Government Bureau of Meteorology, 2010

RESEARCH METHODOLOGY

Plant Health and System Resilience of Living Wall Systems with leafy African vegetables

ACTIVITY 2



Living Wall System modules

Chinese Cabbage plants

S.R1.01

Plant number i.e. 01, 02, 03, 04, 05

Row number i.e. R1, R2, R3, R4

Growing substrate/ medium i.e.
H - Hydroponic medium, S - Soil medium

Identification system

(Fv/Fm)
JIP test with Plant Efficiency Analyser (PEA)

HandyPEA chlorophyll fluorometer

PLANT STRESS
(Chlorophyll Fluorescence)

COLLECTED PLANT HEALTH DATA

Hugo, 2023
Steadman, 1994
Australian Government Bureau of Meteorology, 2010

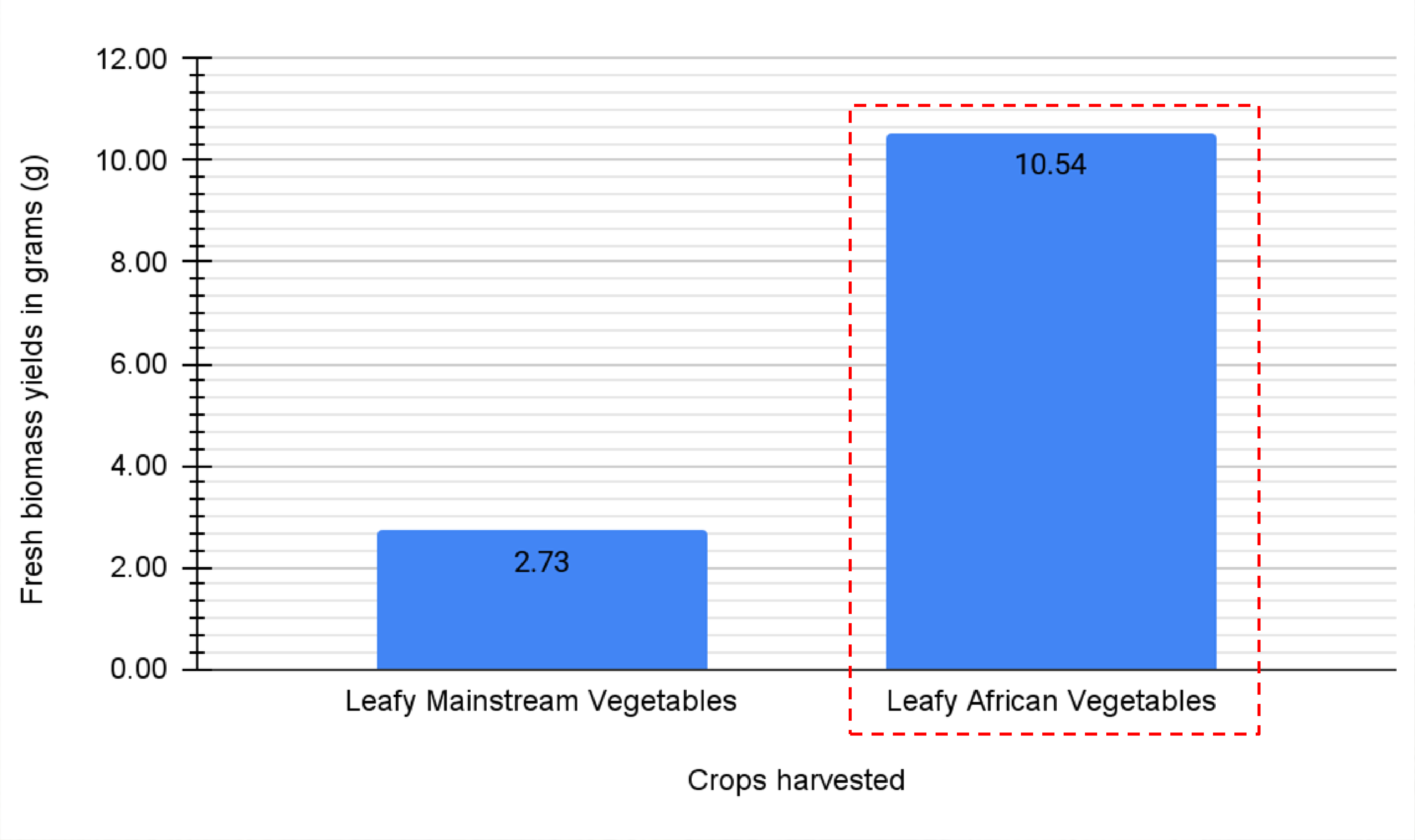
KEY PRELIMINARY FINDINGS

Thermal- and Plant Performance of Living Wall Systems with African leafy vegetables

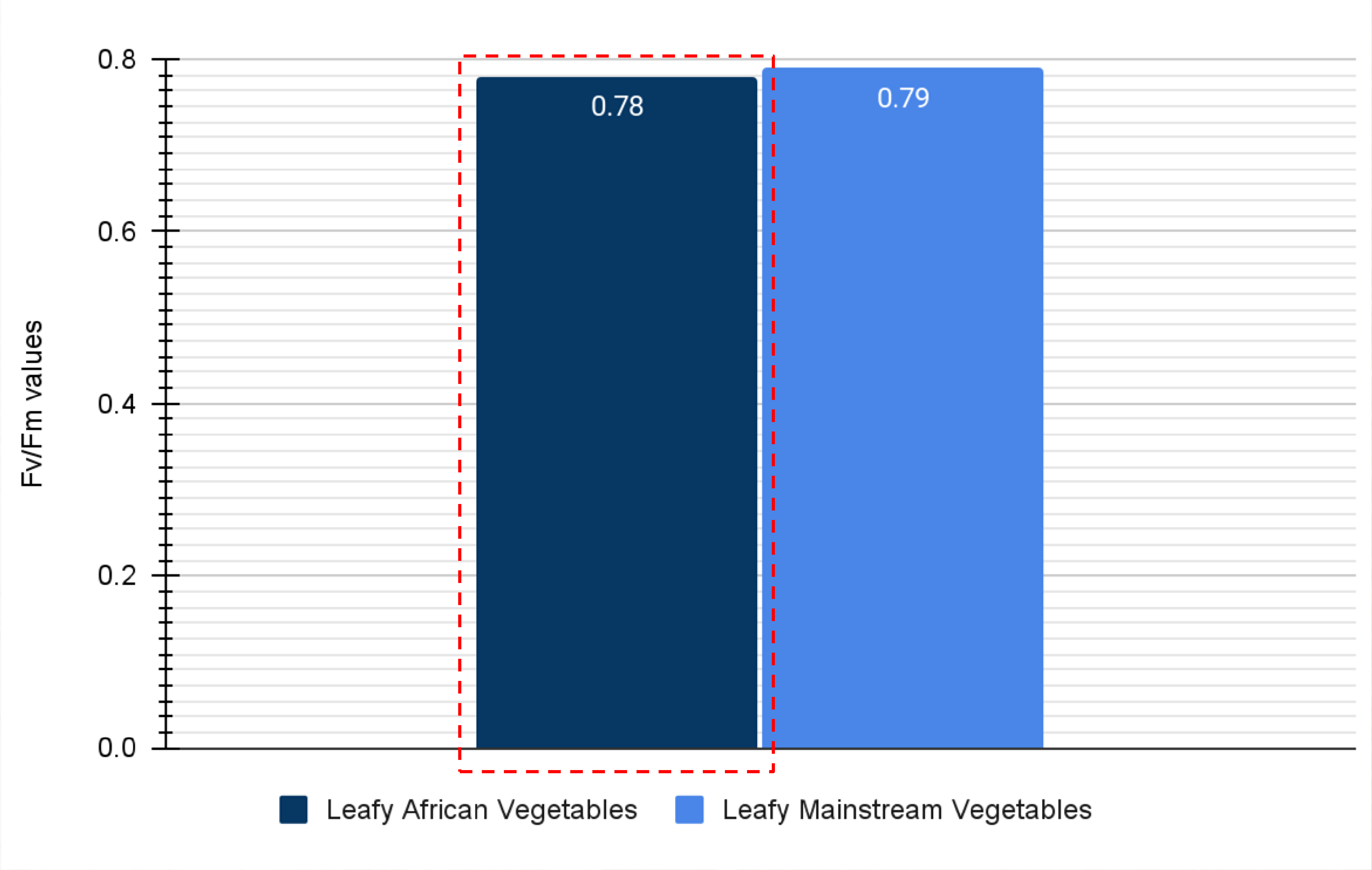
African Vegetables within modular living walls

ACTIVITY 1

Fresh Biomass comparison



Plant stress comparison



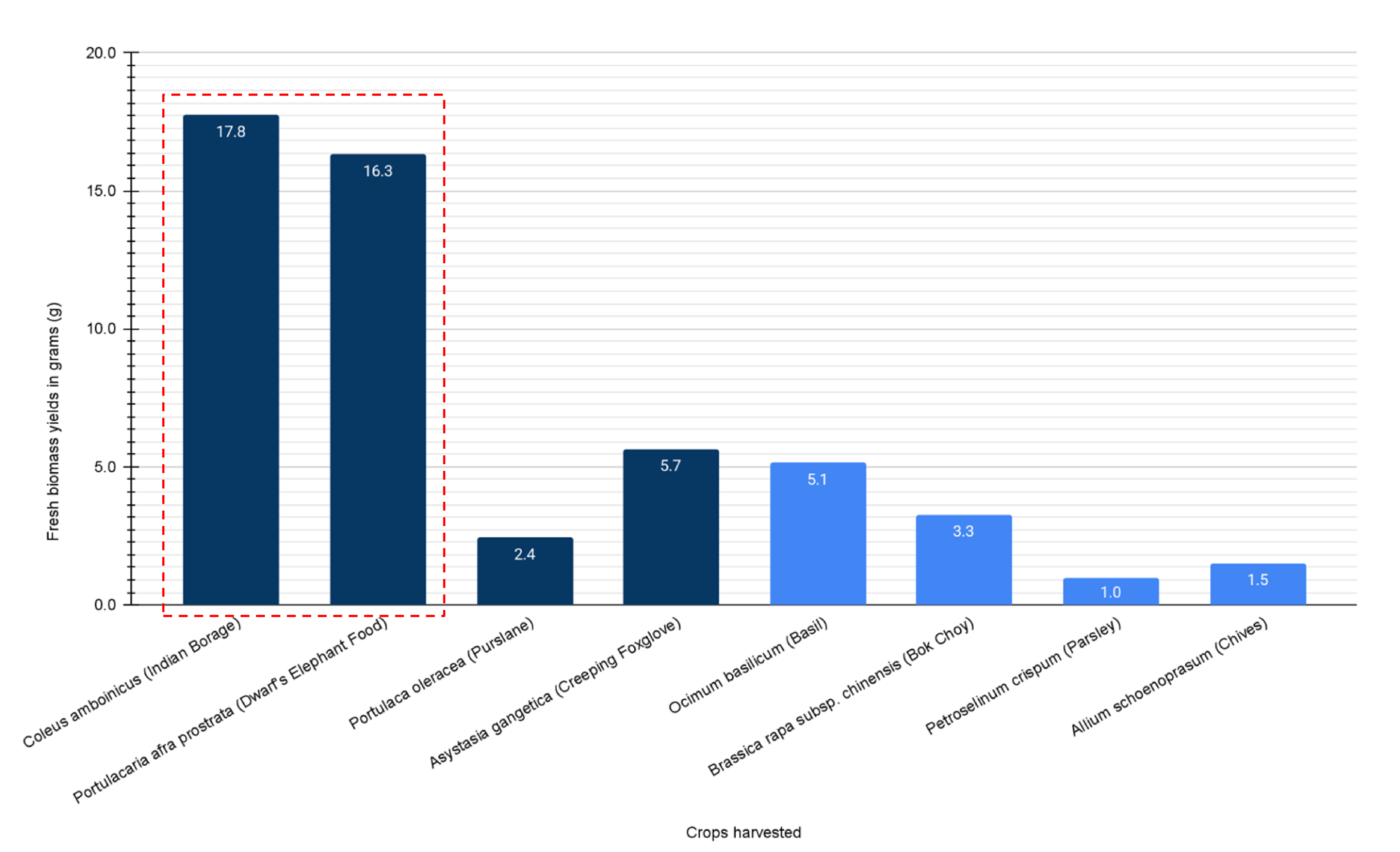
KEY PRELIMINARY FINDINGS

Thermal- and Plant Performance of Living Wall Systems with leafy African vegetables

African Vegetables within modular living walls

ACTIVITY 1

Fresh Biomass comparison



Coleus amboinicus (Indian borage) (Botes, 2025)

Portulacaria afra prostrata (Dwarf elephant’s food) (Botes, 2025)

KEY PRELIMINARY FINDINGS

Thermal- and Plant Performance of Living Wall Systems with African leafy vegetables

ACTIVITY 1

Leafy African Vegetables in modular living walls

Crop	Mean	Number of crops tested	Std. Deviation	Minimum	Maximum
***Coleus amboinicus* (Indian Borage)**	0,80	24	0,02	0,75	0,84
***Portulacaria afra prostrata* (Dwarf elephant's food)**	0,83	24	0,03	0,79	0,87
***Portulaca oleracea* (Purslane)**	0,74	24	0,07	0,52	0,80
***Asystasia gangetica* (Creeping foxglove)**	0,72	23	0,05	0,62	0,78
***Ocimum basilicum* (Basil)**	0,77	24	0,07	0,54	0,85
***Brassica rapa* subsp. *chinensis* (Bok Choy)**	0,79	10	0,05	0,67	0,85
***Petroselinum crispum* (Parsley)**	0,79	24	0,03	0,71	0,82
***Allium schoenoprasum* (Chives)**	0,83	23	0,02	0,79	0,86
Total	0,78	176	0,06	0,52	0,87

KEY PRELIMINARY FINDINGS

Thermal- and Plant Performance of Living Wall Systems with leafy African vegetables

Leafy African Vegetables in modular living walls

ACTIVITY 1

Plant stress comparison between orientations

		Sum of Squares	Sig.
Fv/Fm * Orientation	**Between Groups (Combined)**	0,008	0,110
	Within Groups	0,568	
	Total	0,577	

KEY PRELIMINARY FINDINGS

Thermal- and Plant Performance of Living Wall Systems with leafy African vegetables

Leafy African Vegetables in modular living walls

ACTIVITY 1

Fresh Biomass comparison between orientations

Orientation	Mean	Std. Deviation	Minimum	Maximum
N	6,20	7,53	0,00	28,47
W	7,08	7,40	0,53	34,82
Total	6,64	7,44	0,00	34,82

Plant stress statistical significance between orientations

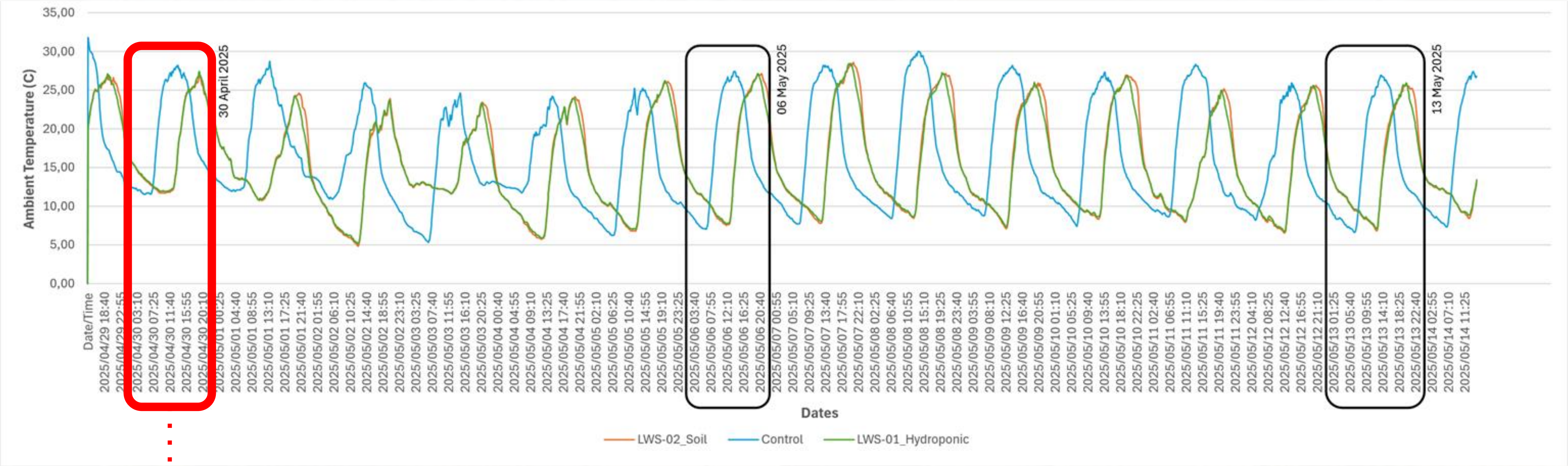
		Sum of Squares	Sig.
Fv/Fm * Orientation	Between Groups (Combined)	19,15	0,559
	Within Groups	5241,68	
	Total	5260,84	

KEY PRELIMINARY FINDINGS

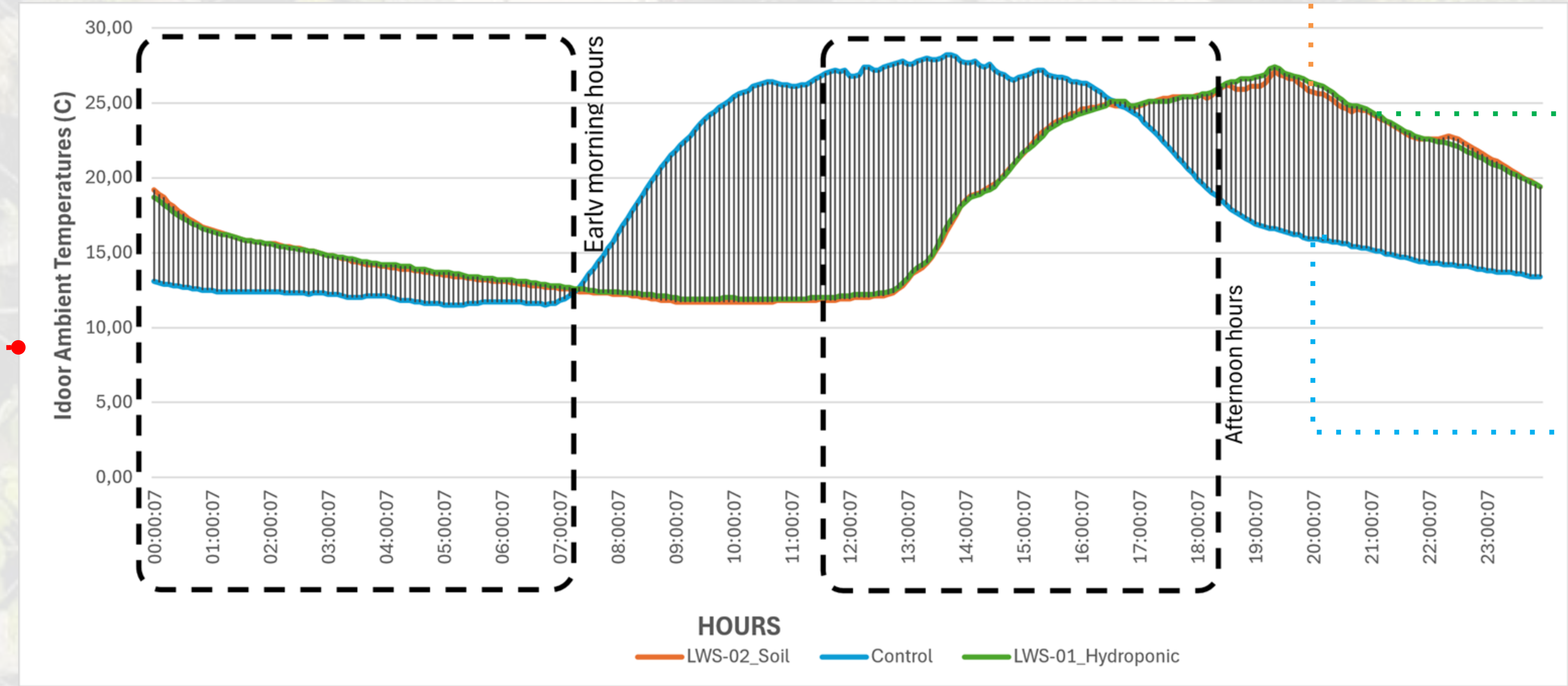
Thermal- and Plant Performance of Living Wall Systems with leafy African vegetables

Thermal Control and Stability

ACTIVITY 2



Comparison of Indoor ambient temperatures from 29 April to 14 May 2025 (Author, 2025)



Indoor ambient temperature comparisons for 30 April 2025 (Author, 2025)

EXPERIMENTAL UNIT 1:
SOIL-BASED LWS

EXPERIMENTAL UNIT 2:
HYDROPONIC LWS

CONTROL UNIT

KEY PRELIMINARY FINDINGS

Thermal- and Plant Performance of Living Wall Systems with leafy African vegetables

Reducing Diurnal Fluctuations

ACTIVITY 2

Experiment Period	Setup	Ta.max (°C)	Ta.min (°C)	ΔDTR (°C)
29 April 2025 - 14 May 2025	Control	31,8	5,3	26,5
	LWS 01 (Hydroponic)	28,4	5,1	23,3
	LWS 02 (Soil-based)	28,6	4,8	23,8

Diurnal Temperature range values for select days during the in-situ experiment

10.7%

reduction of Ta.max between Hydroponic & Control unit

EXPERIMENTAL UNIT 1: **SOIL-BASED LWS**

EXPERIMENTAL UNIT 2: **HYDROPONIC LWS**

CONTROL UNIT

KEY PRELIMINARY FINDINGS

Thermal- and Plant Performance of Living Wall Systems with leafy African vegetables

Plant Health and System Resilience
ACTIVITY 2

	N	Mean	Std. Deviation	Std. Error Mean
LWS-01 (Hydroponics)	61	0,785	0,049	0,0062
LWS-02 (Soil-based)	40	0,666	0,176	0,0278

Comparison of the mean Fv/Fm of the Hydroponic and soil-based LWSs

EXPERIMENTAL UNIT 1:
SOIL-BASED LWS

Shed-off leaves from LWS-01 as of 01 May (Author, 2025)

EXPERIMENTAL UNIT 2:
HYDROPONIC LWS

Shed-off leaves from LWS-01 as of 01 May (Author, 2025)

DISCUSSION

Leafy African Vegetables has a significantly higher yield than conventional leafy vegetables

Coleus amboinicus (Indian borage) and *Portulacaria afra prostrata (dwarf elephant's food)* outperformed other crops

Appropriate Technologies are needed, in this case Hydroponic systems performed better than soil-based systems.
Need for further research.

Appropriate application of these technologies is critical to enable co-benefits.

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EDIBLE GREEN WALLS

Addressing Food Security and Heat Stress in South Africa's Informal Settlements

THANK YOU

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UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Shané de Beer
sdebeer713@gmail.com | 071 130 5191

Arthur Baleeta
balart30@gmail.com | 073 867 1678

Dr. Karen Botes
karen.botes@up.ac.za

Dr. Jan Hugo
jan.hugo@up.ac.za

Flexible Facades & Ecosystem Services Project