LIVING GREEN WALL SYSTEMS

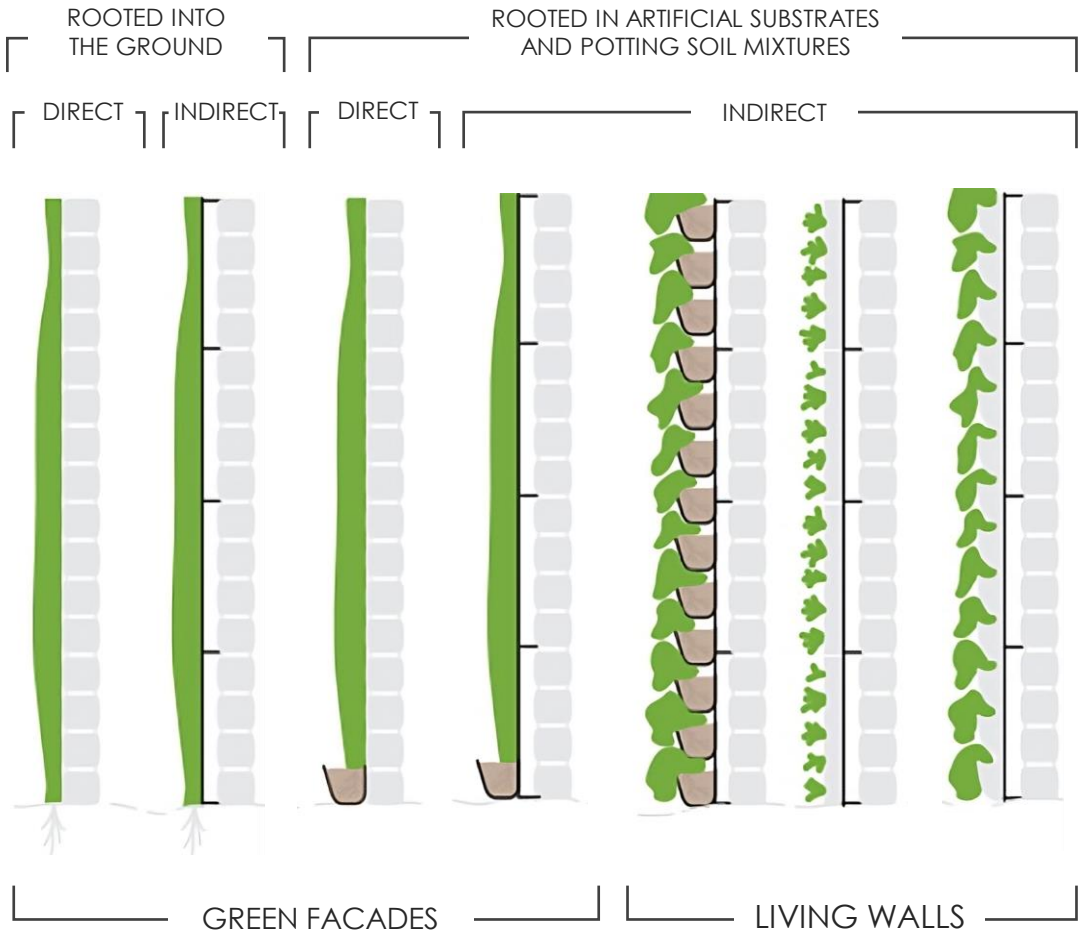
A STRATEGY TO LIMIT MAINTENANCE

P5 PRESENTATION

Aria Hassanzadeh

2023, July 3rd

GREEN WALLS


ROOTED INTO THE GROUND
ROOTED IN ARTIFICIAL SUBSTRATES AND POTTING SOIL MIXTURES
DIRECT
INDIRECT
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GREEN FACADES
LIVING WALLS

GREEN WALLS


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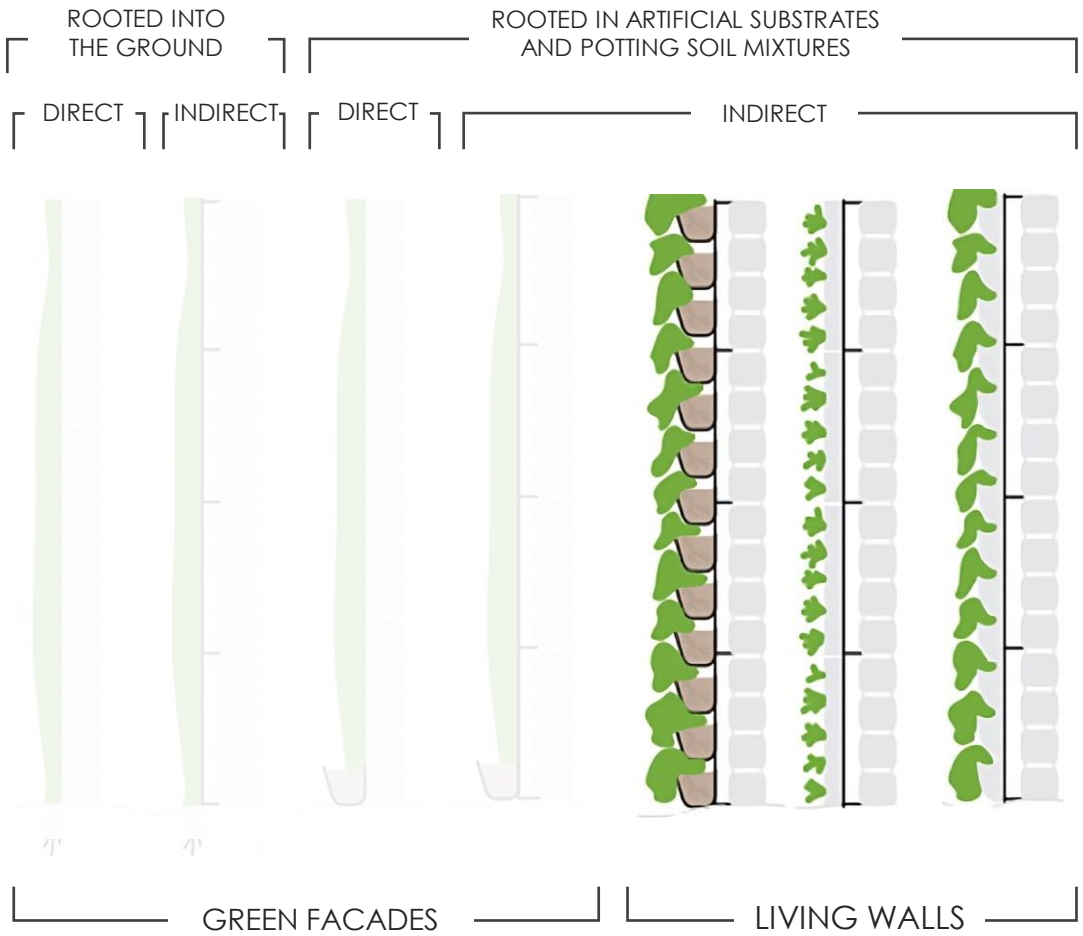
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L I T E R A T U R E

The water volume used to irrigate them will not be equal to the actual water transpired by the vegetation.

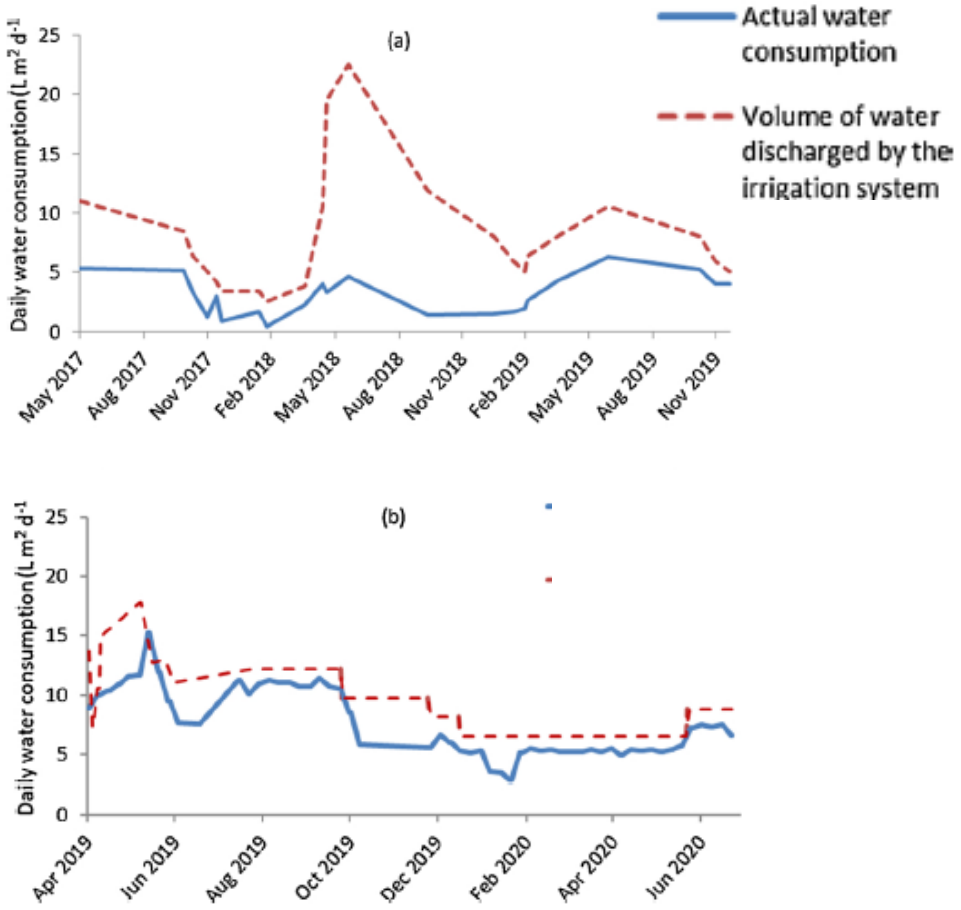
Pérez-Urrestarazu. 2021

The installation managers highlighted plant stress management as the principal challenge.

Gunawardena & Steemers, 2020

Human management processes must therefore recognise stress symptoms as early as possible and intervene with appropriate measures.

Gunawardena & Steemers, 2020



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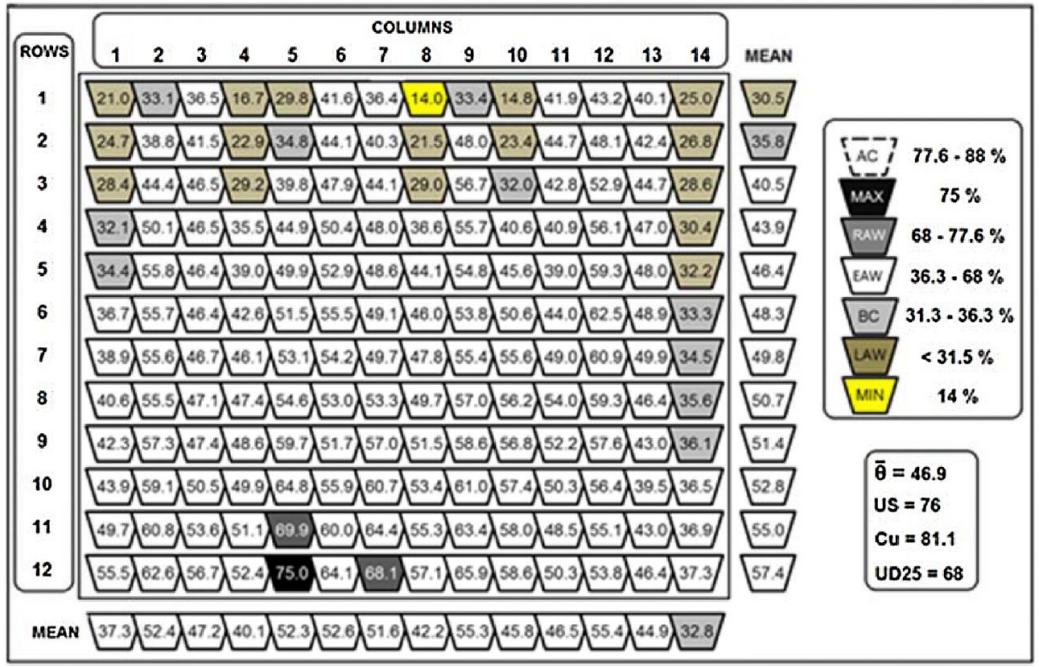
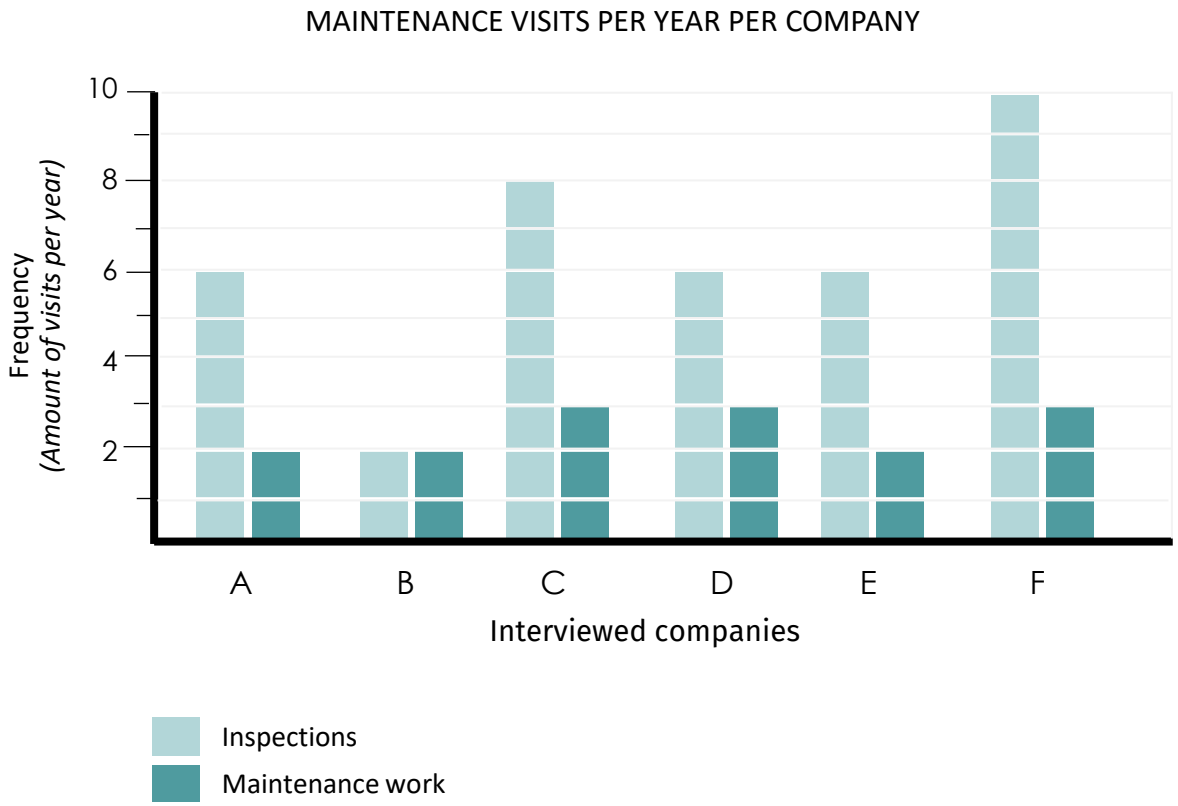


Segovia-Cardozo, 2019

EXPERIENCES



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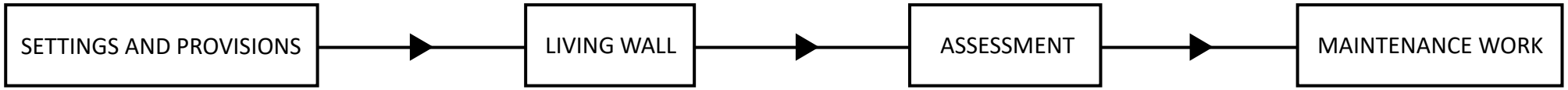
P R O B L E M & O B J E C T I V E



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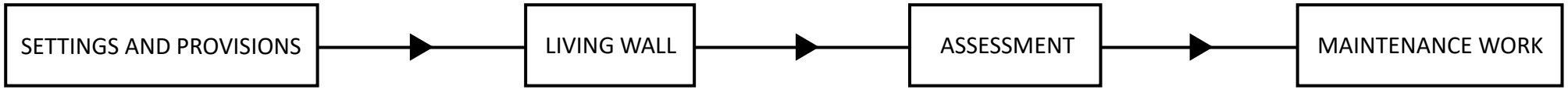


Irrigation capacity

Irrigation time

By observation

Pruning and cutting

Replacing plants

Clogged pipes

Remove dead leafs

PROBLEM & OBJECTIVE

''The plants dont look so healthy, these need to be replaced soon!''

SETTINGS AND PROVISIONS → LIVING WALL → **ASSESSMENT** → MAINTENANCE WORK

Irrigation capacity

Irrigation time

By observation

Pruning and cutting

Replacing plants

Clogged pipes

Remove dead leafs

PROBLEM & OBJECTIVE

''The camera shows that there are dry spots on the wall. Lets change the irrigation settings before this has effect on the plant quality!''

SETTINGS AND PROVISIONS → LIVING WALL → **ASSESSMENT** → MAINTENANCE WORK

Irrigation capacity

Irrigation time

~~*By observation*~~

With monitoring methods

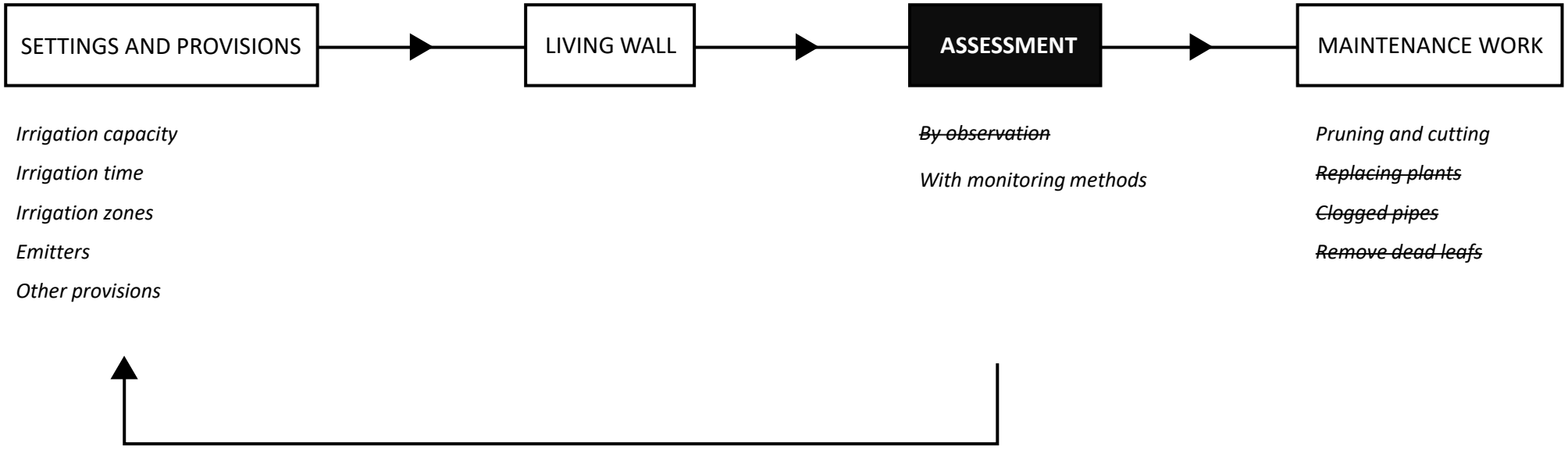
Pruning and cutting

Replacing plants

Clogged pipes

Remove dead leafs

P R O B L E M & O B J E C T I V E



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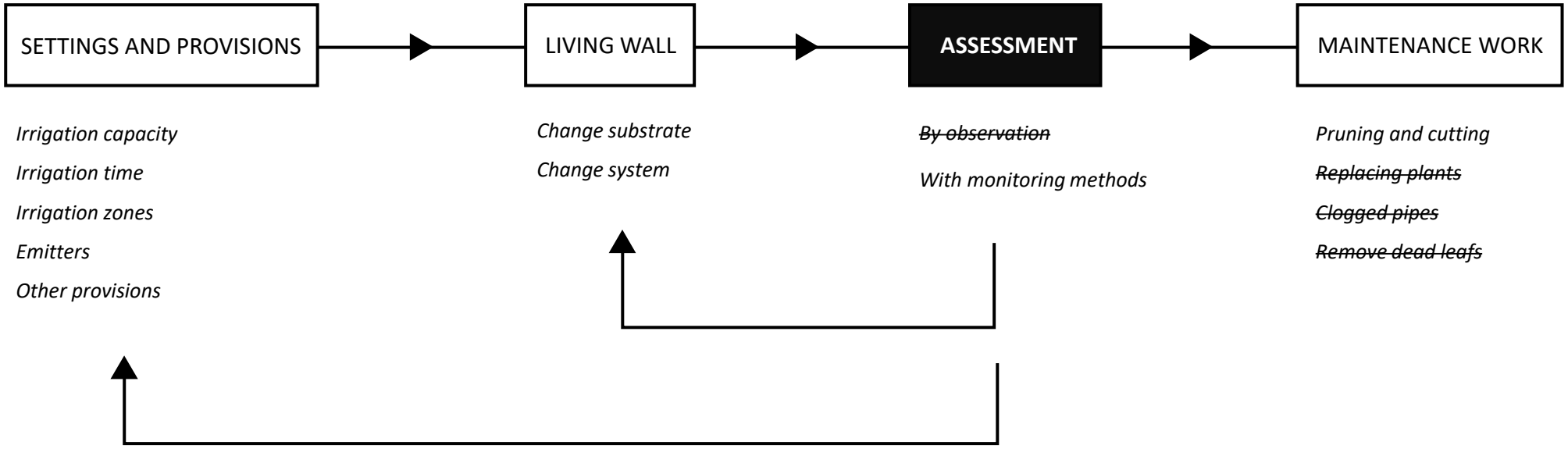

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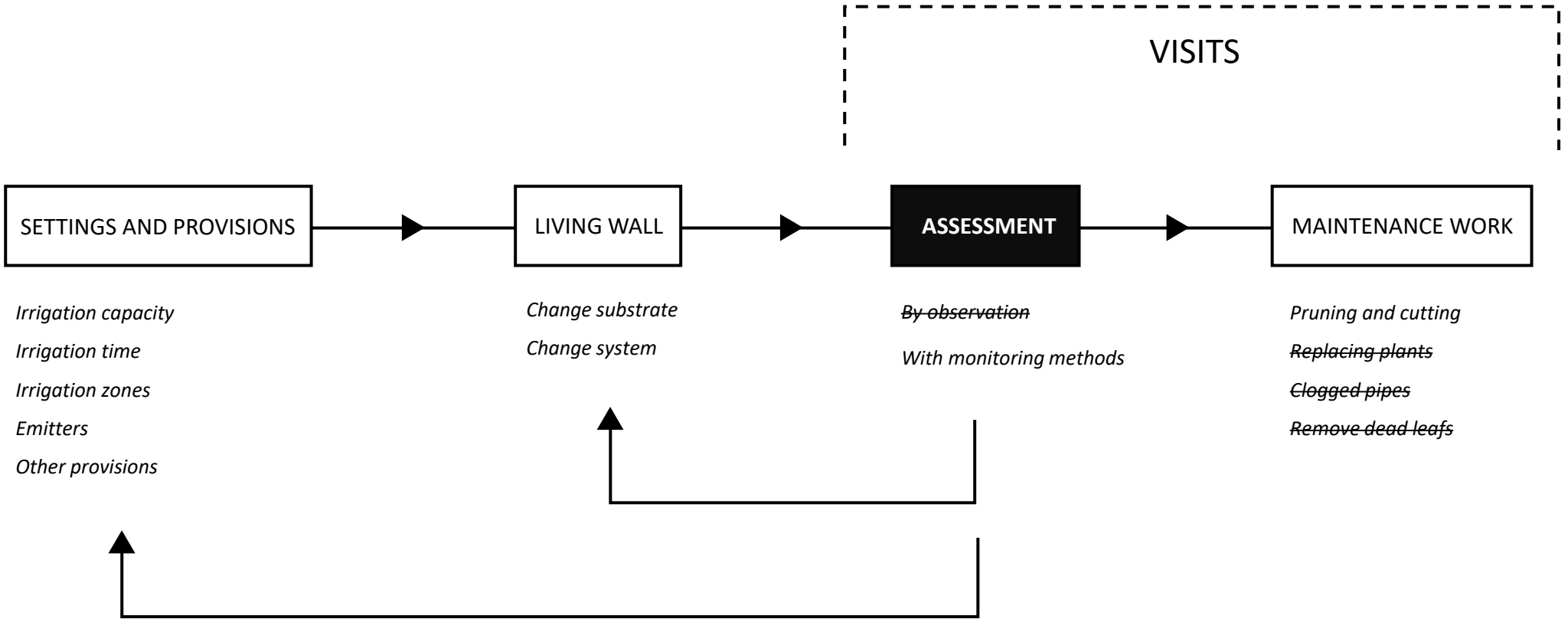

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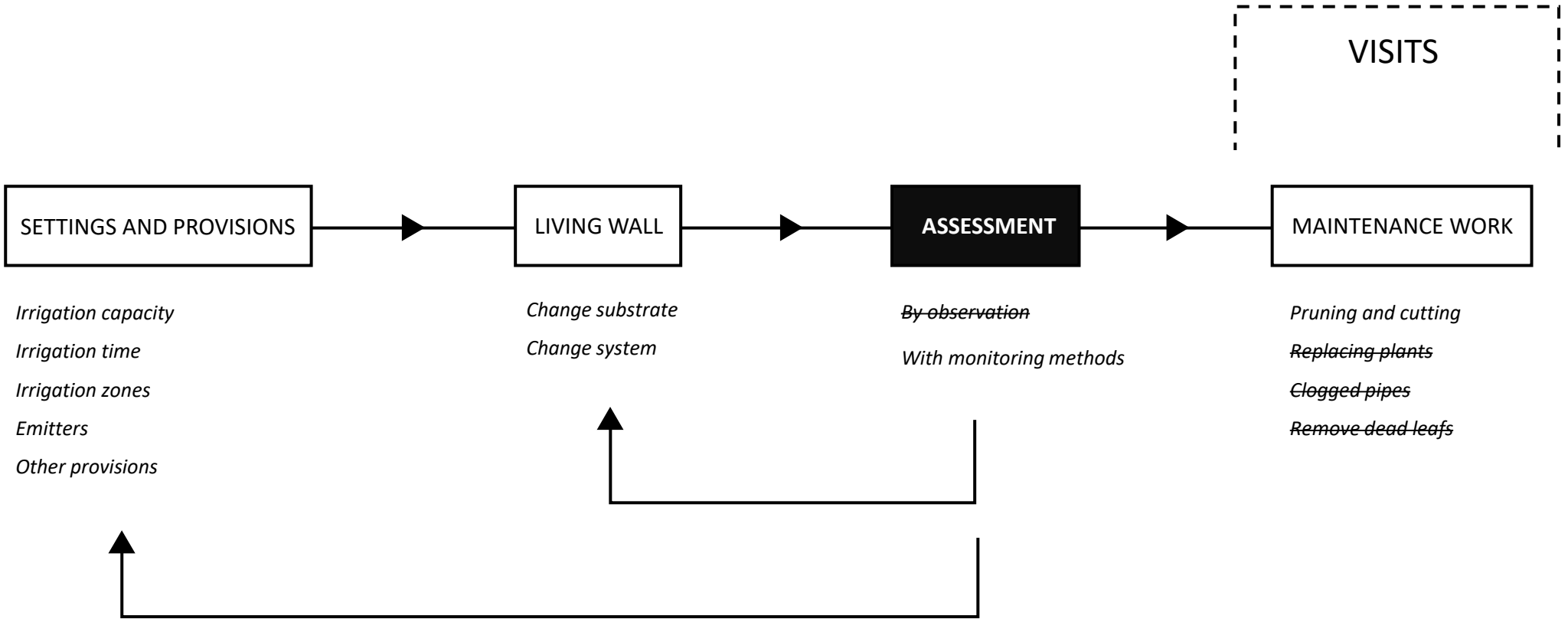


RESEARCH QUESTION

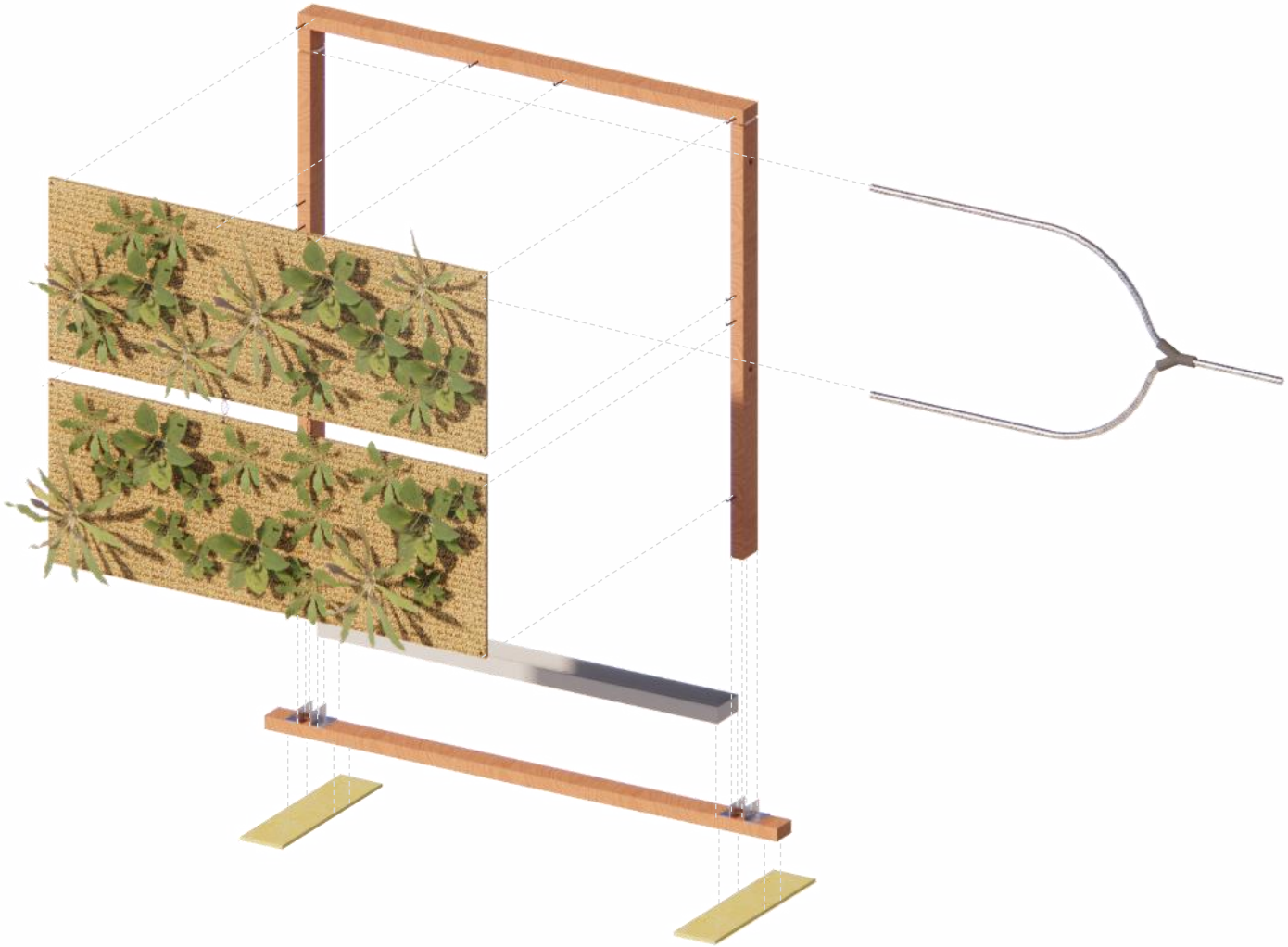
WHAT IS THE BEST STRATEGY FOR **MONITORING** THE WATER DISTRIBUTION OF THE **IRRIGATION SYSTEM** ON A LIVING GREEN WALL SYSTEM THAT ULTIMATELY LEADS TO MORE EFFECTIVE **MAINTENANCE** ?

MATERIALS & METHODS

TEST MODEL

MATERIALS & METHODS

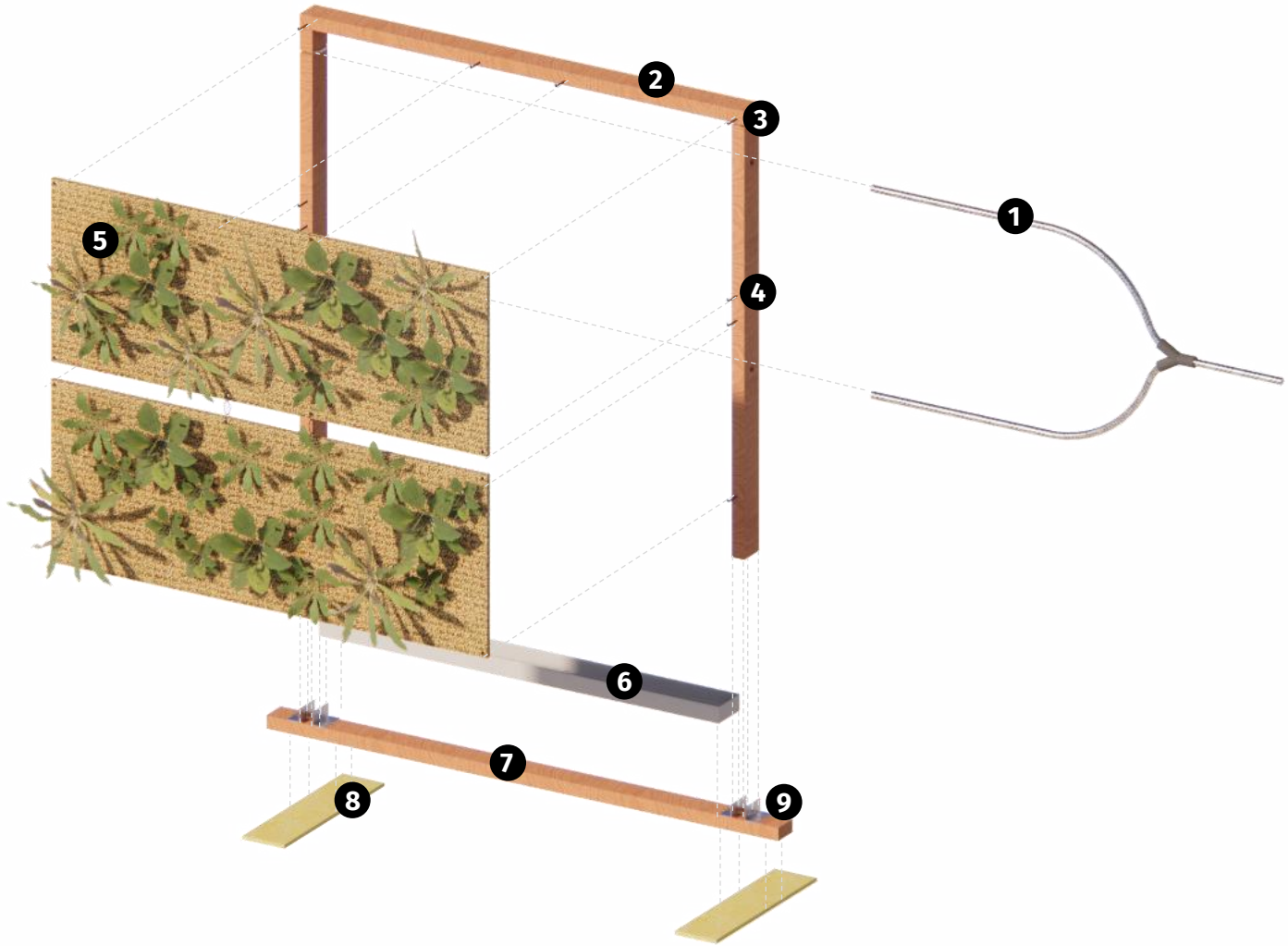
TEST MODEL



MATERIALS & METHODS

TEST MODEL

1. WATER HOSE ⌀ 12.7 mm
2. TIMBER FRAME
3. HINGES
4. HOOKS AND EYES CONNECTION
5. PRE-SEEDED MATS
6. GUTTER
7. TIMBER BEAM FOR STABILITY
8. TIMBER PLATE FOR STABILITY
9. STEEL PROFILES



MATERIALS & METHODS

MONITORING TOOLS

THERMAL CAMERA

MOISTURE SENSORS

RUN–OFF WATER

NDVI CAMERA

MATERIALS & METHODS

THERMAL CAMERA

ADVANTAGES

_Gives an indication of water distribution

_Gives an indication of water content

_Big range

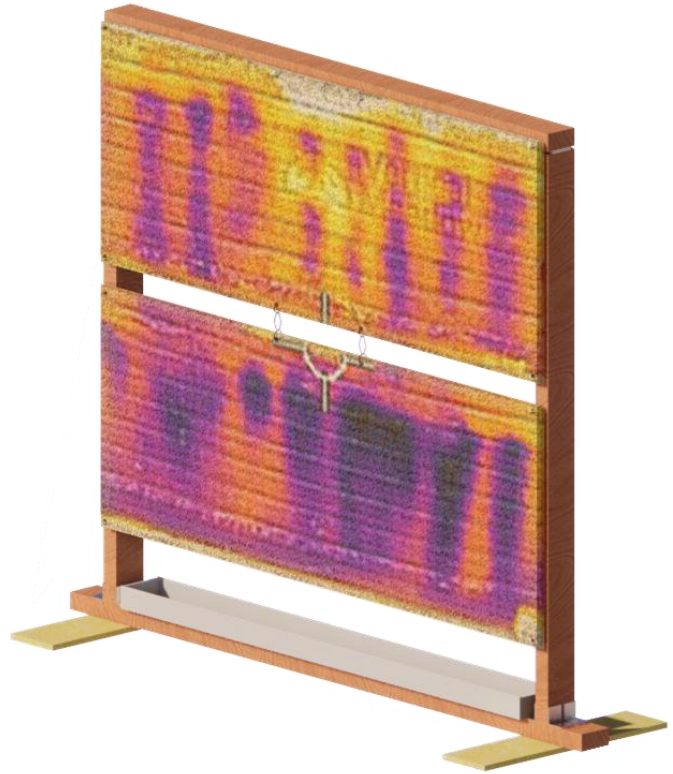
_Easy to use

_Possible to pre-set the temperature scale

LIMITATIONS

_Gives no direct value for the water content

_Result can be influenced by external factors



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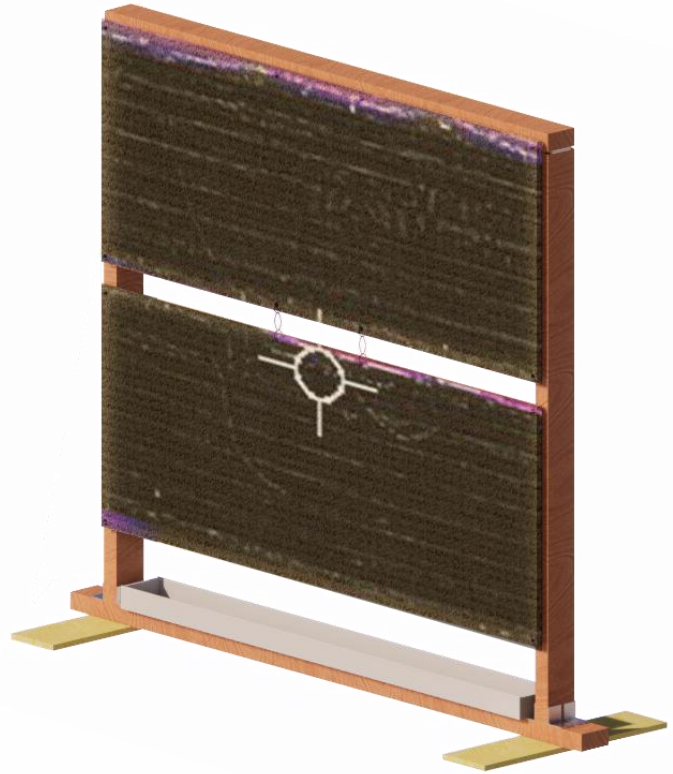

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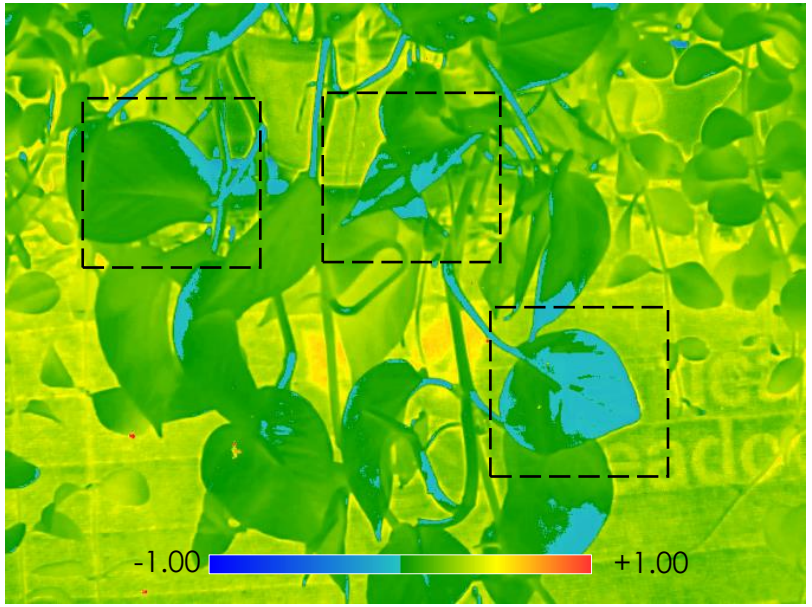


MATERIALS & METHODS

RUN-OFF

ADVANTAGES

_Easy to measure

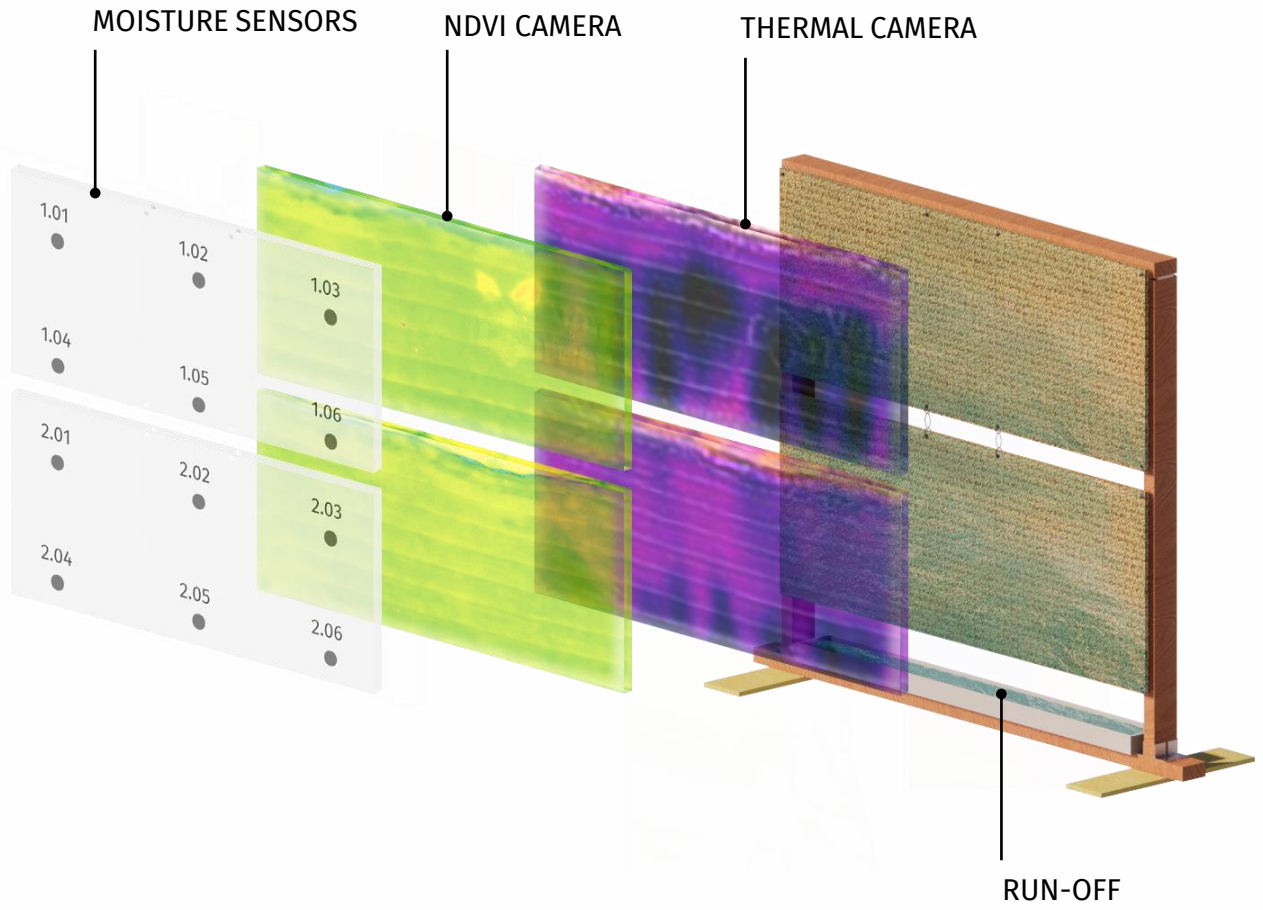
_Says something directly about the water content

LIMITATIONS

_Doesn’t say anything about the water distribution

MEASUREMENT PLAN

TEST A	**A.01** Default 4 l/min – 1:30 min **A.02** Default 4 l/min – 1:30 min
TEST B	**B.01** 5 l/min **B.02** 6 l/min
TEST C	**C.01** 3:00 minutes **C.02** 6:00 minutes
TEST D	**D.01** Dripline distance 100 mm **D.02** Waterpipe distance 0 mm
TEST E	**E.01** Before irrigating



RESULTS

MOISTURE SENSORS

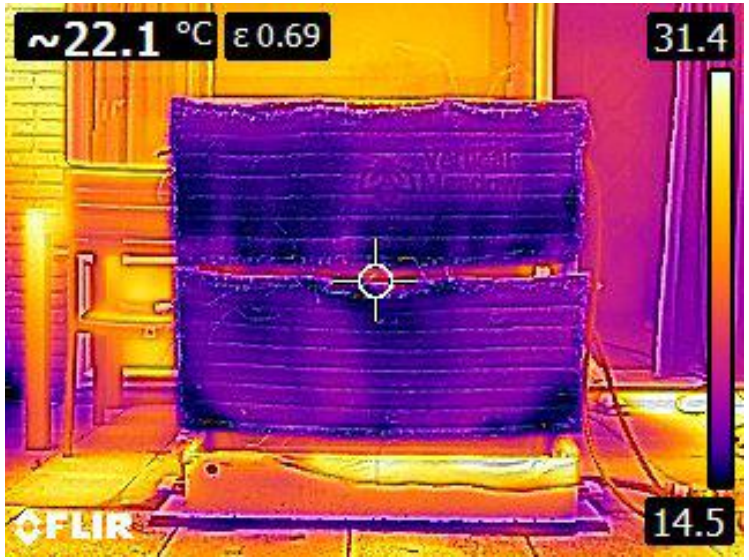
Moisture sensor results									
Sensor	A.01	A.02	B.01	B.02	C.01	C.02	D.01	D.02	E.01
1.01	76	295	178	192	186	346	277	263	0
1.02	88	266	370	349	177	462	370	310	0
1.03	85	241	135	279	163	363	290	232	0
1.04	140	321	513	605	230	609	487	546	0
1.05	190	532	622	669	361	645	516	470	0
1.06	174	521	508	593	348	632	505	617	0
2.01	303	350	303	361	326	532	426	323	0
2.02	314	309	174	330	312	370	296	255	0
2.03	309	255	156	673	282	313	250	260	0
2.04	483	552	578	631	518	651	520	604	0
2.05	502	491	545	626	497	613	490	436	0
2.06	525	479	449	625	502	575	460	327	0

RUN-OFF WATER

Water retention comparison					
Measurement	Water flow	Water time	Total water	Run-off water	Water retention
A.01	4 L/min	1:30 min	06.0 L	04.9 L	18.3 %
A.02	4 L/min	1:30 min	06.0 L	04.3 L	28.3 %
B.01	5 L/min	1:30 min	07.5 L	05.5 L	26.7 %
B.02	6 L/min	1:30 min	09.0 L	07.5 L	16.7 %
C.01	4 L/min	3:00 min	12.0 L	07.0 L	41.7 %
C.02	4 L/min	6:00 min	24.0 L	18.9 L	21.3 %
D.01	4 L/min	1:30 min	06.0 L	4.1 L	31.7 %
D.02	4 L/min	1:30 min	06.0 L	3.8 L	36.7 %

RESULTS

THERMAL CAMERA



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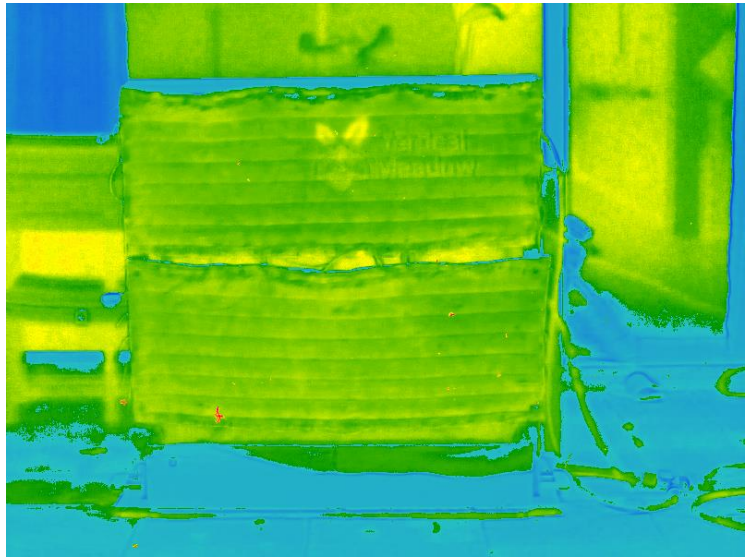

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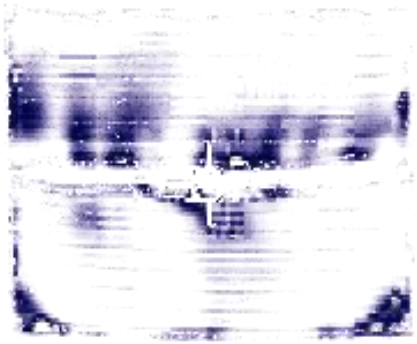
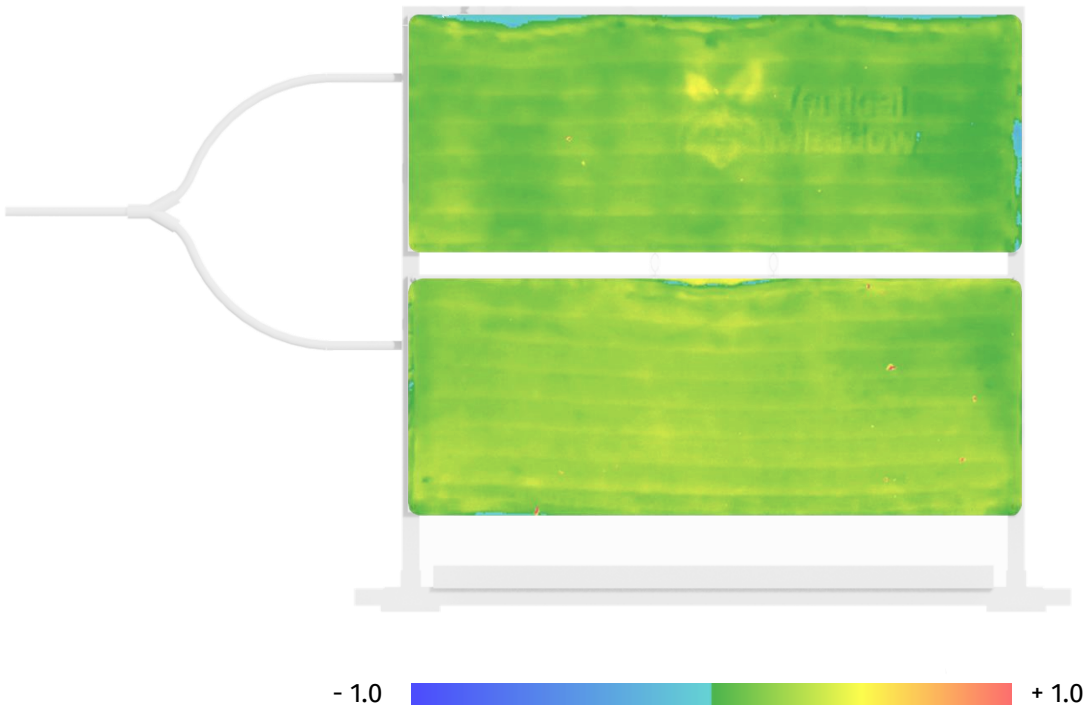
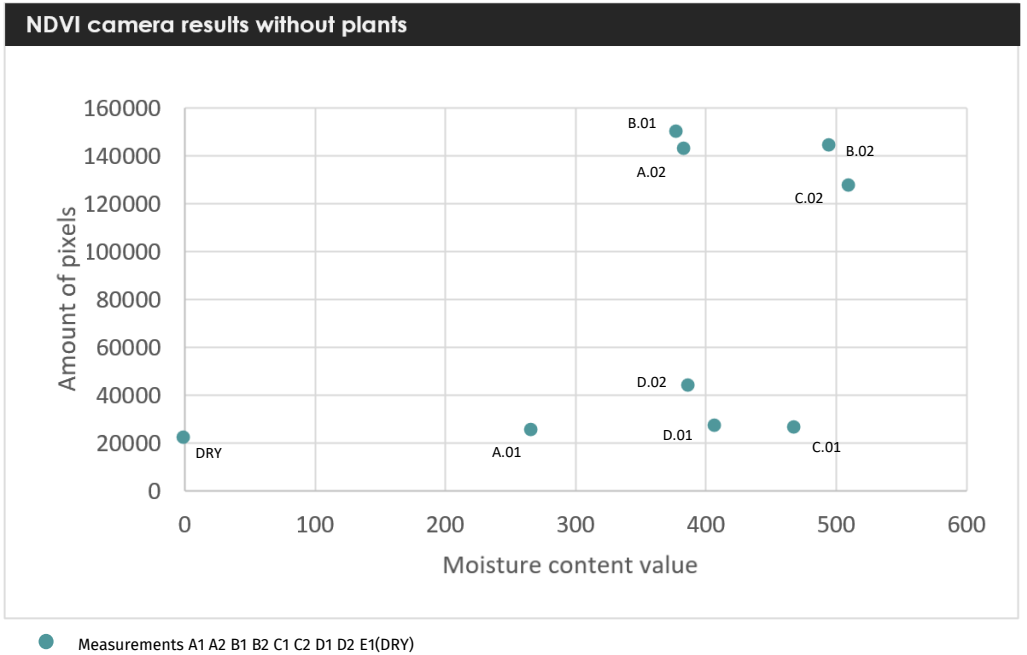


NDVI

RESULTS

NDVI CAMERA X SENSORS





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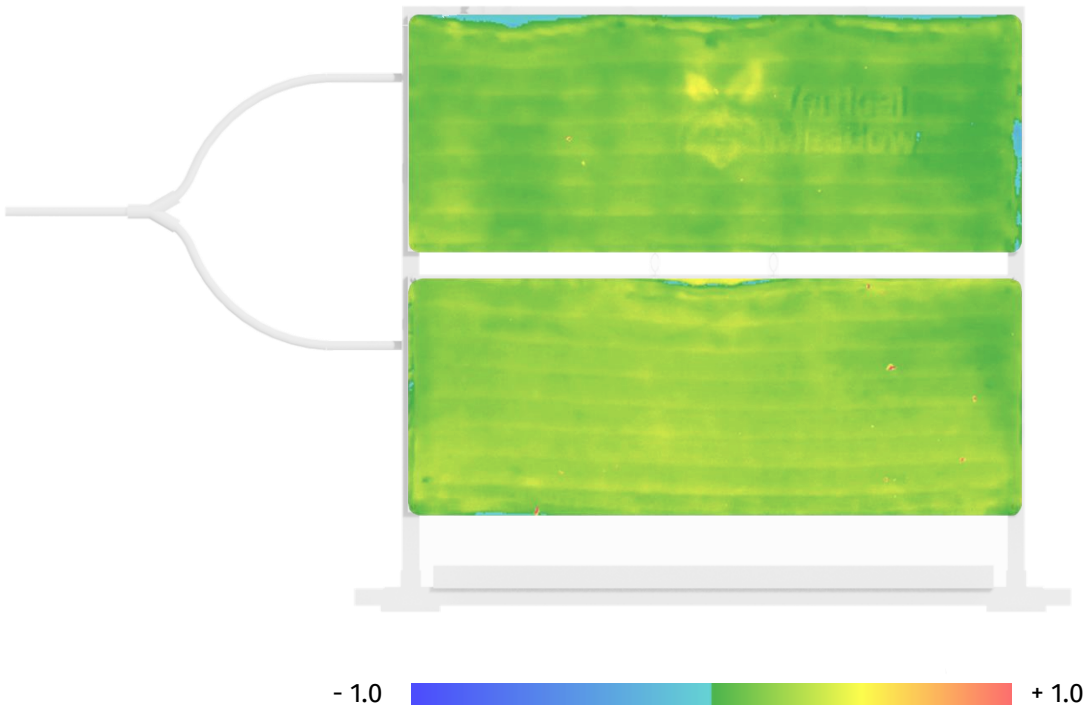

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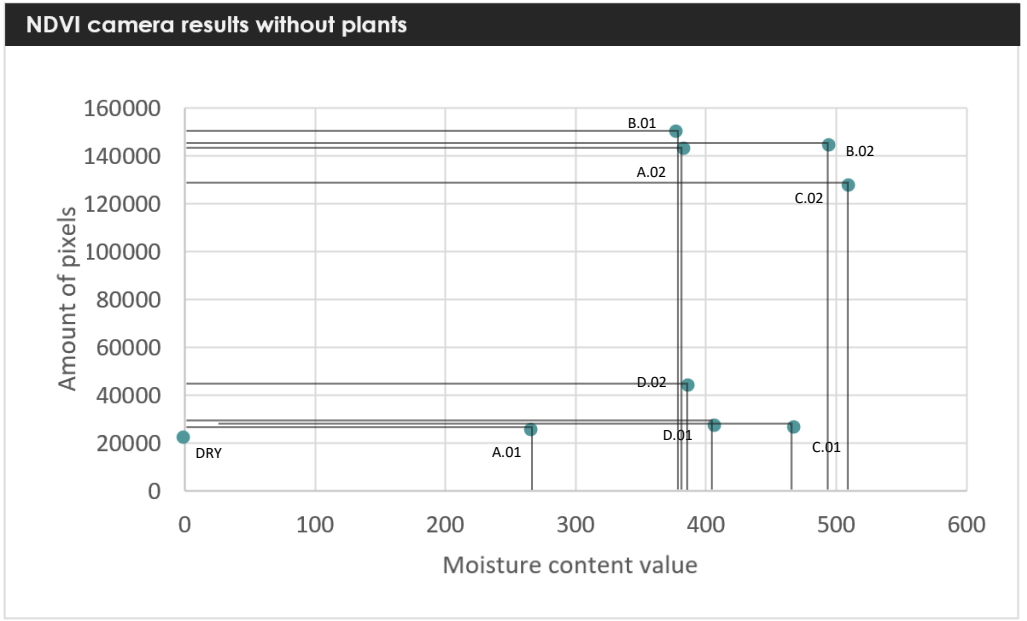

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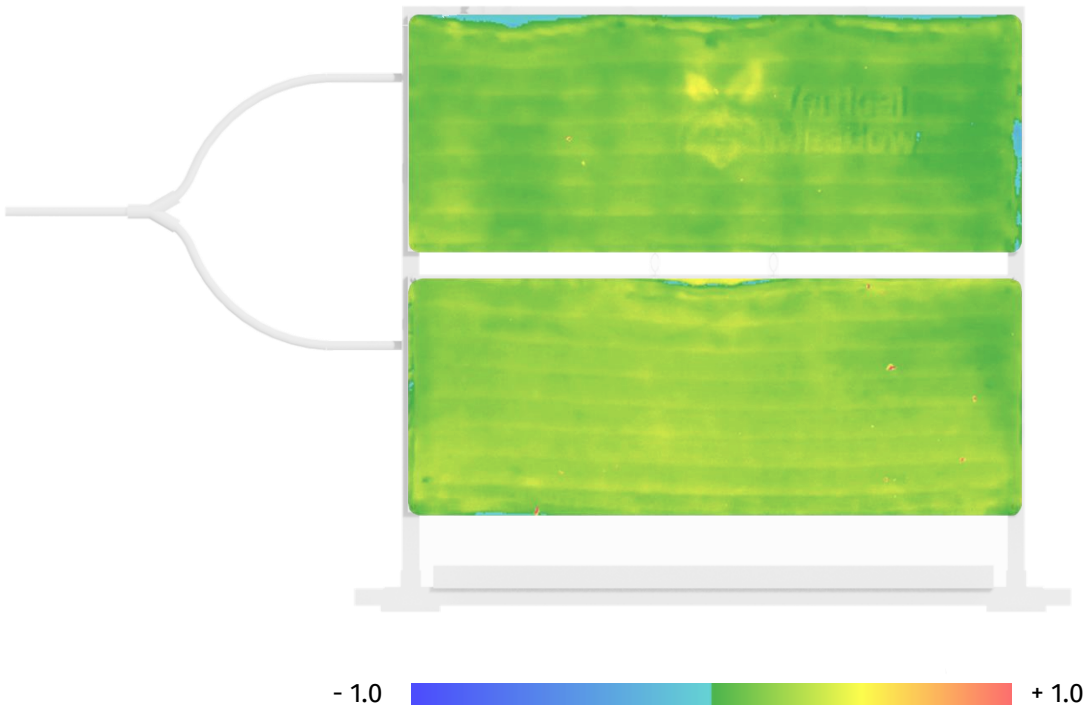

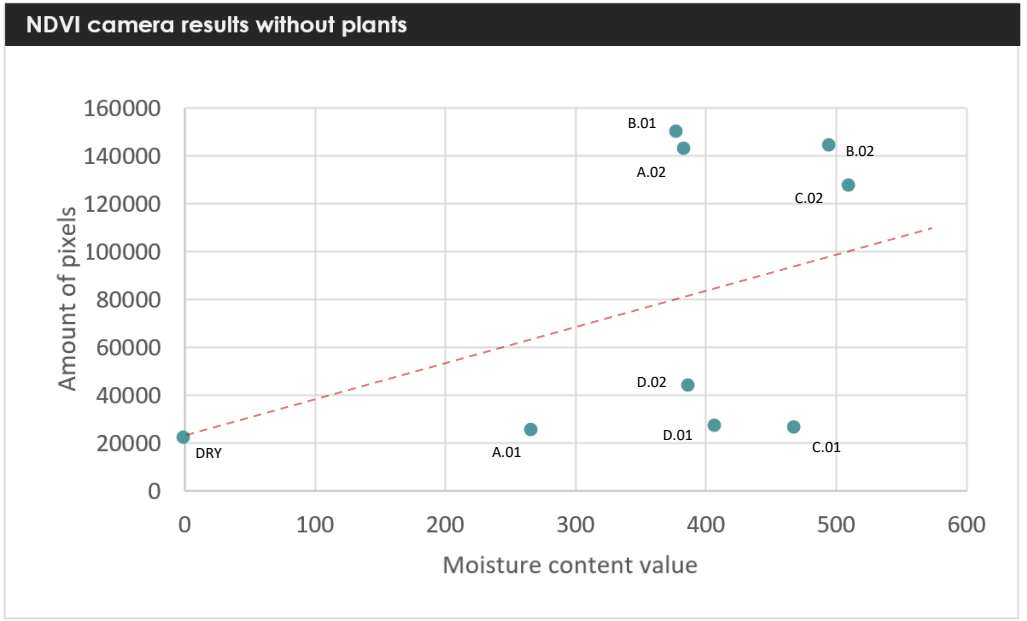

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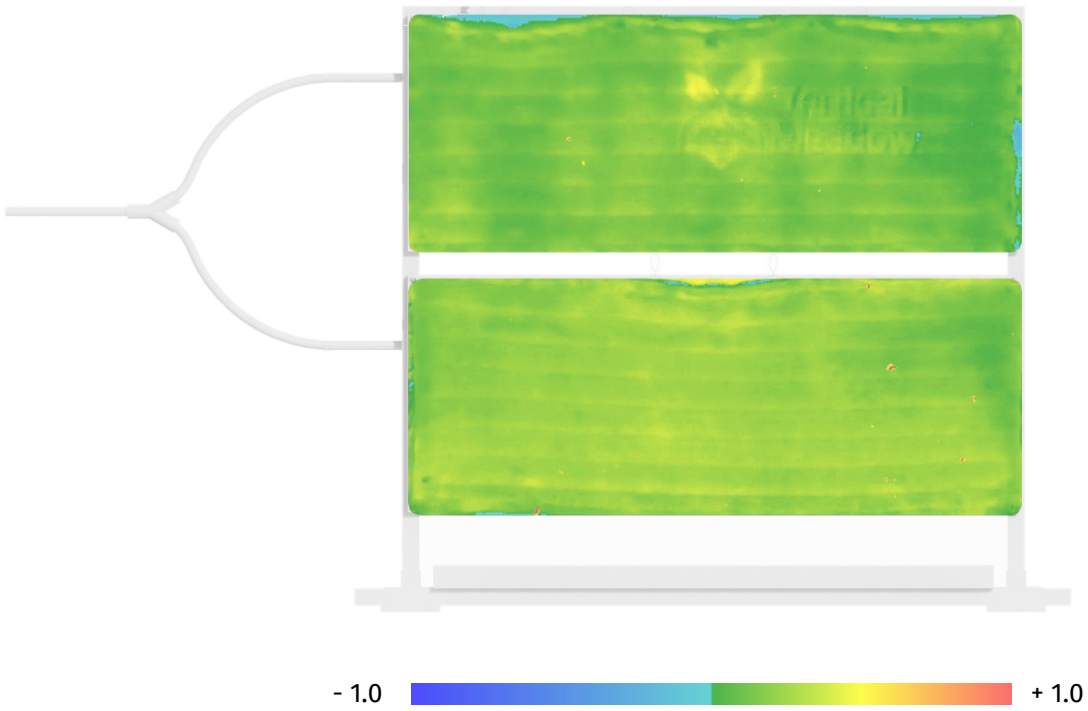

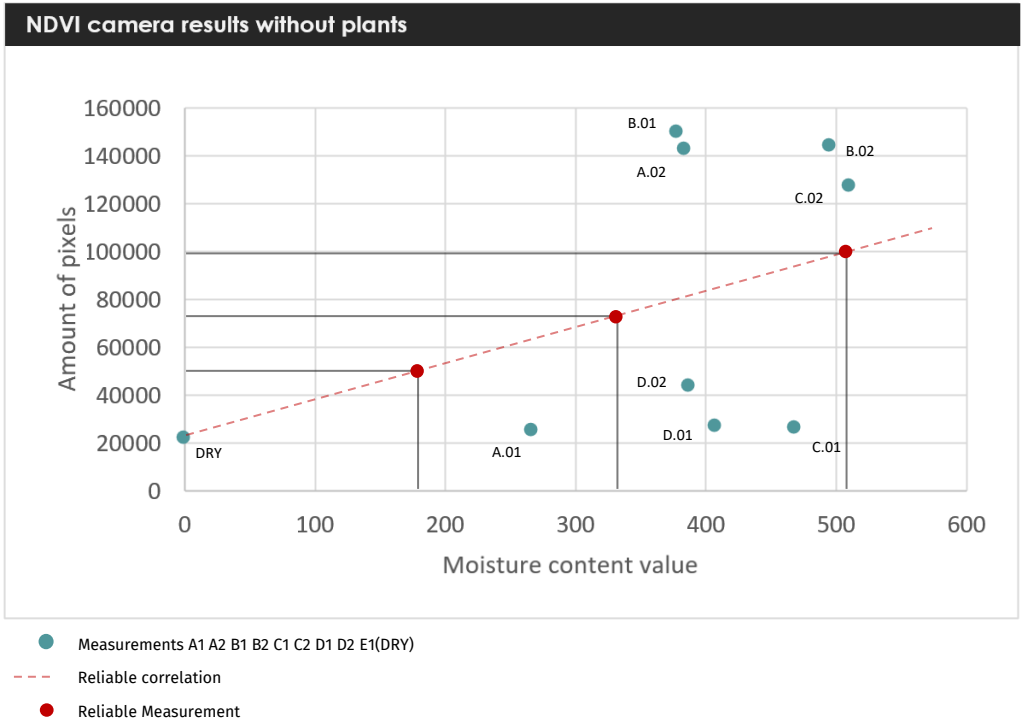

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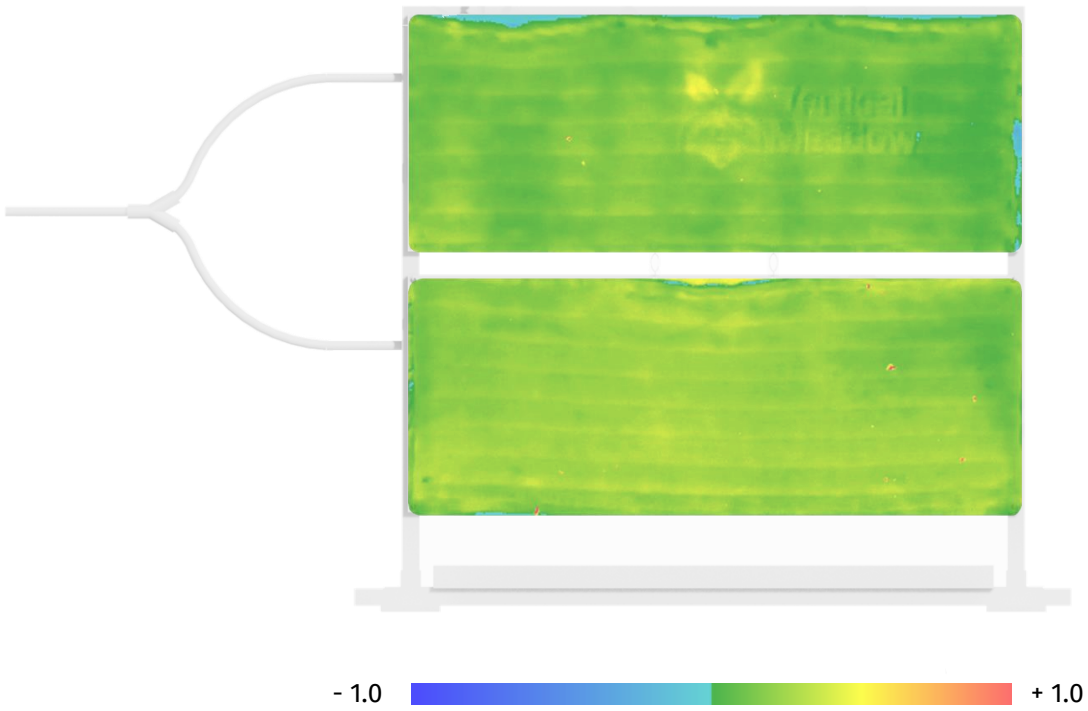

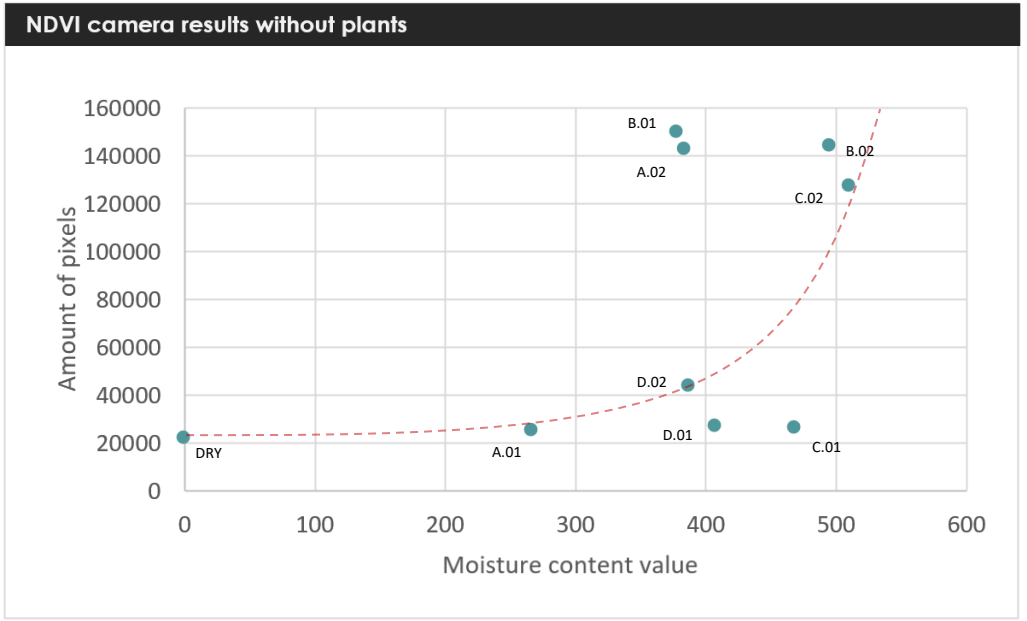

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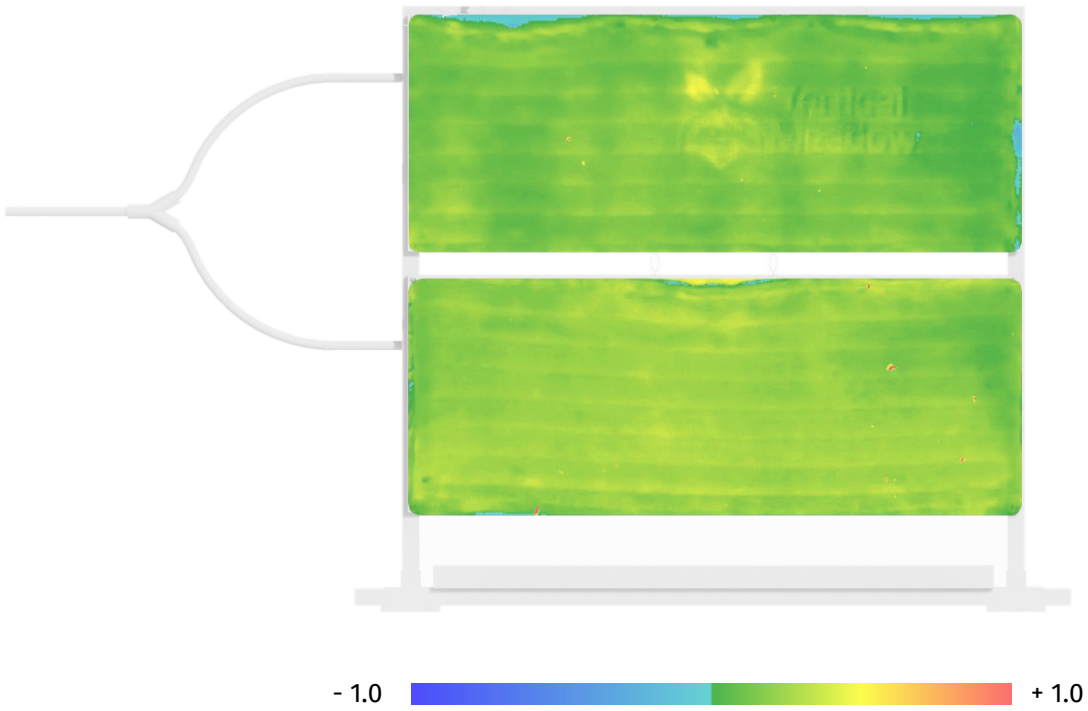

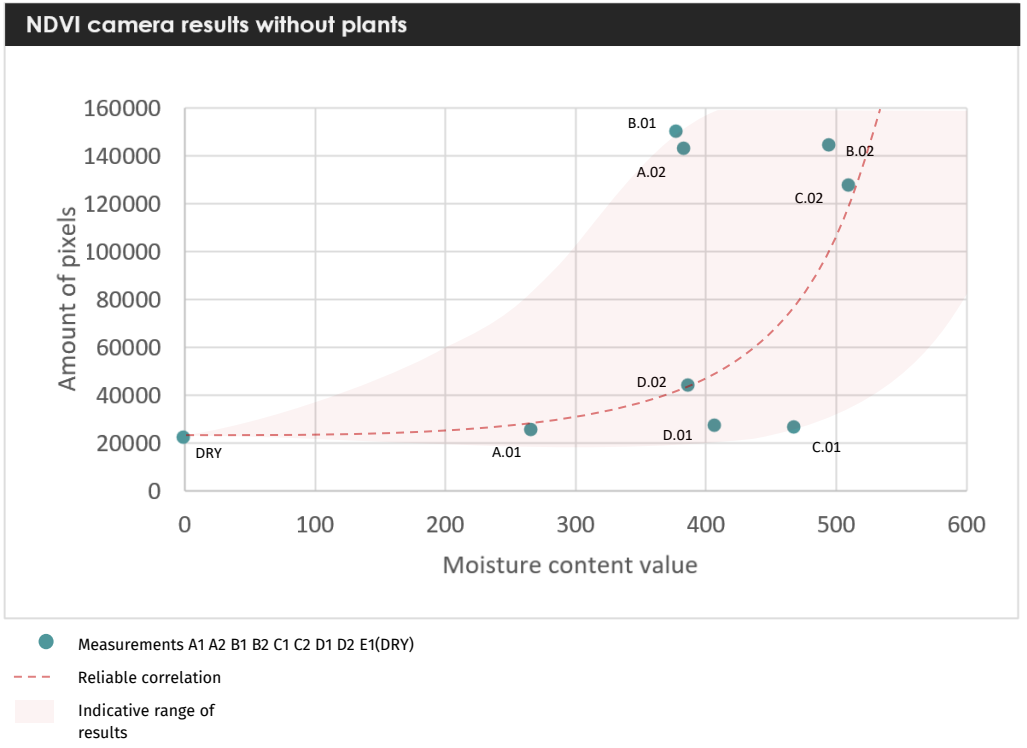

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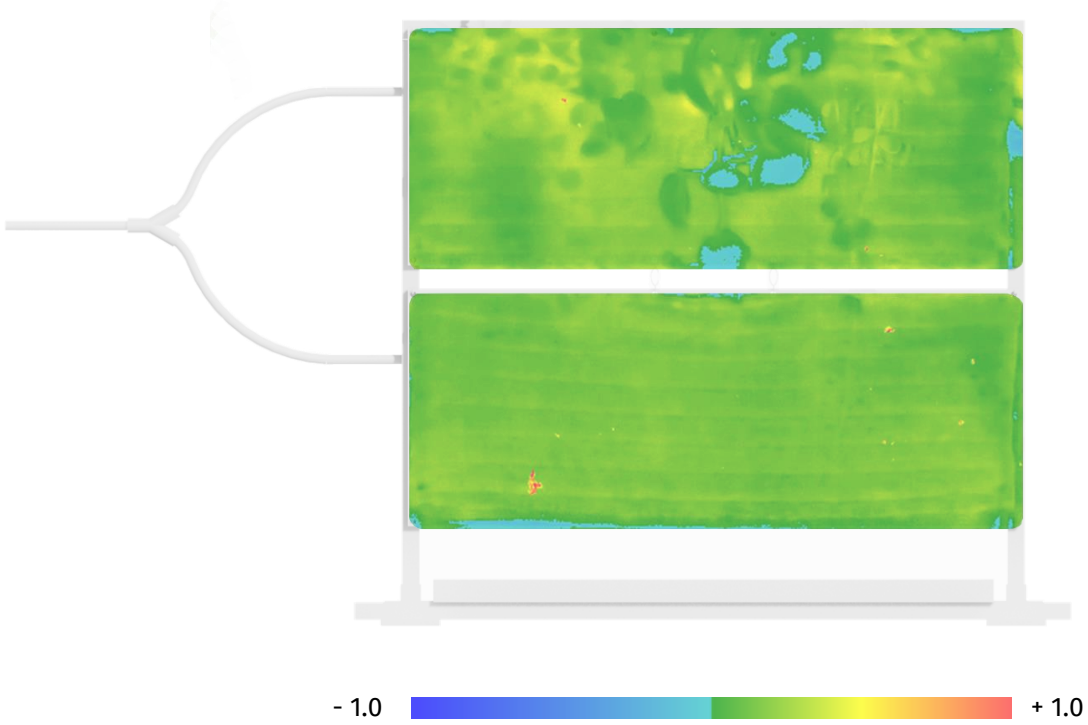

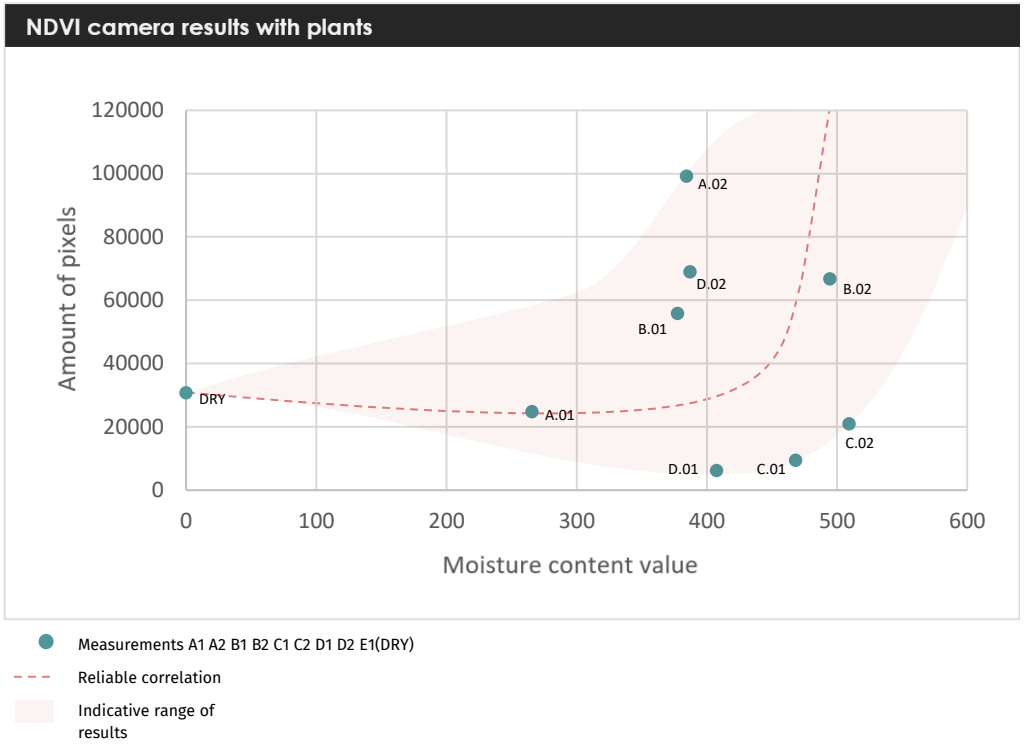

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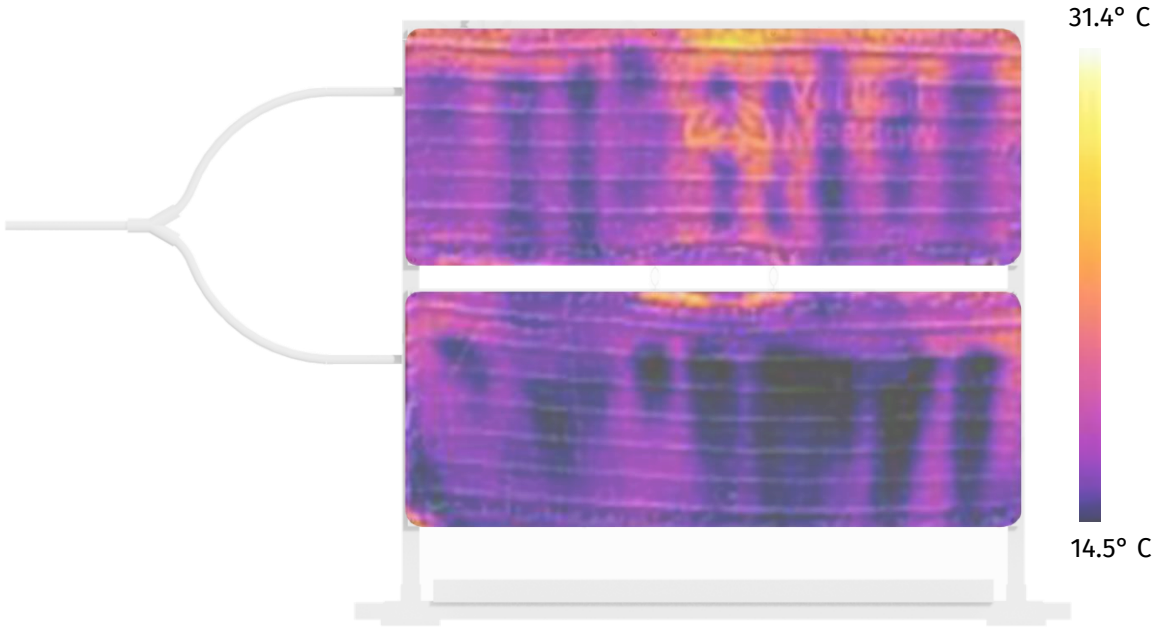
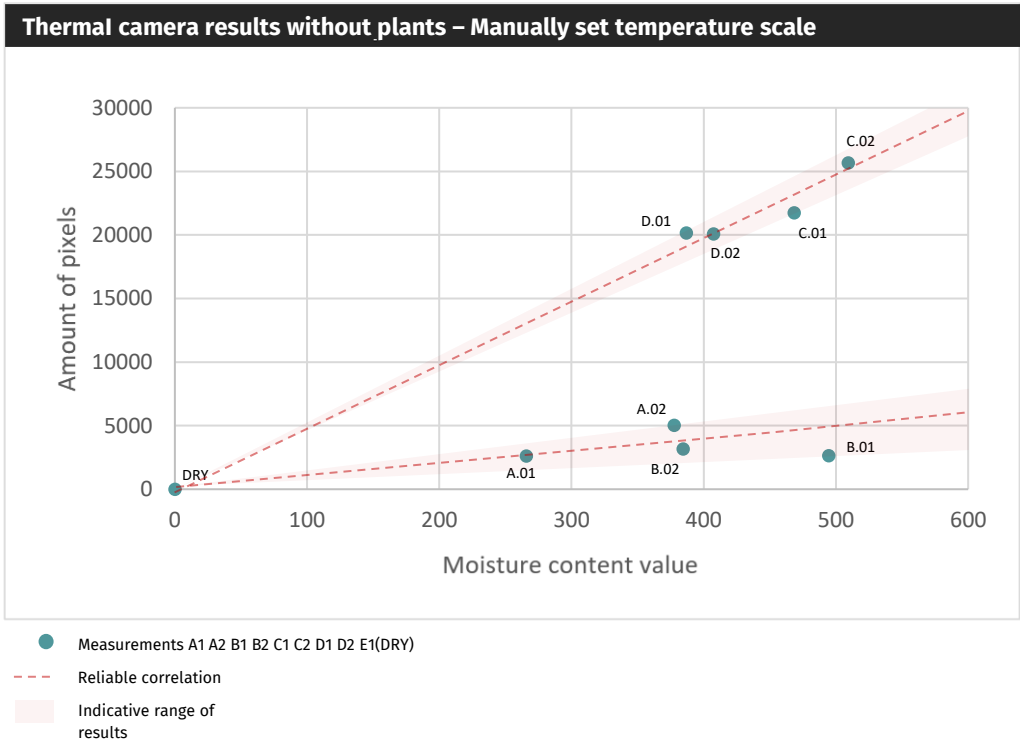
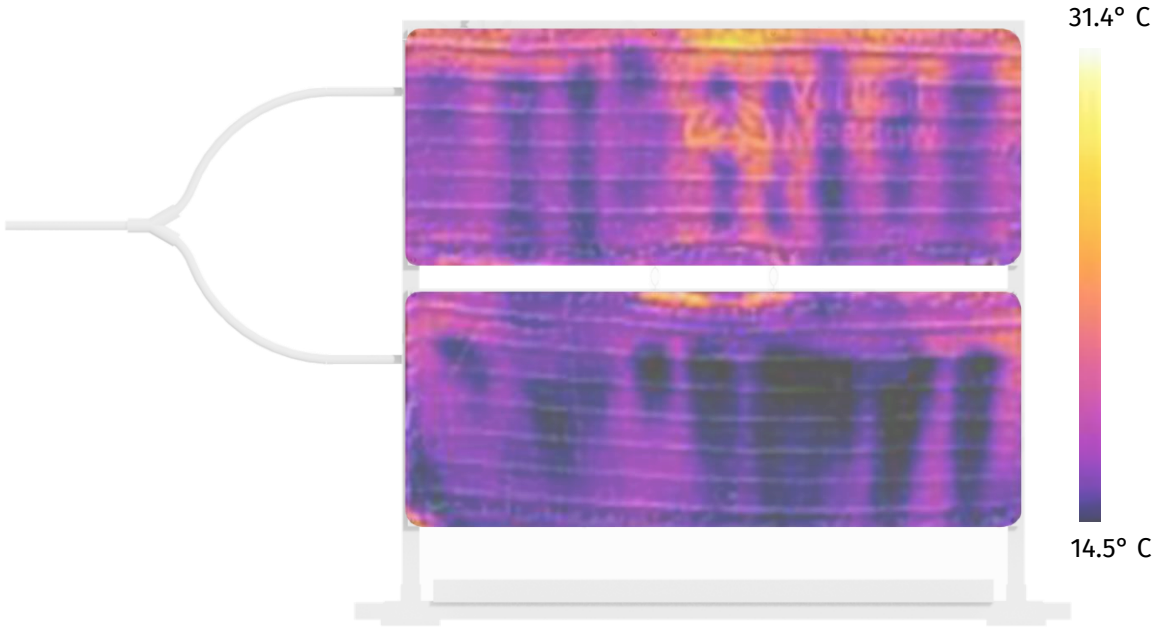
THERMAL CAMERA X SENSORS

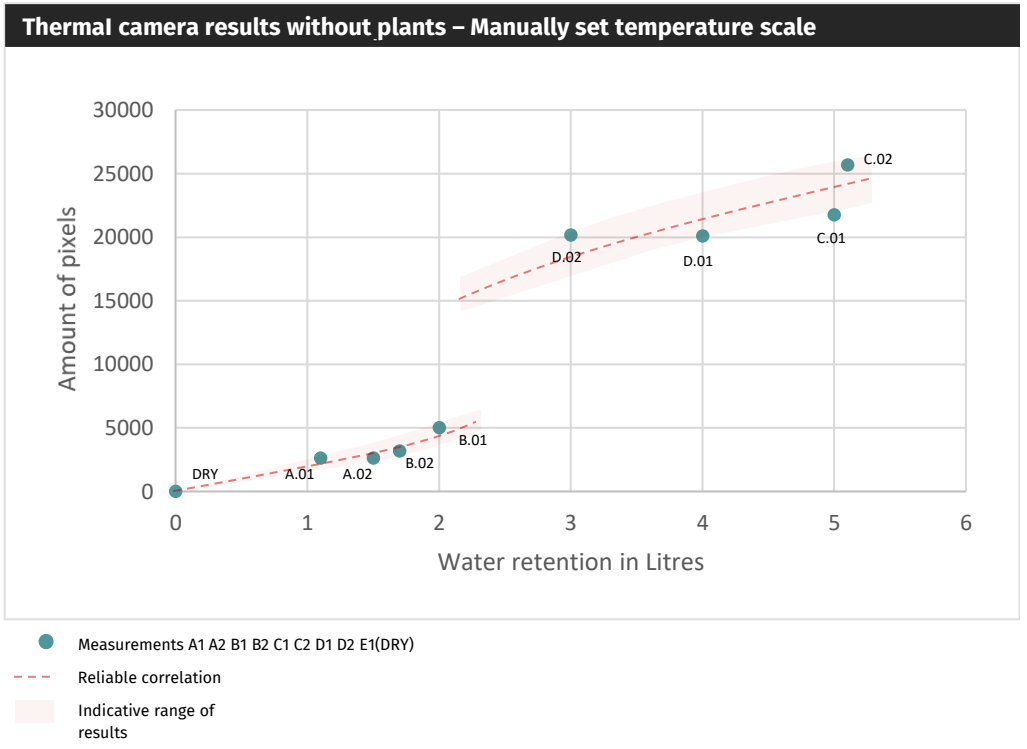




RESULTS

THERMAL CAMERA X RUN-OFF





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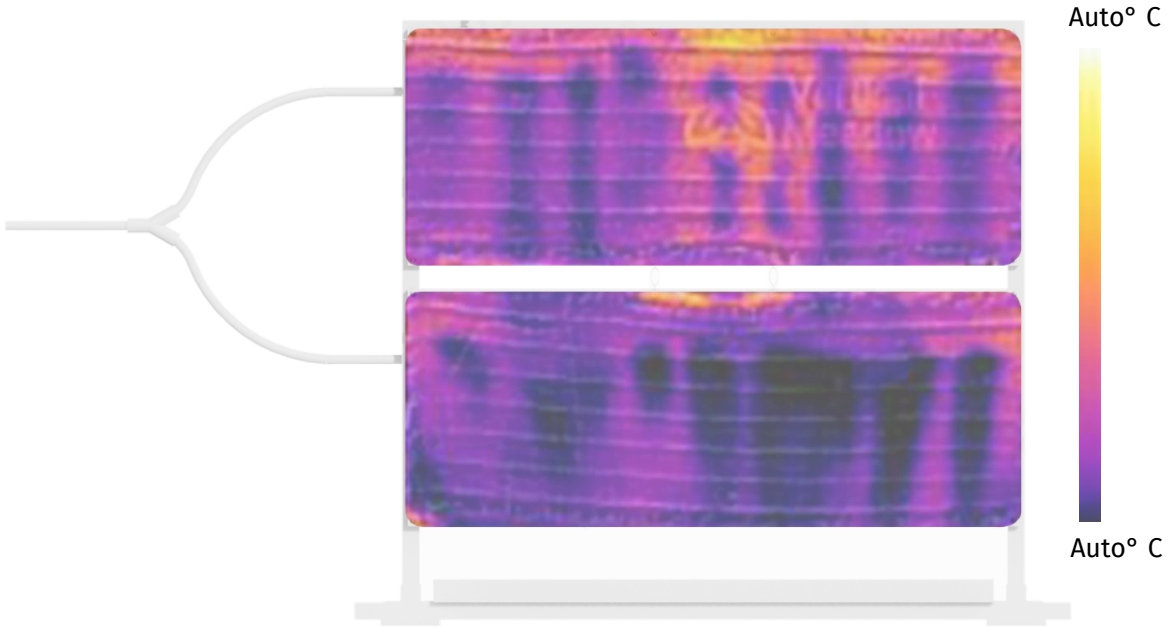

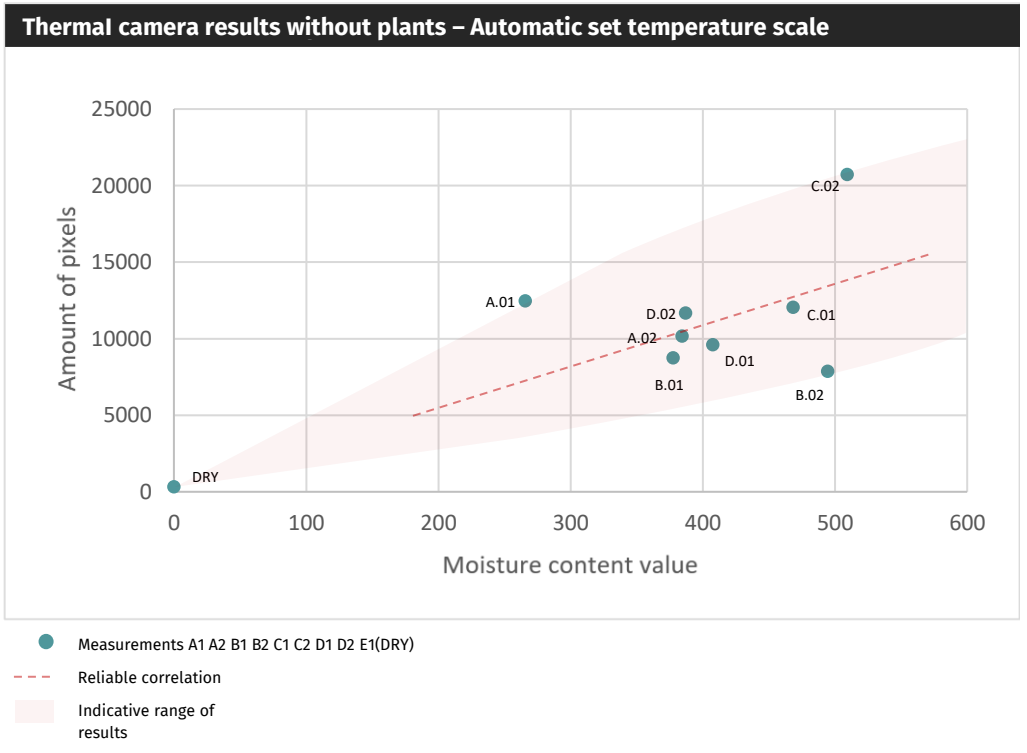

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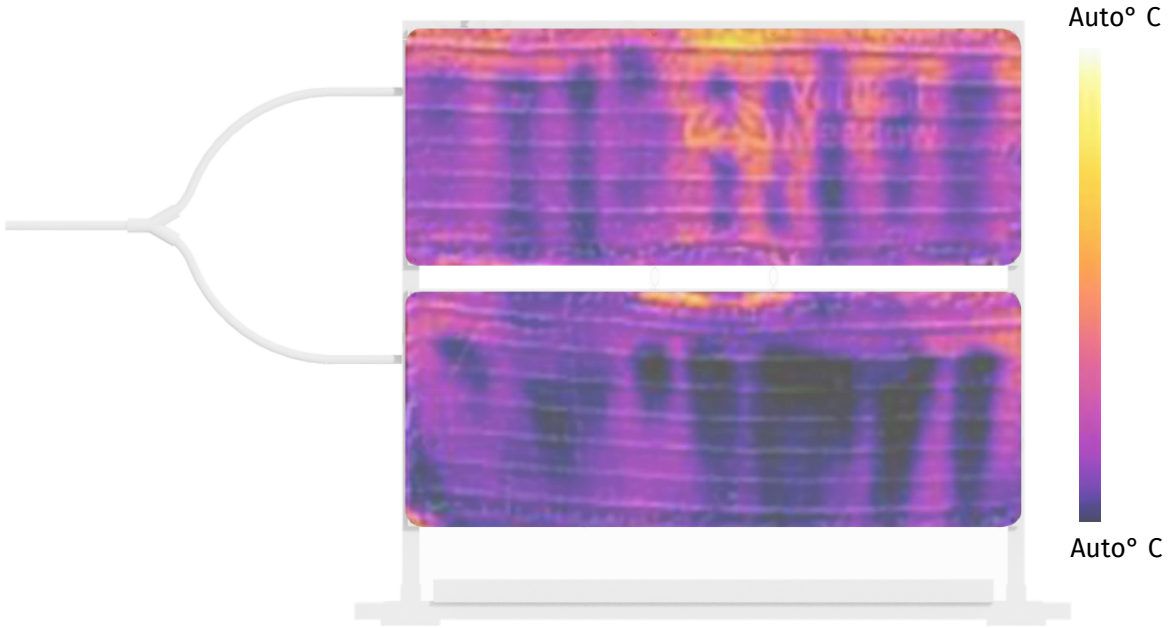

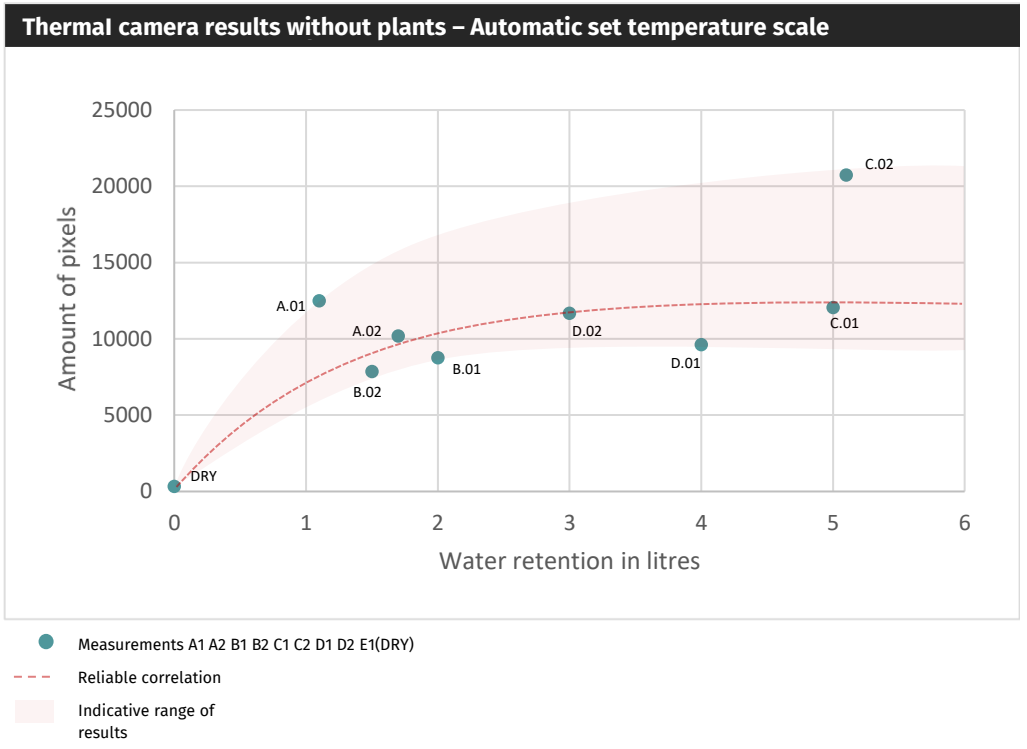

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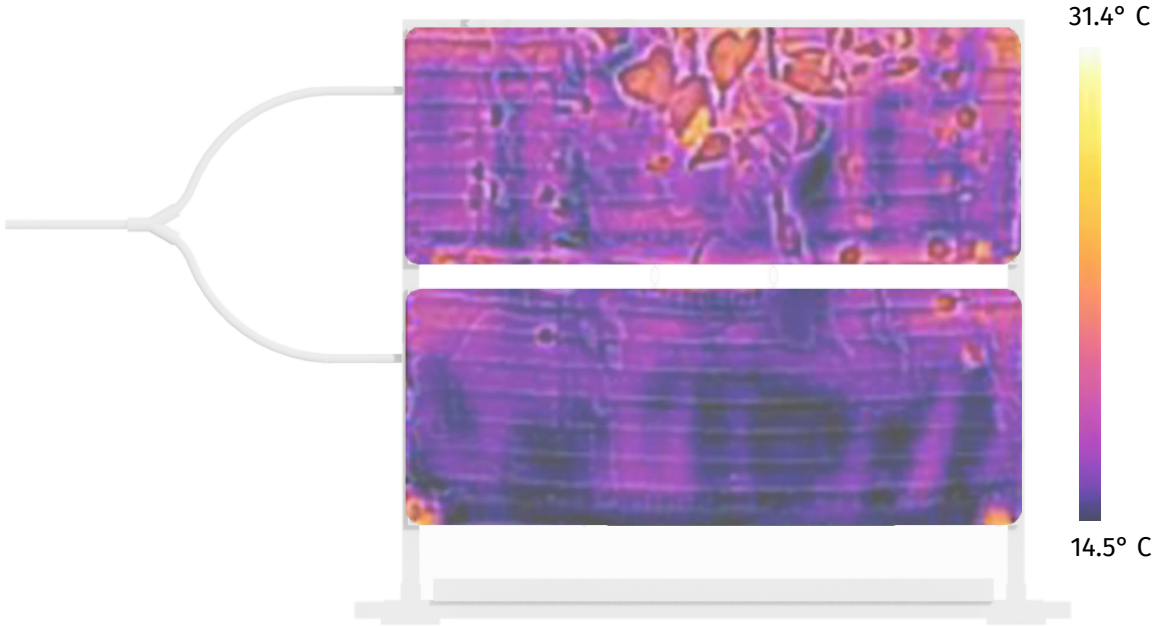
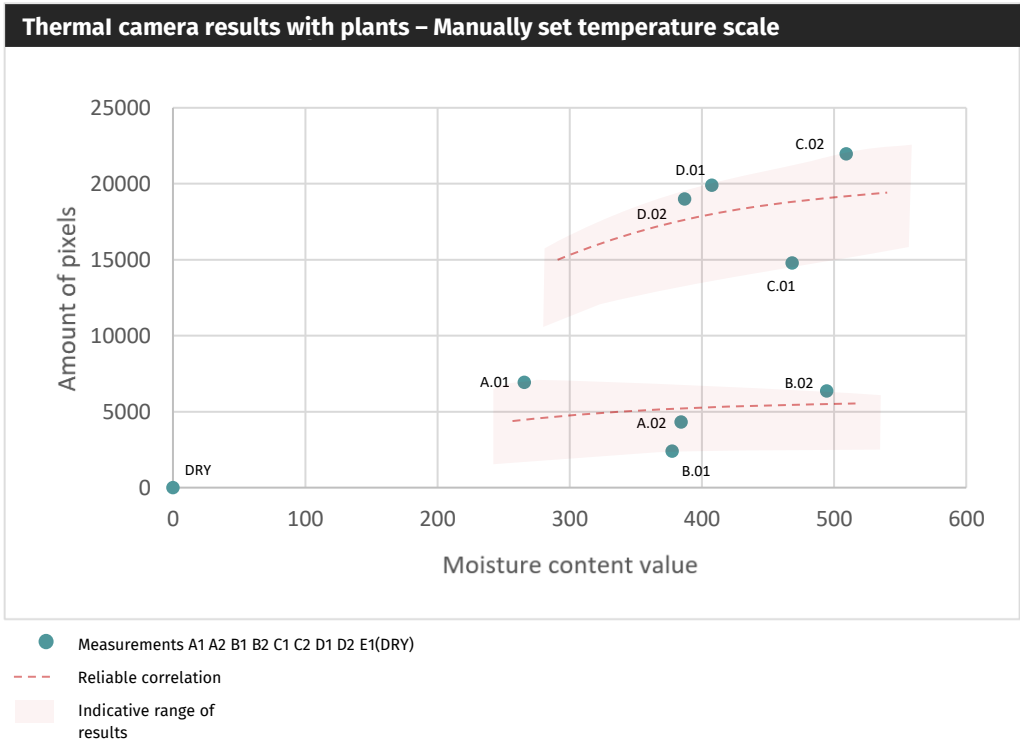
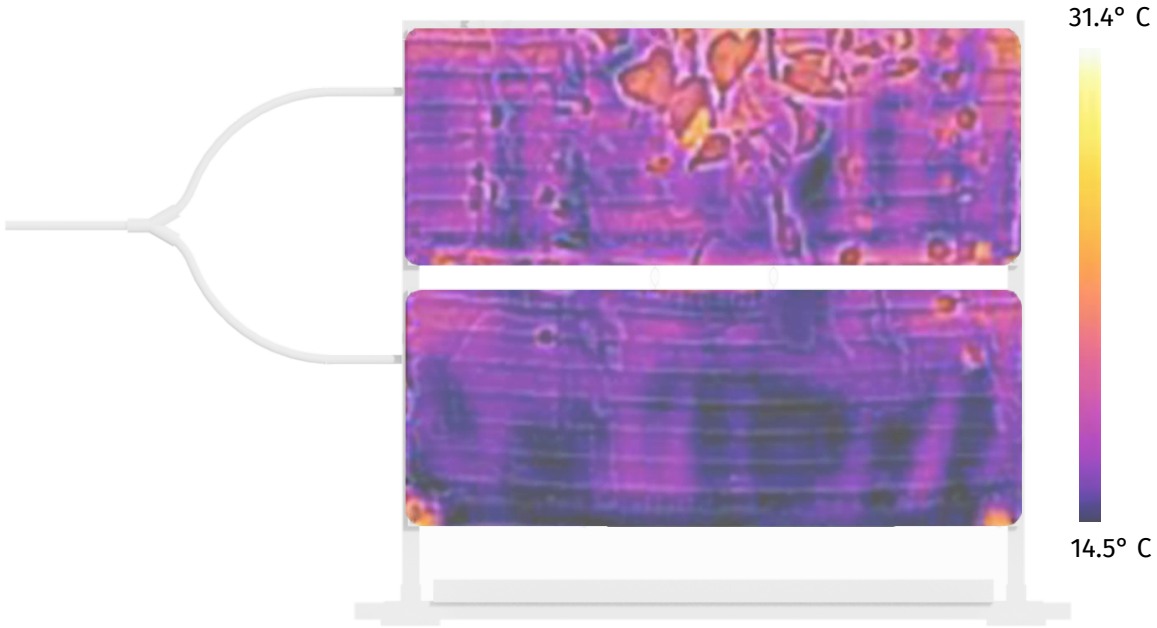
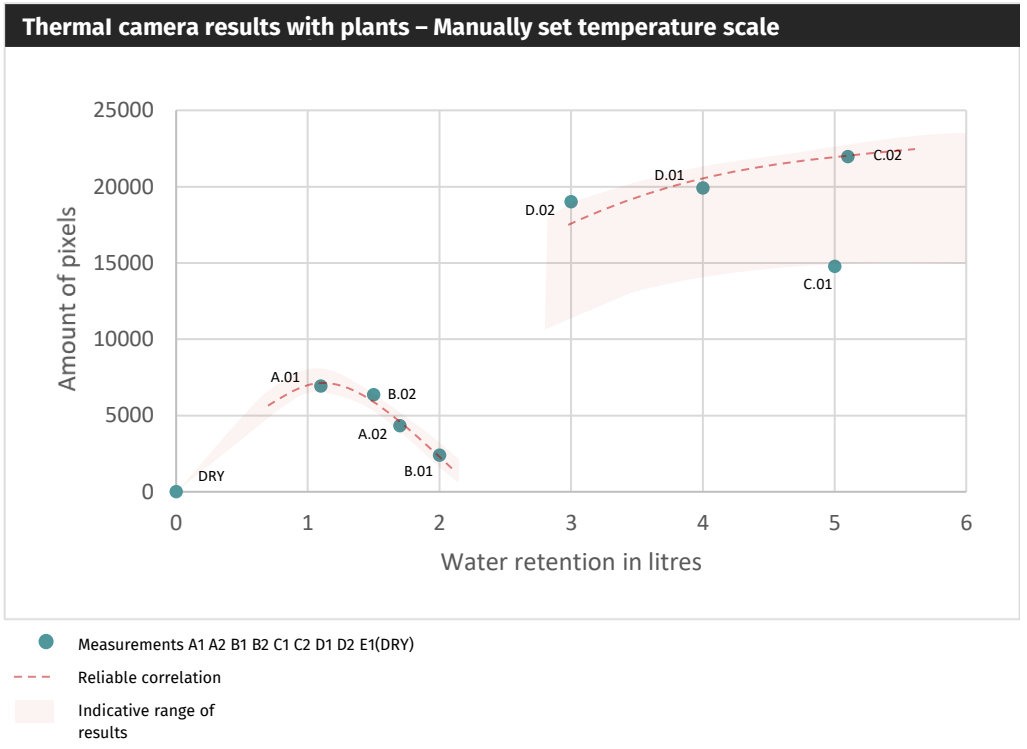




RESULTS

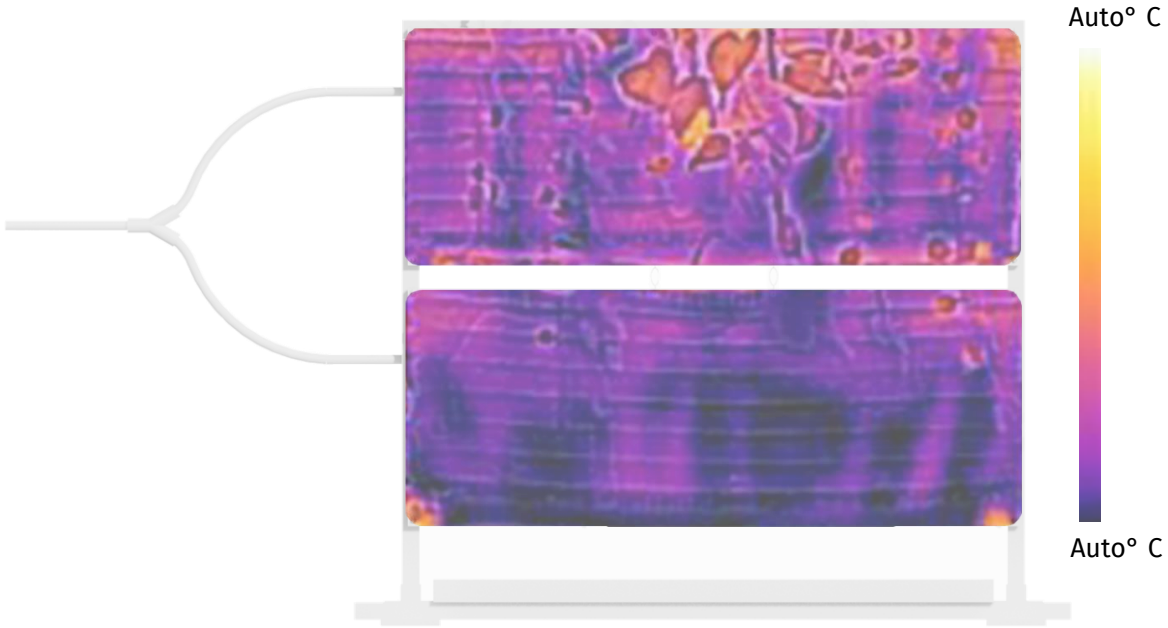
THERMAL CAMERA X RUN-OFF

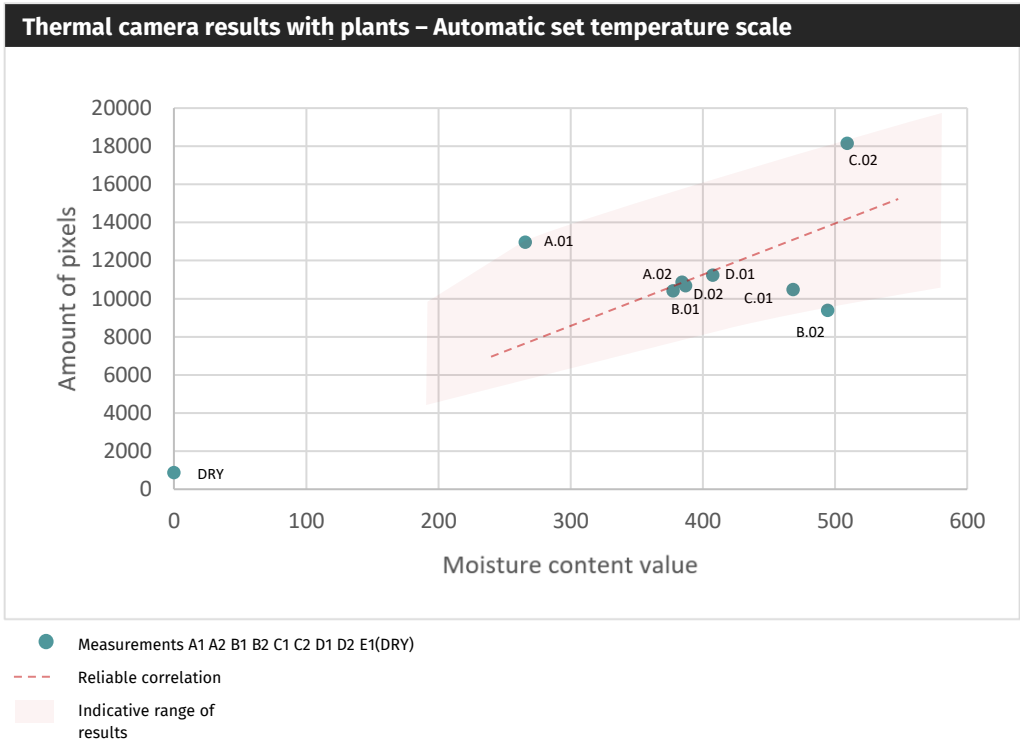




RESULTS

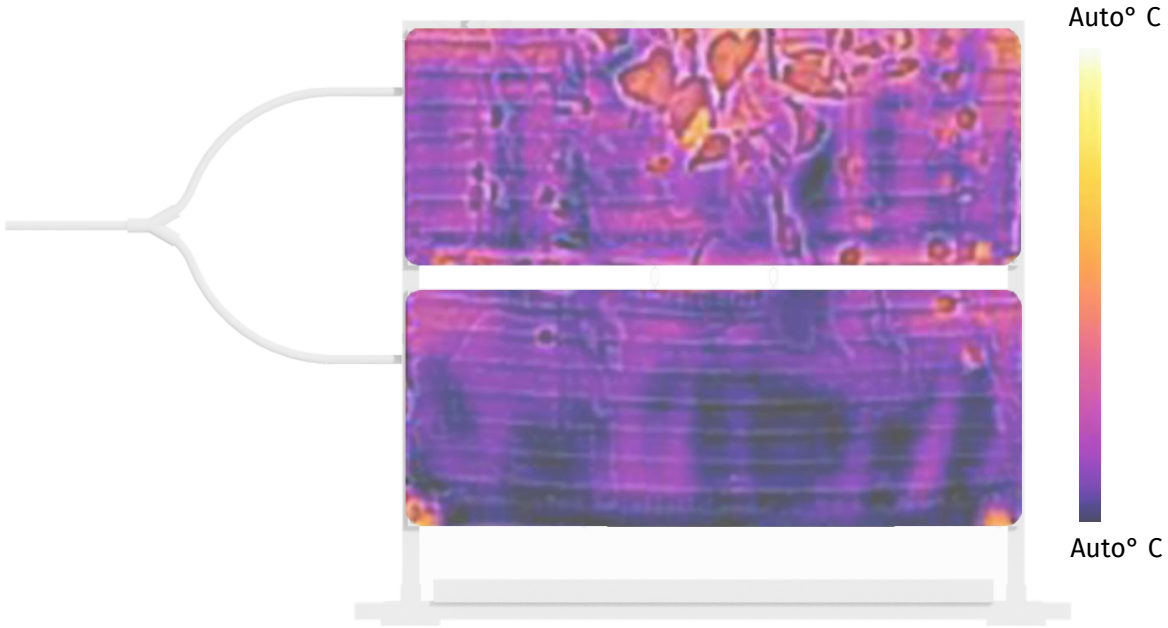
THERMAL CAMERA X SENSORS

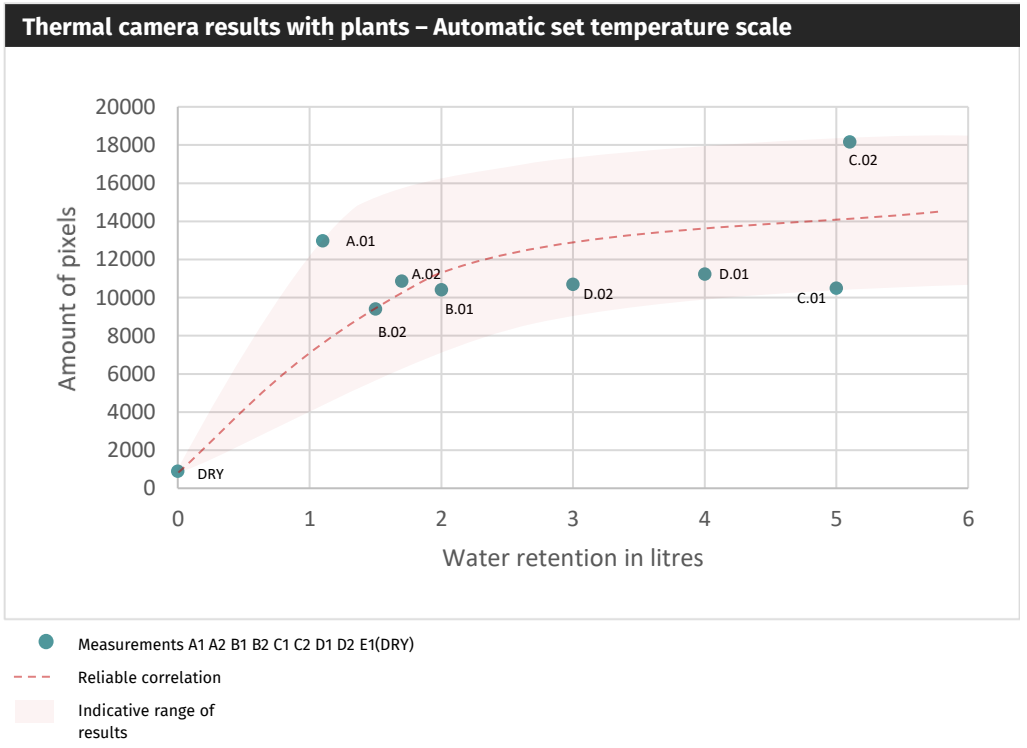




RESULTS

THERMAL CAMERA X RUN-OFF





RESULTS

TEMPERATURE SCALE SETTINGS

MANUALLY

Amount of pixels that represent water			
	Without plants	With plants	Difference
TEST A.01	2.609	6.920	165.2%
TEST A.02	3.180	4.315	35.7%
TEST B.01	5.022	2.393	109.0%
TEST B.02	2.629	6.363	142%
TEST C.01	21.742	14.776	47.1%
TEST C.02	25.678	21.965	16.9%
TEST D.01	20.088	19.898	1%
TEST D.02	20.169	18.995	6.2%
BEFORE IRRIGATING	0	0	0%

AUTOMATIC

Amount of pixels that represent water			
	Without plants	With plants	Difference
TEST A.01	12.485	12.967	3.9%
TEST A.02	10.181	10.865	6.7%
TEST B.01	8.763	10.410	18.8%
TEST B.02	7.870	9.392	19.3%
TEST C.01	12.064	10.483	15.1%
TEST C.02	20.738	18.152	14.2%
TEST D.01	9.621	11.230	16.7%
TEST D.02	11.678	10.686	9.3%
BEFORE IRRIGATING	333	886	166%

RESULTS

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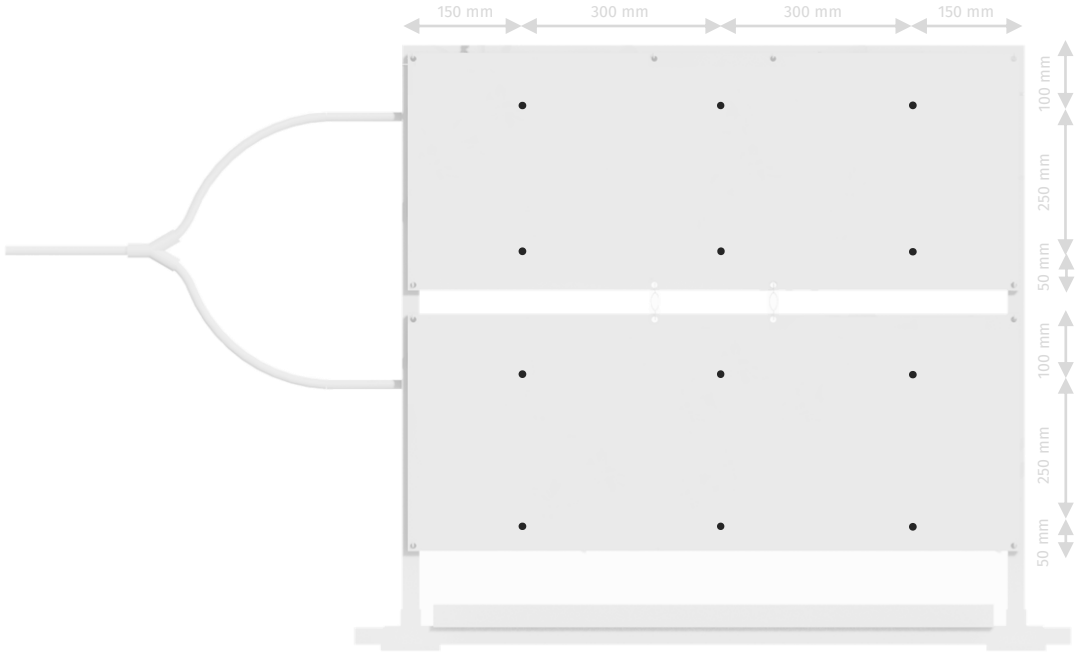
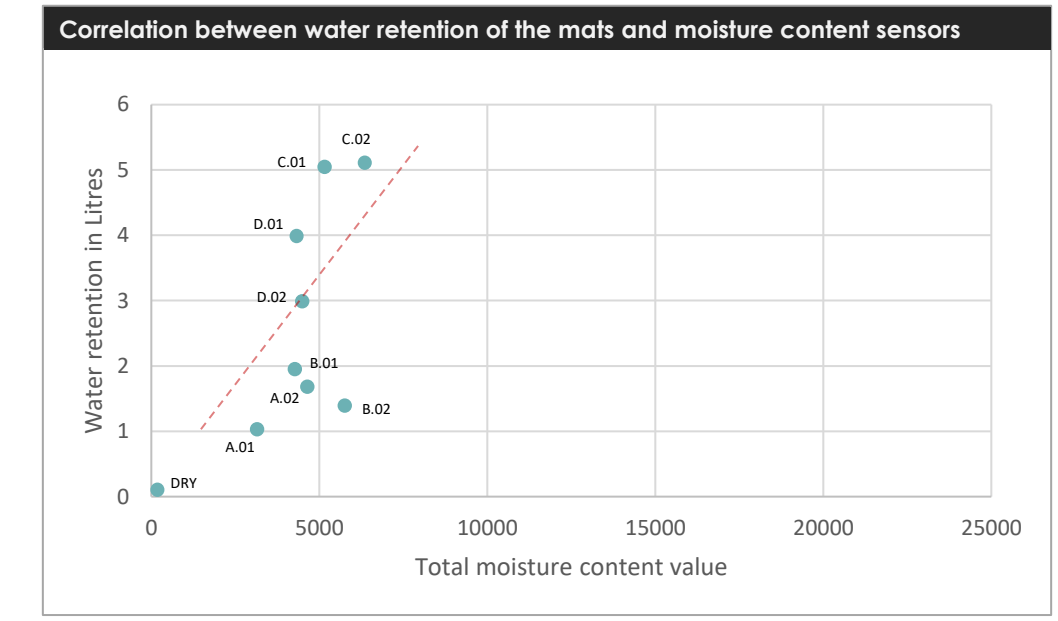
RESULTS

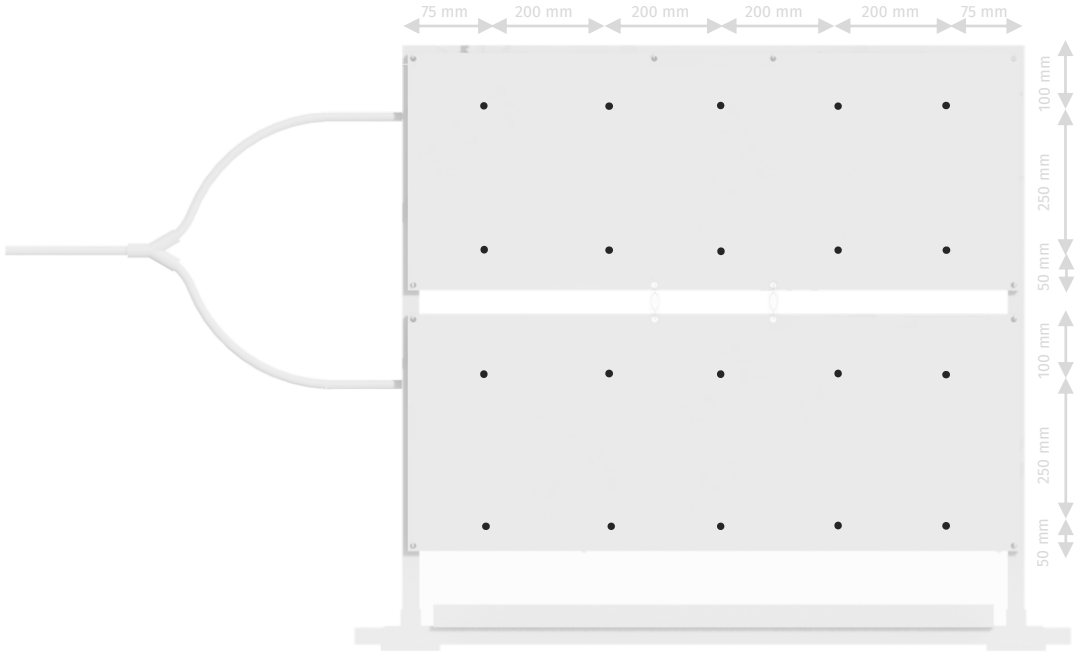
SENSOR RANGE

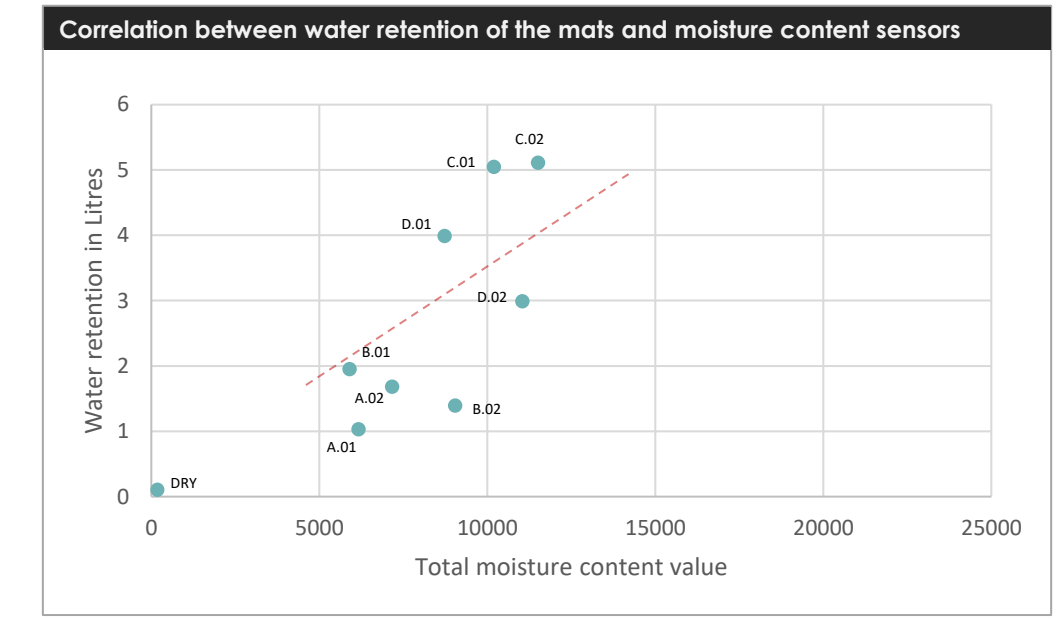




RESULTS

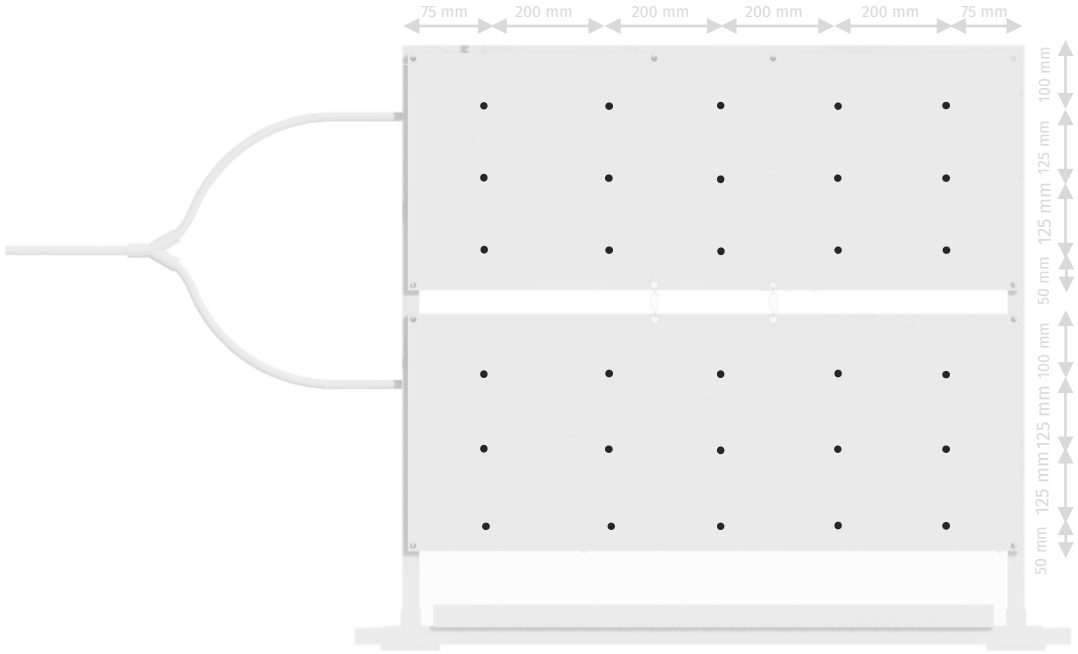
SENSOR RANGE

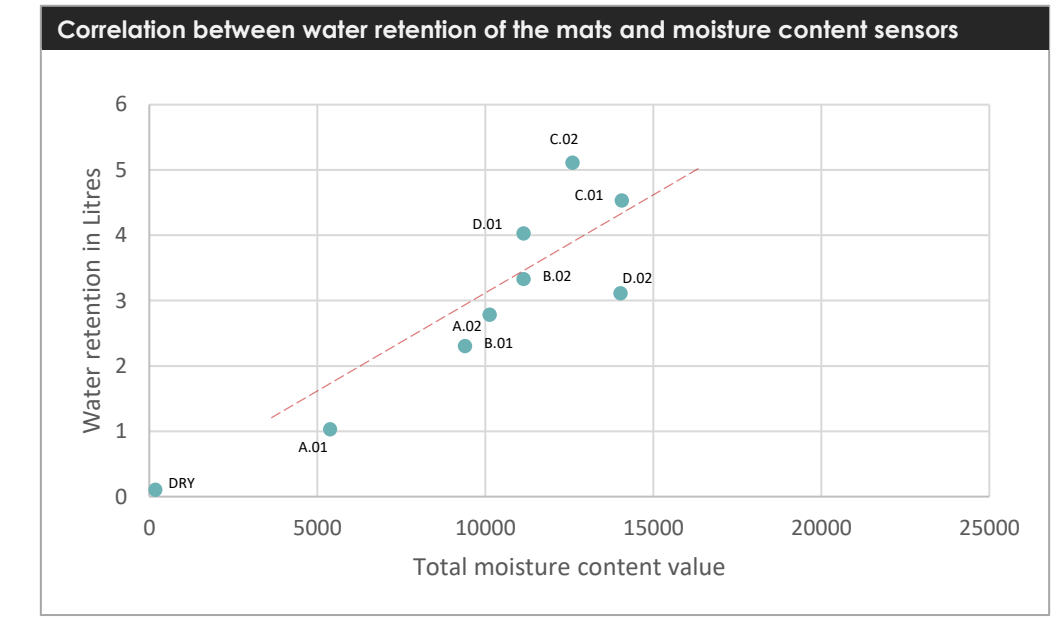




RESULTS

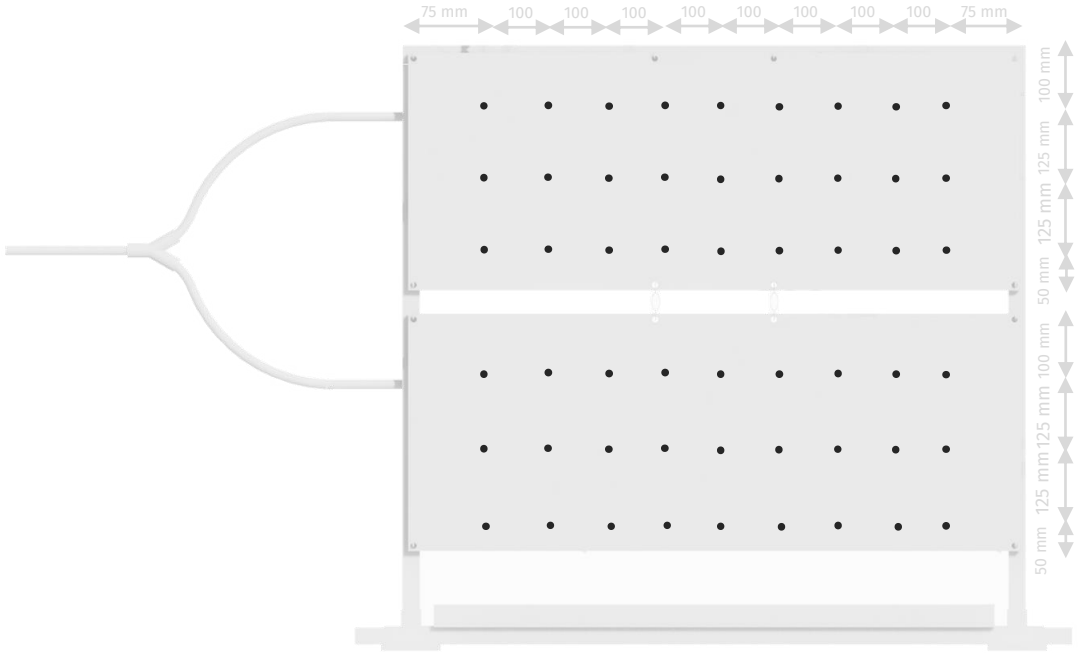
SENSOR RANGE

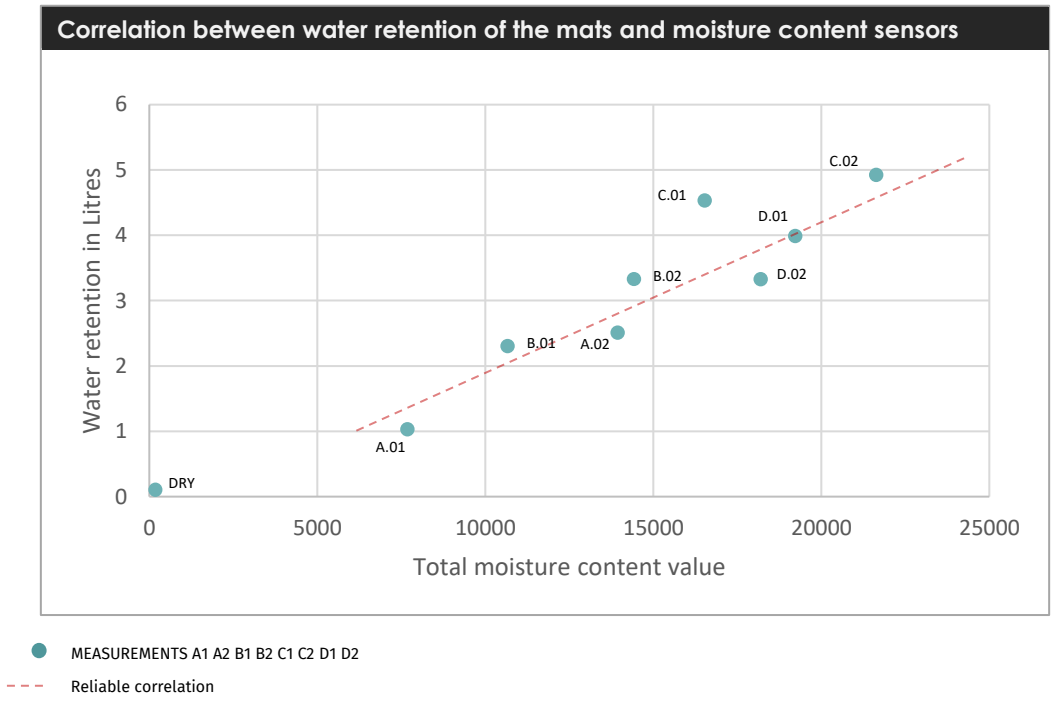




RESULTS

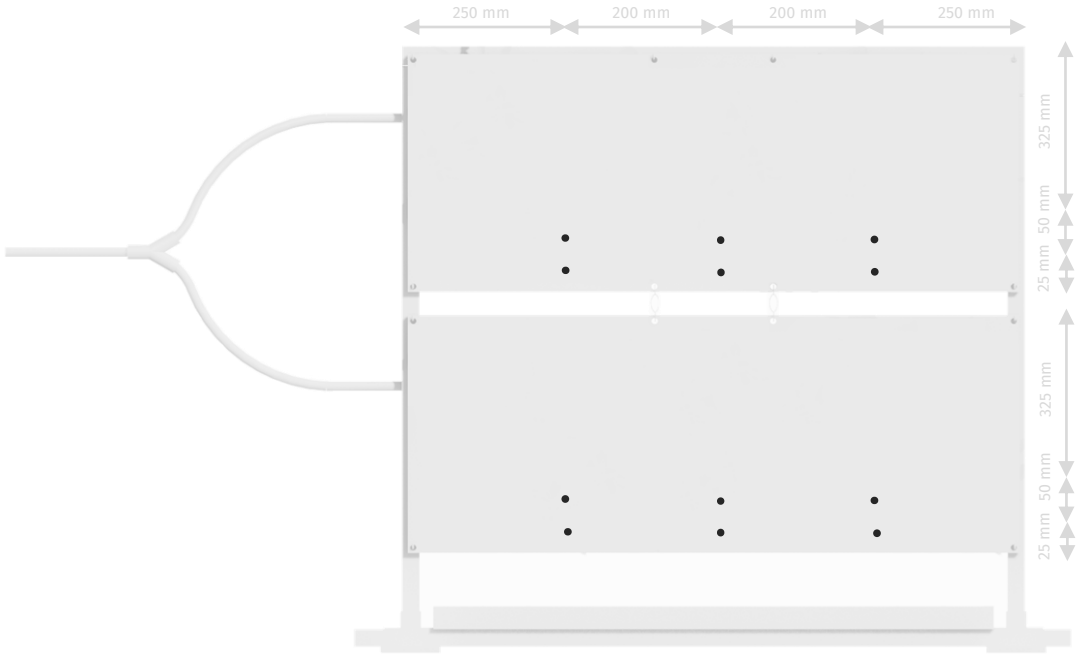
SENSOR RANGE

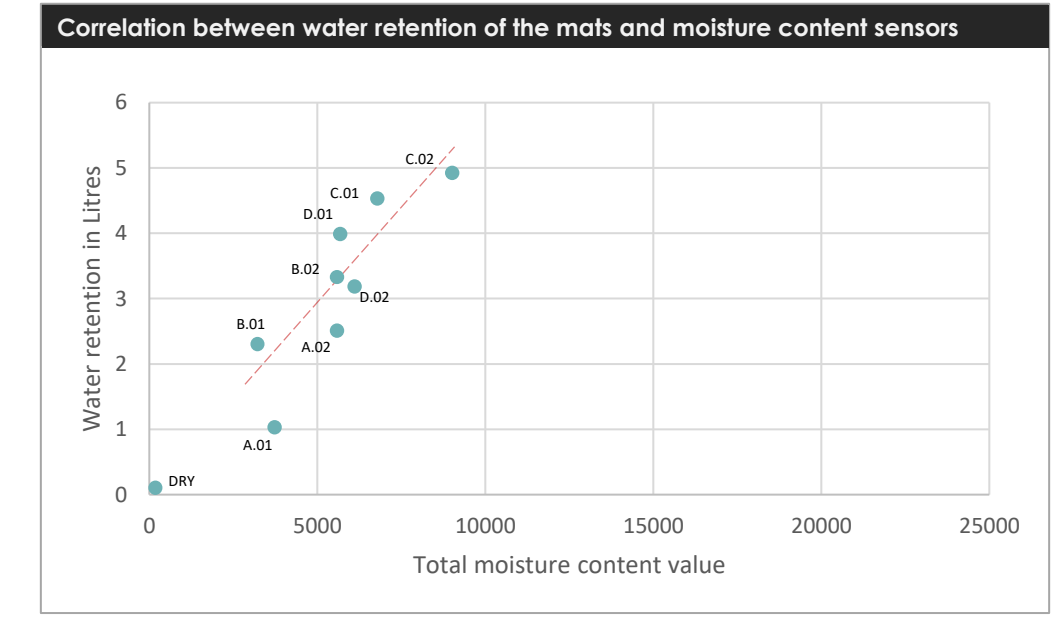




RESULTS

SENSOR RANGE

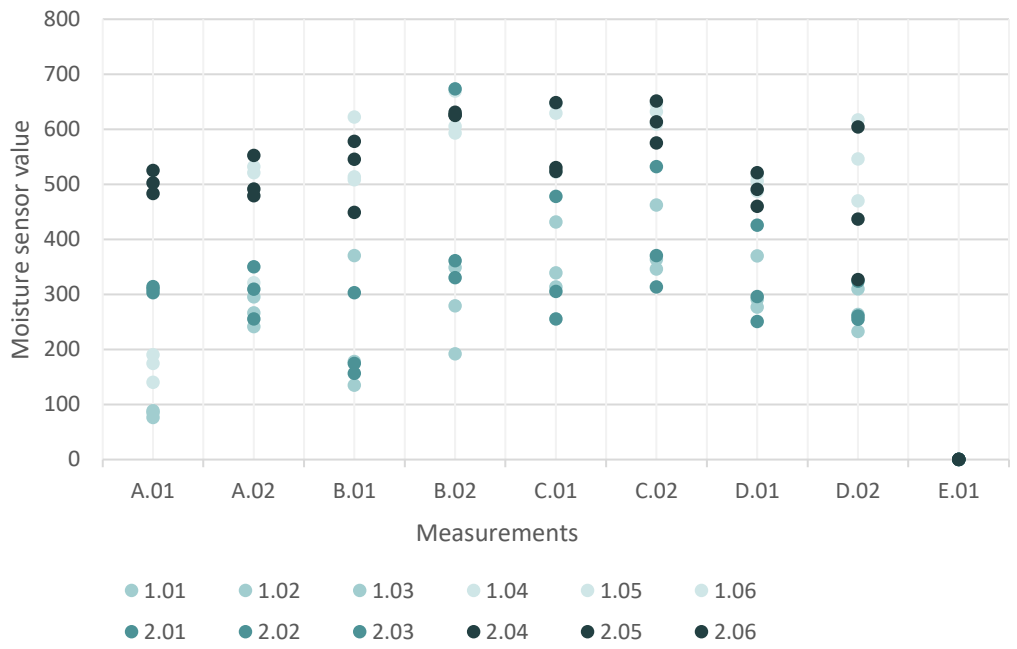




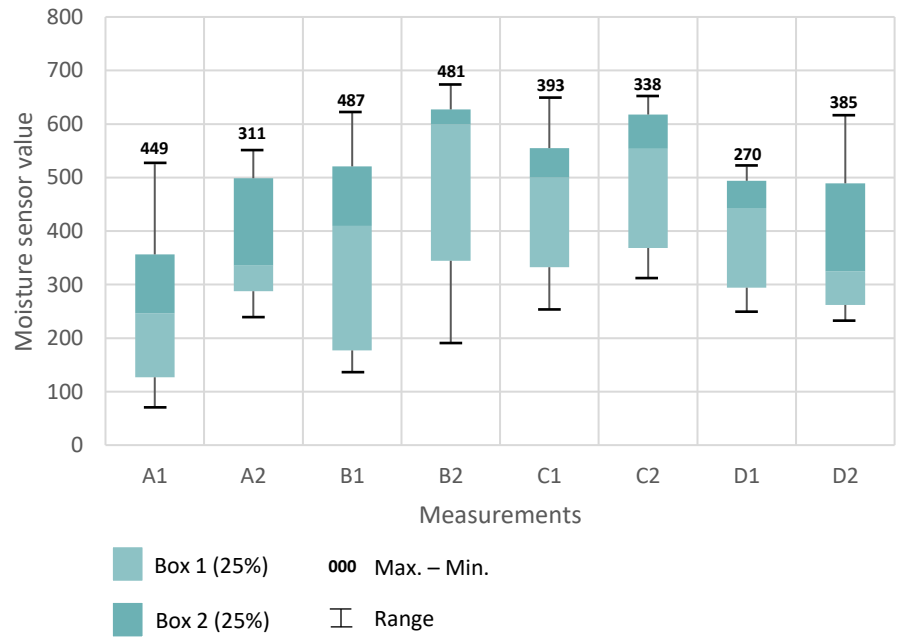
RESULTS

MOISTURE SENSORS

Measured moisture content value per sensor point



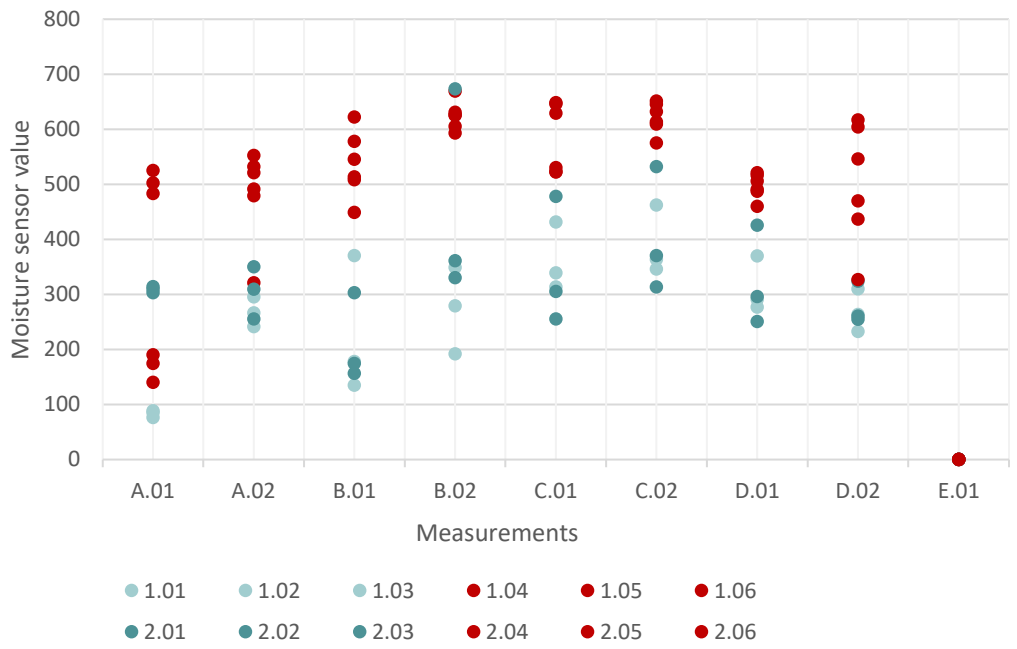
Range of measured moisture value with the sensors



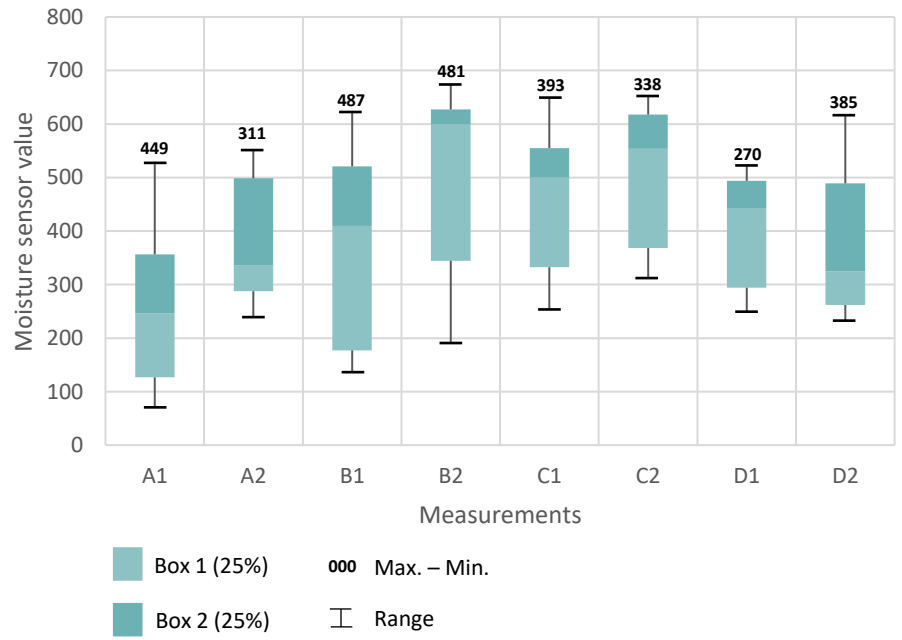
RESULTS

MOISTURE SENSORS

Measured moisture content value per sensor point



Range of measured moisture value with the sensors



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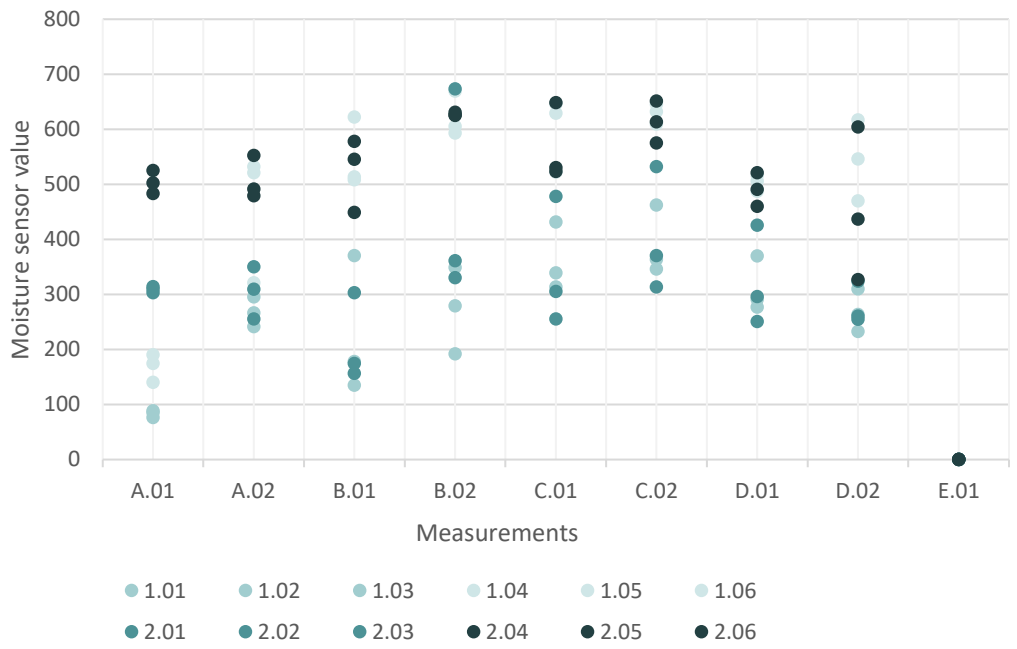
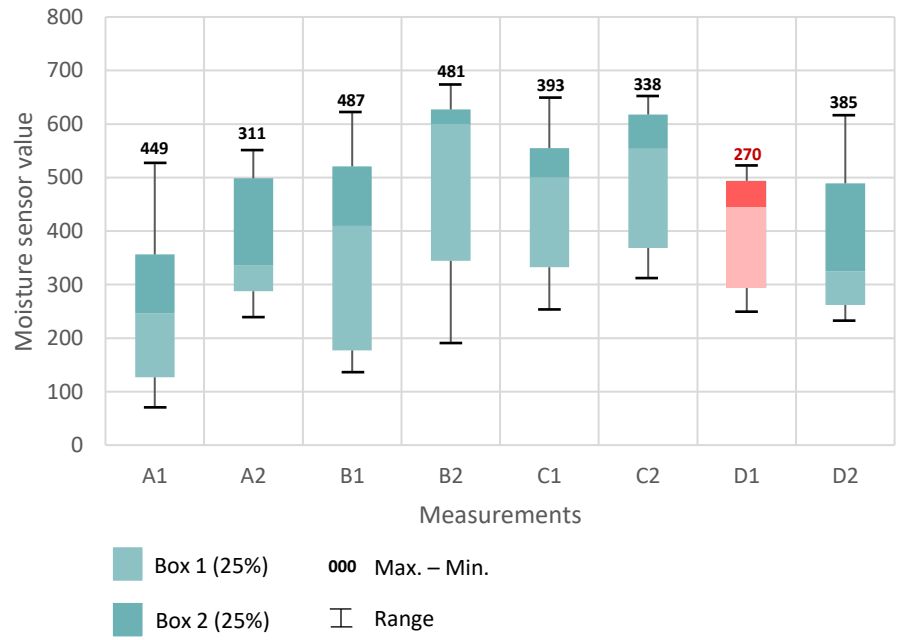


Range of measured moisture value with the sensors



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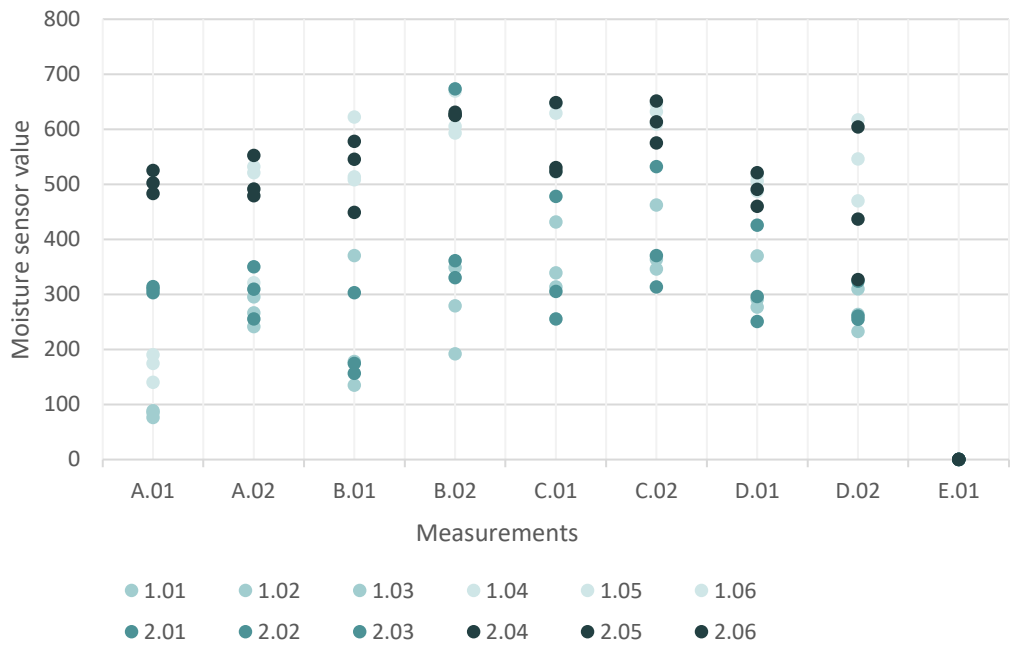
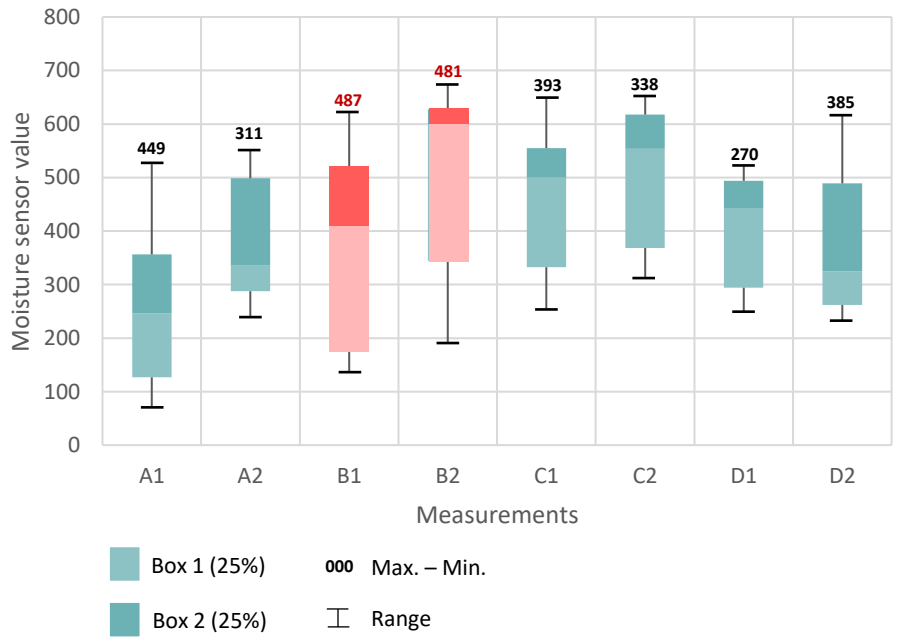
Measured moisture content value per sensor point

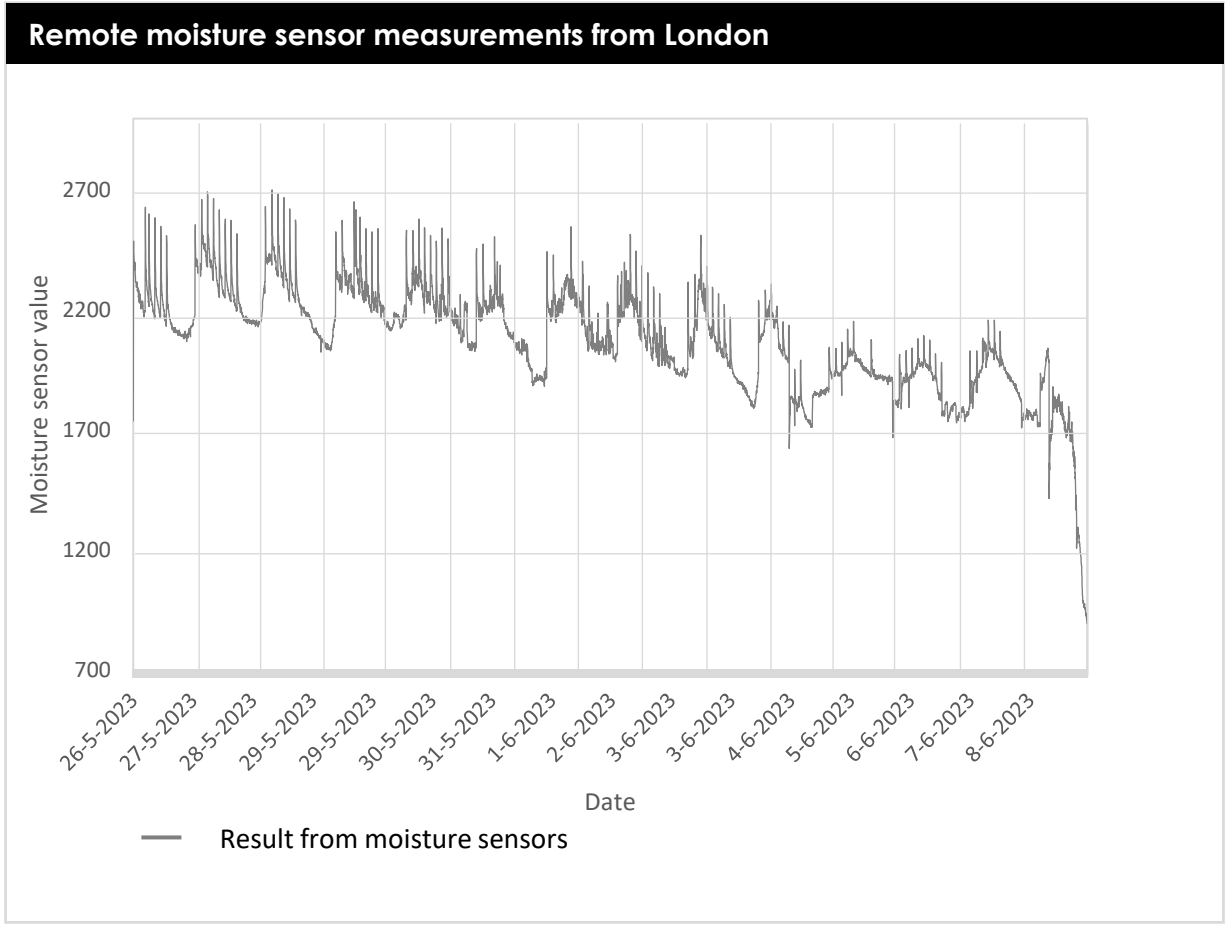


Range of measured moisture value with the sensors



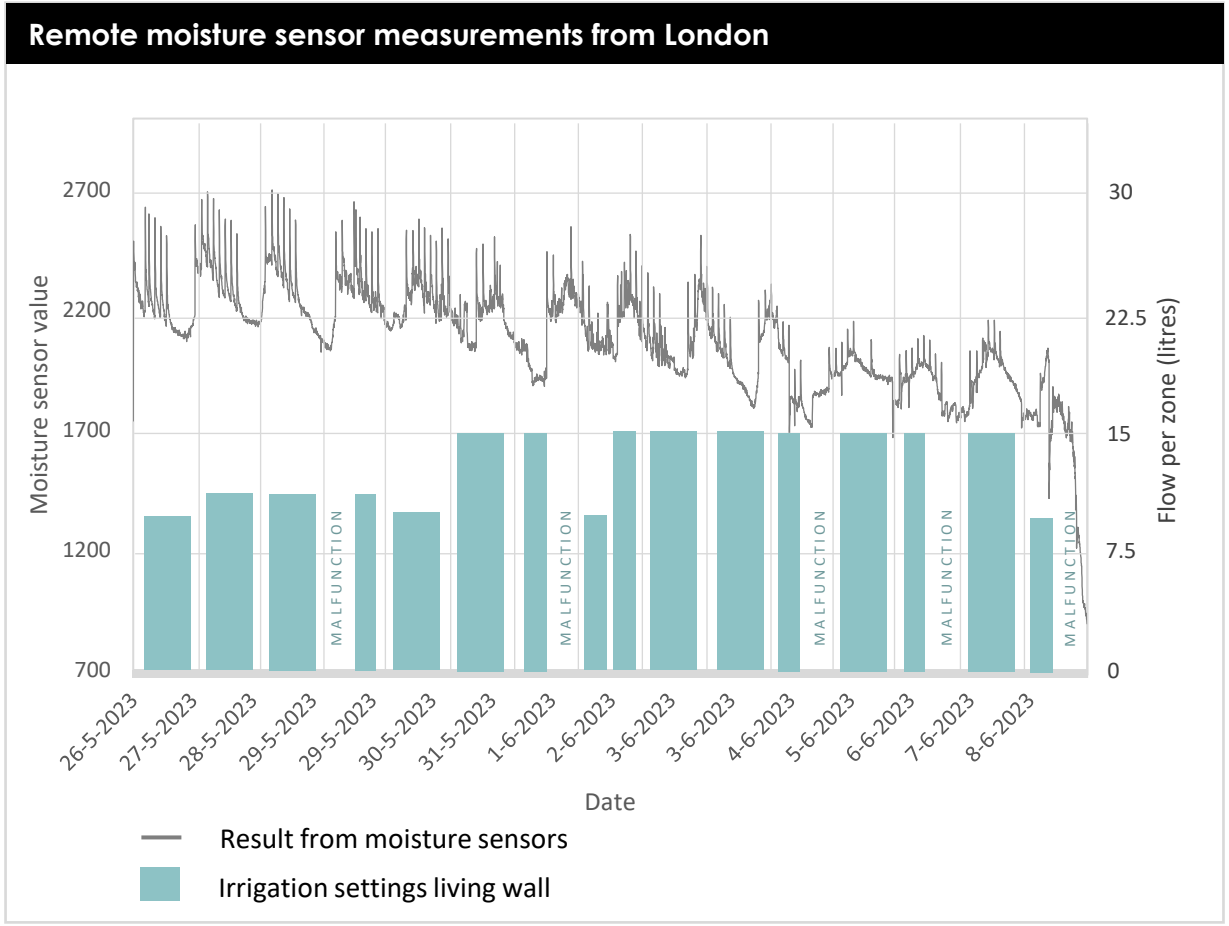
RESULTS

VERTICAL MEADOW



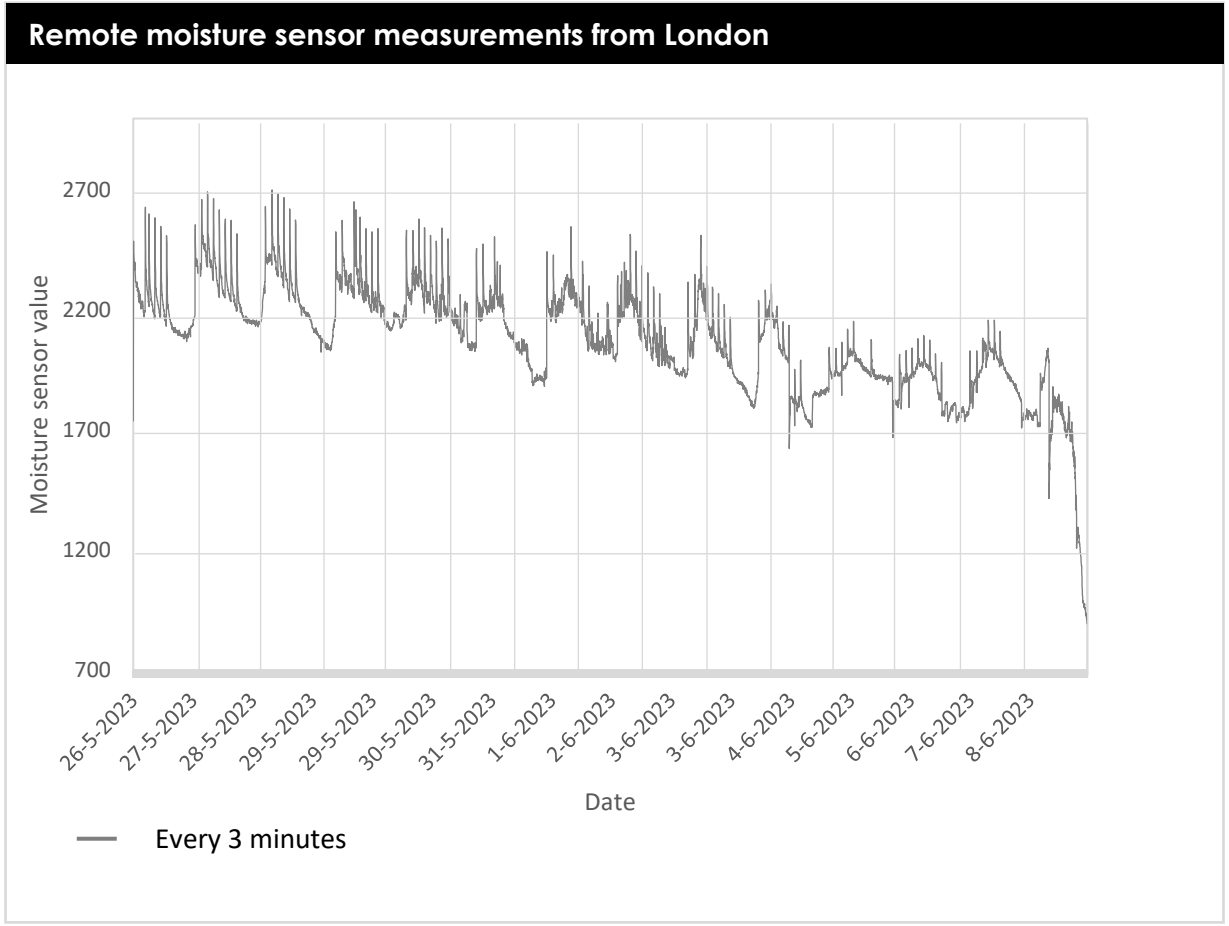
RESULTS

VERTICAL MEADOW



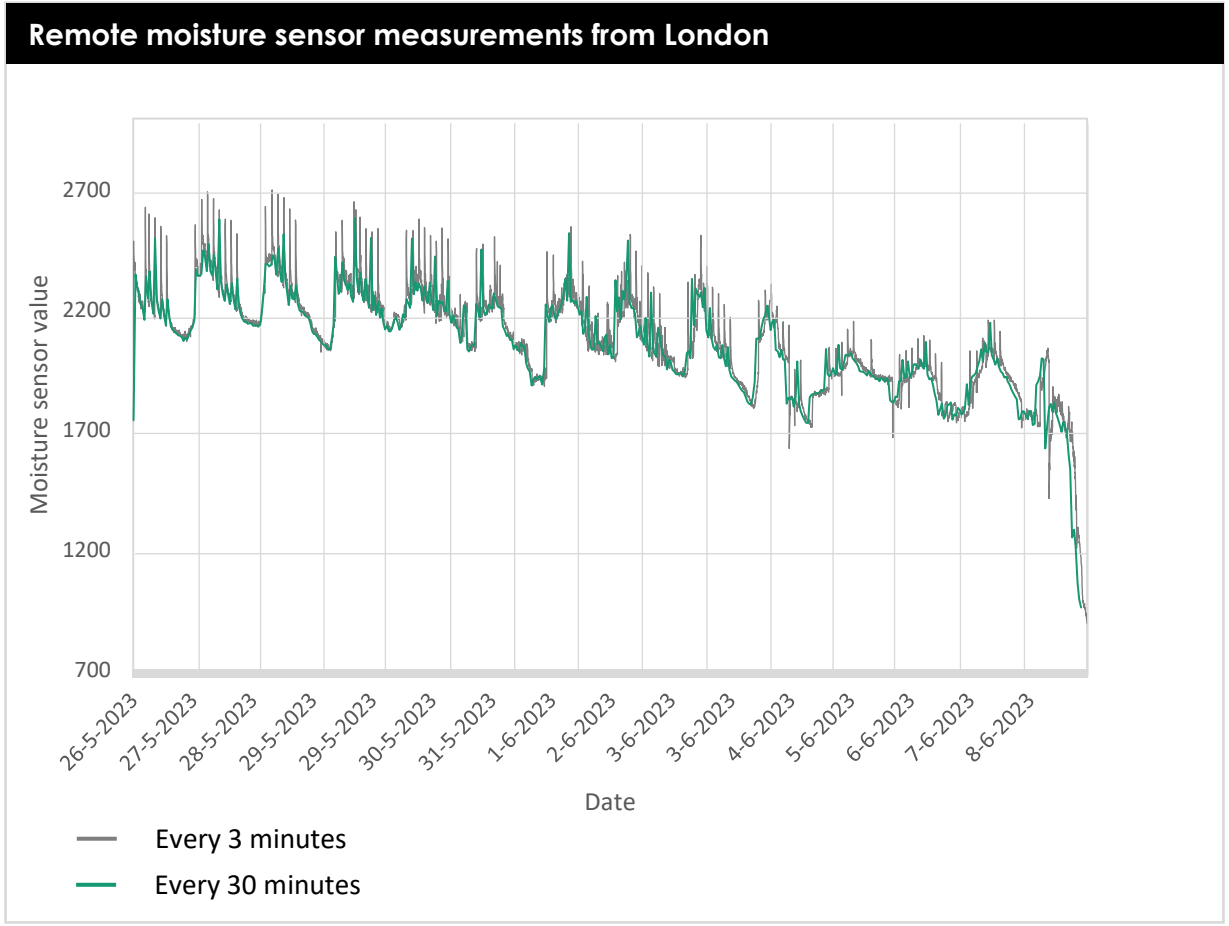
RESULTS

VERTICAL MEADOW



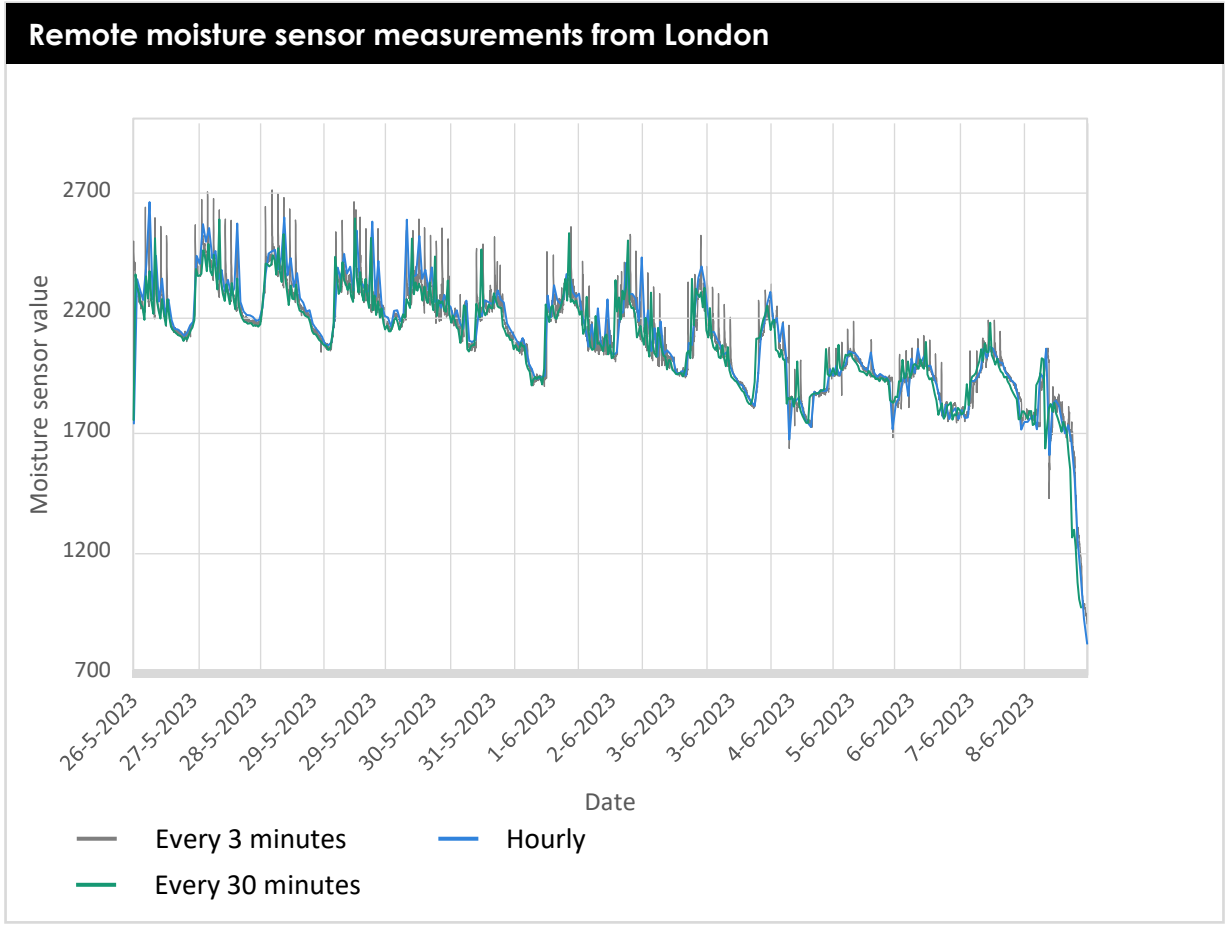
RESULTS

VERTICAL MEADOW



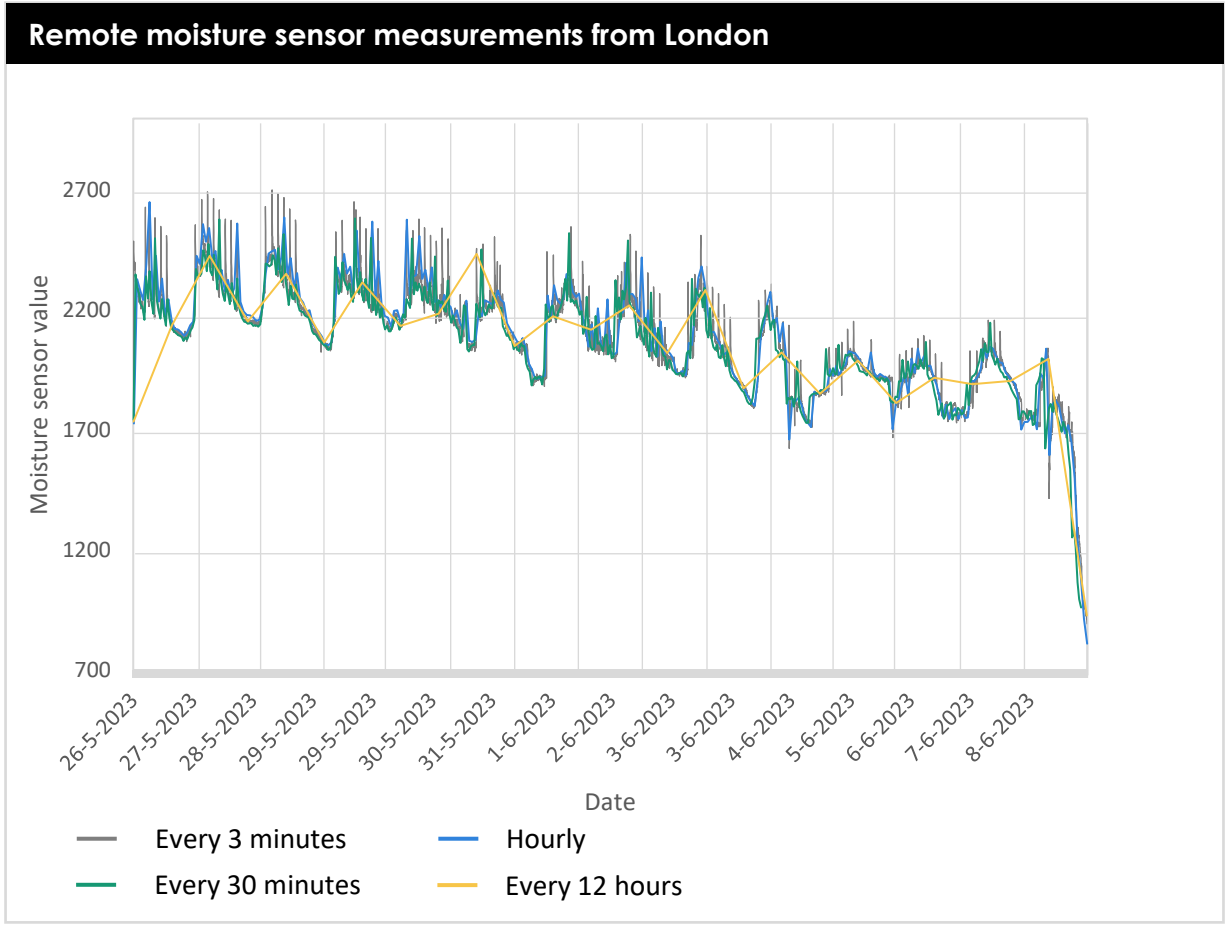
RESULTS

VERTICAL MEADOW



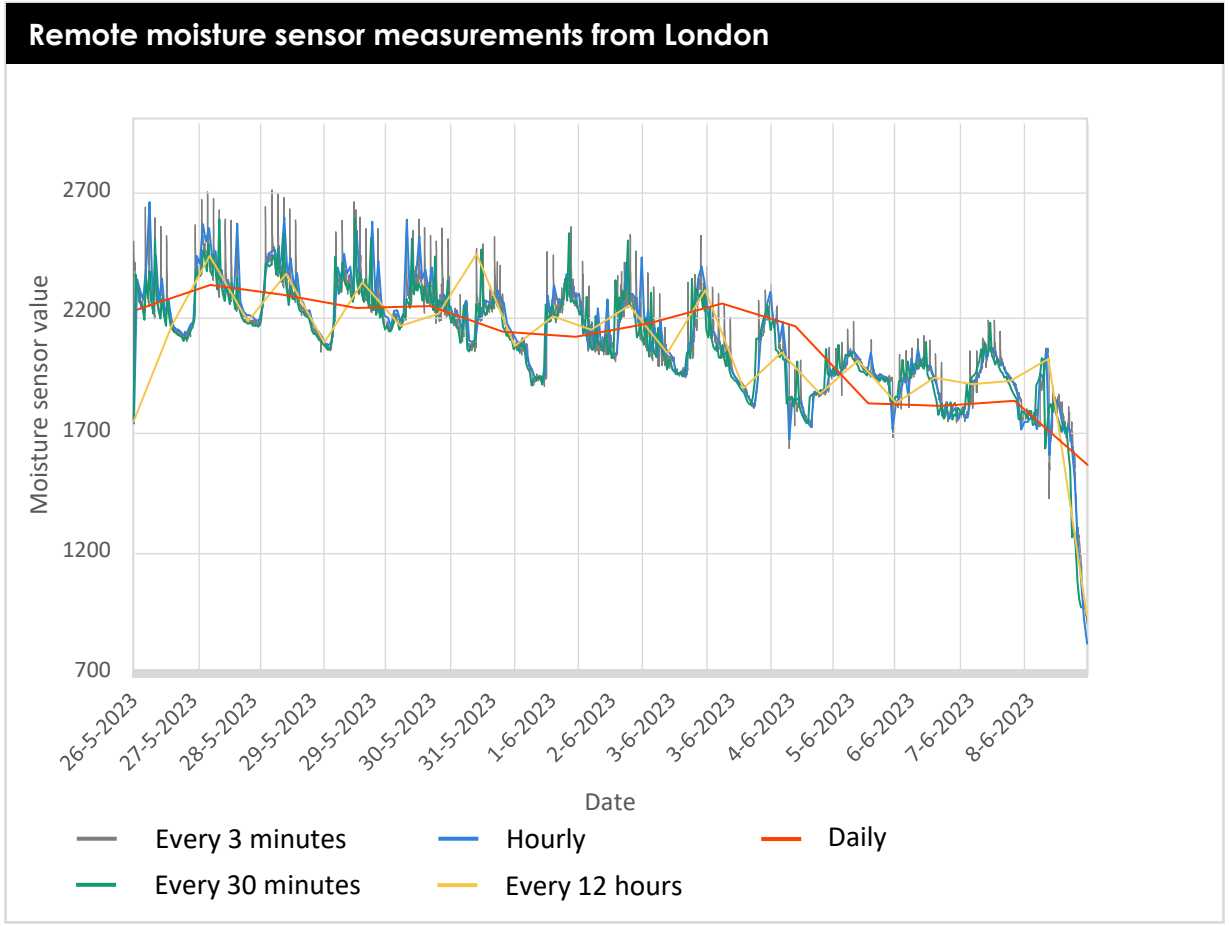
RESULTS

VERTICAL MEADOW



RESULTS

VERTICAL MEADOW



C O N C L U S I O N

WHAT IS THE BEST STRATEGY FOR **MONITORING** THE WATER DISTRIBUTION OF THE **IRRIGATION SYSTEM** ON A LIVING GREEN WALL SYSTEM THAT ULTIMATELY LEADS TO MORE EFFECTIVE **MAINTENANCE** ?

CONCLUSION

WITHOUT PLANTS

SCENARIOS	NDVI	THERMAL	SENSORS	RUN-OFF
Water content & water distribution		●	●	
Water content				●
		●	●	
Water distribution		●		

WITH PLANTS

SCENARIOS	NDVI	THERMAL	SENSORS	RUN-OFF
Water content & water distribution		●	●	●
Water content				●
Water distribution			●	●
Plant quality	●			

CONCLUSION

WITHOUT PLANTS

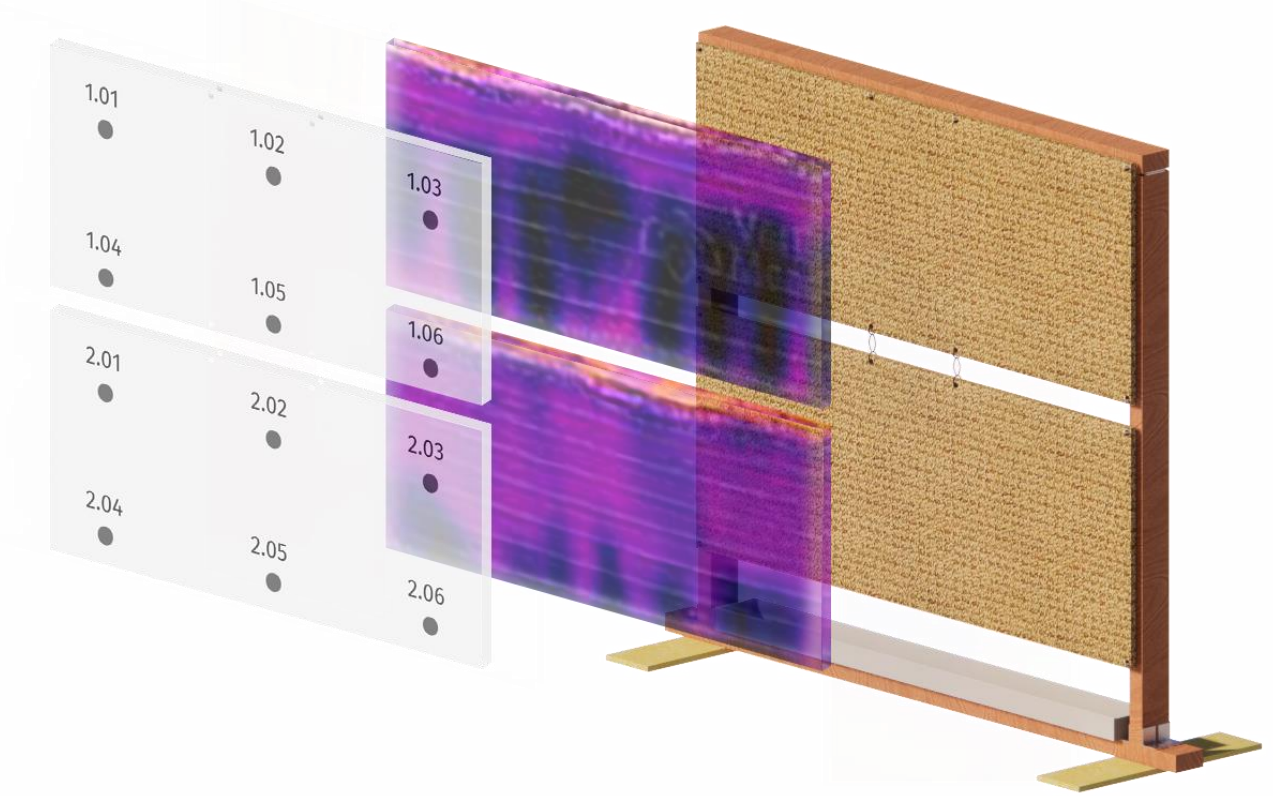
SCENARIOS	NDVI	THERMAL	SENSORS	RUN-OFF
Water content & water distribution		●	●	
Water content				●
		●	●	
Water distribution		●		

WITH PLANTS

SCENARIOS	NDVI	THERMAL	SENSORS	RUN-OFF
Water content & water distribution		●	●	●
Water content				●
Water distribution			●	●
Plant quality	●			

SENSORS
+ACCURACY
+DATA

THERMAL
+RANGE
+VISUAL



CONCLUSION

WITHOUT PLANTS

SCENARIOS	NDVI	THERMAL	SENSORS	RUN-OFF
Water content & water distribution		●	●	
Water content				●
		●	●	
Water distribution		●		

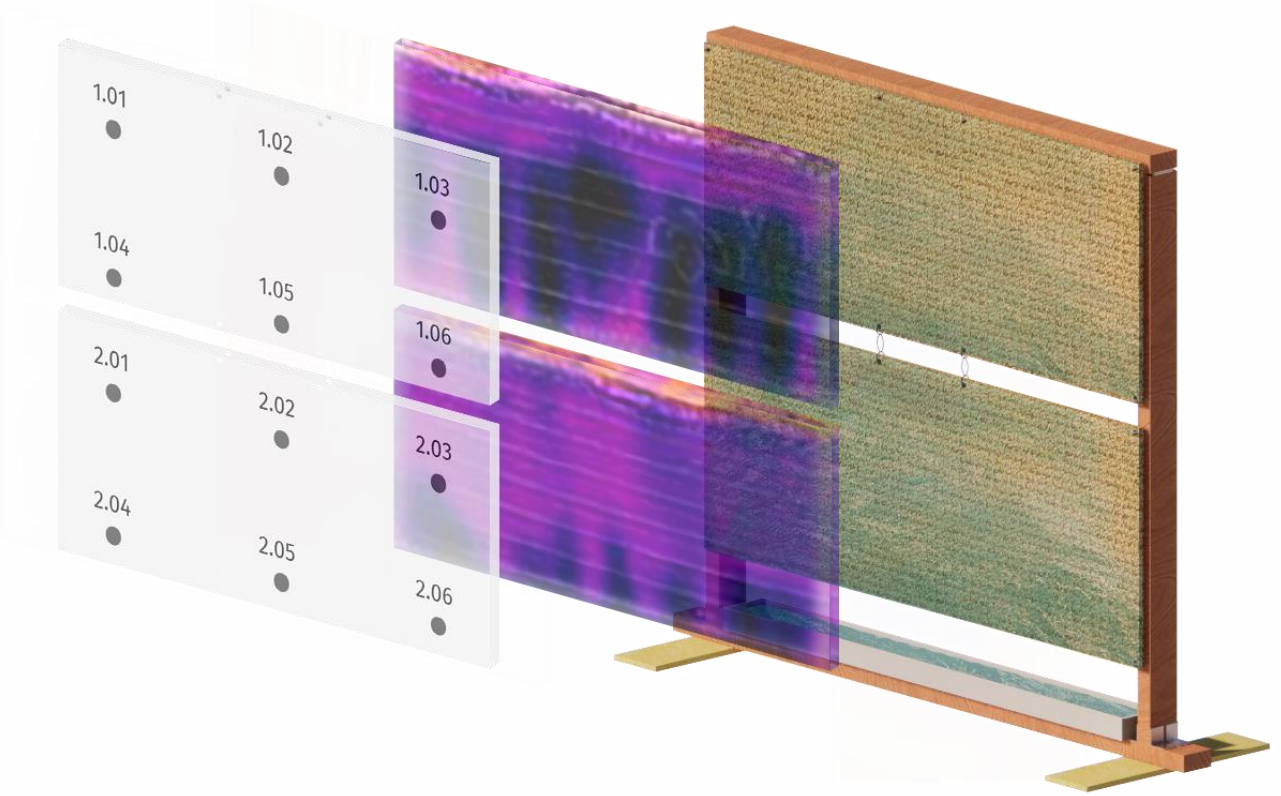
WITH PLANTS

SCENARIOS	NDVI	THERMAL	SENSORS	RUN-OFF
Water content & water distribution		●	●	●
Water content				●
Water distribution			●	●
Plant quality	●			

SENSORS
+ACCURACY
+DATA

THERMAL
+RANGE
+VISUAL

RUN-OFF
+RELIABILITY



CONCLUSION

WITHOUT PLANTS

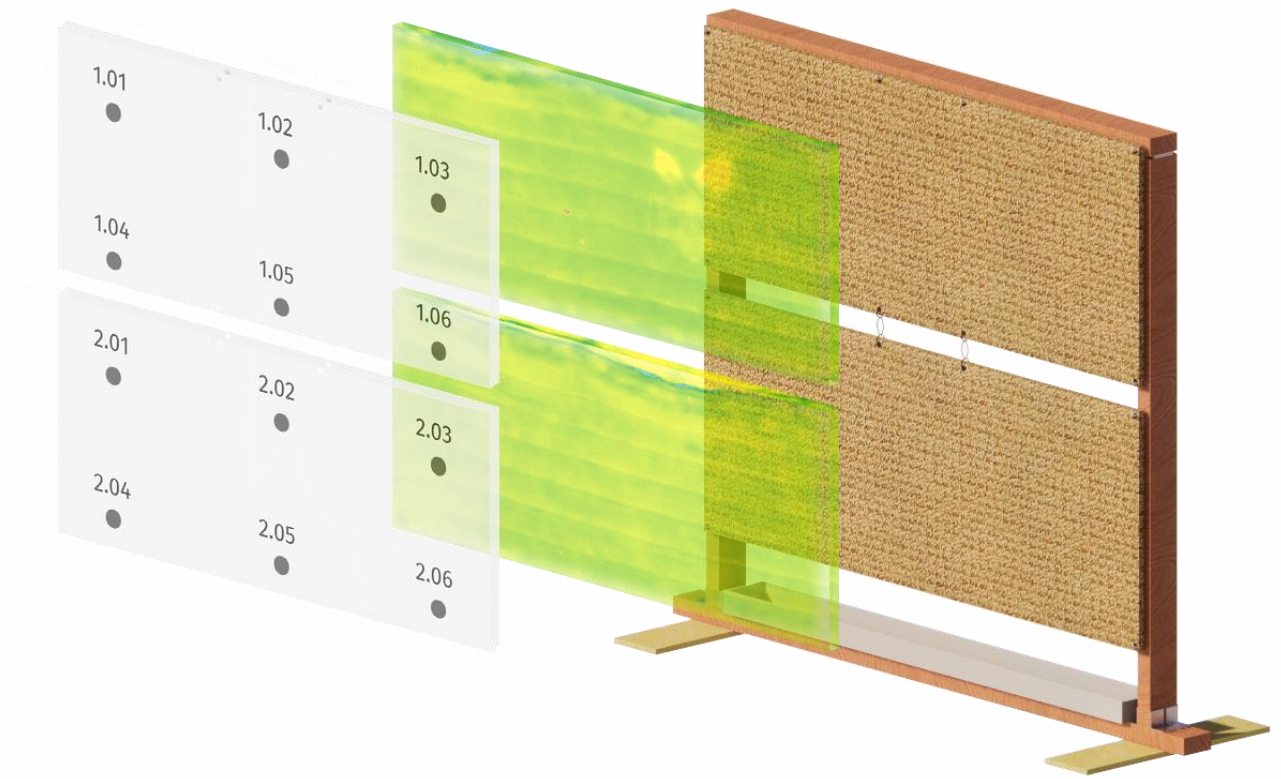
SCENARIOS	NDVI	THERMAL	SENSORS	RUN-OFF
Water content & water distribution		●	●	
Water content				●
		●	●	
Water distribution		●		
+ Water distribution	●		●	

WITH PLANTS

SCENARIOS	NDVI	THERMAL	SENSORS	RUN-OFF
Water content & water distribution		●	●	●
Water content				●
Water distribution			●	●
Plant quality	●			
+ Water distribution		●	●	

SENSORS
+ACCURACY
+DATA

NDVI
+RANGE
+VISUAL



L I M I T A T I O N S

_Living wall dimensions

_Type of living wall

_Climate

_Time frame

_Plant density

_’Proof of concept’

THANK YOU FOR LISTENING