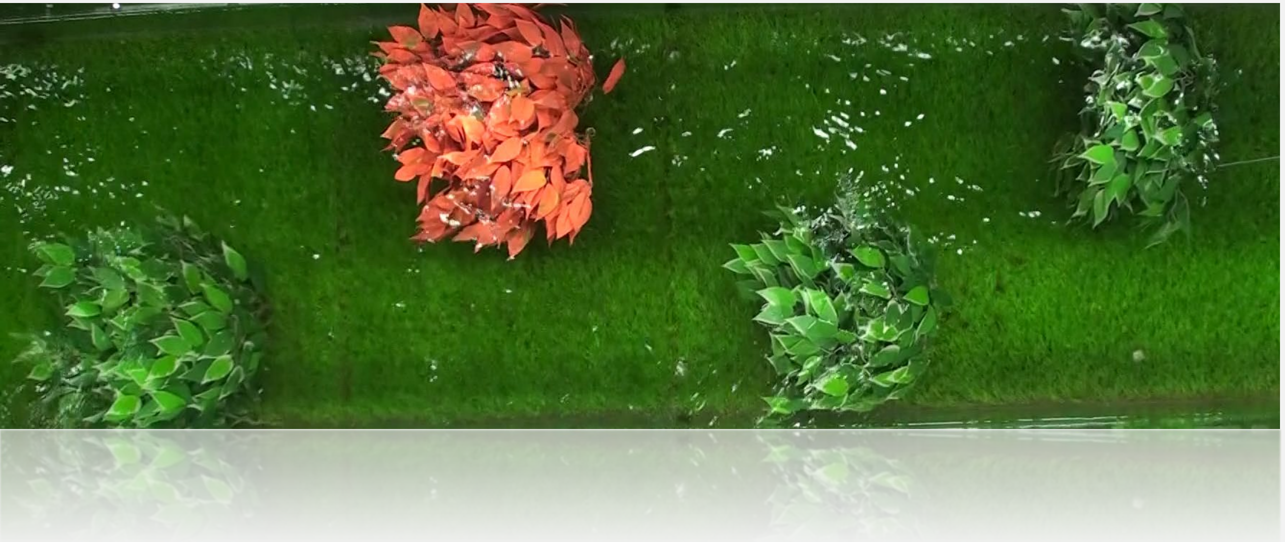
Aalto University
School of Engineering

Research Overview

Flume Investigation of Hydraulics of Nature-like Patchy Vegetation

Authors: **Hafiza Aisha KHALID** , Kaisa VÄSTILÄ and Juha JÄRVELÄ



This presentation builds on findings from our recent study, accepted for publication and forthcoming in: Khalid et al. (2025), Incorporating the blockage effect of flexible woody vegetation patches in flow resistance analyses, *Acta Geophysica*

Presentation Contents

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Introduction (1)

- Natural growth pattern of riverine and floodplain vegetation
- Balance approach to maintain vegetation
- Alteration of flow regime and impacts of patch characteristics
- Limitations of existing research

Patchy Vegetation in
(a) Luther Water near Laurencekirk, Scotland
(b) Evrotas River, Greece
and (c) River Hooke in Dorset, UK

Sources of figure: (a) Carbonari et al. 2022, (b) LIFE project by Nikolaos Nikolaidis, (c) Environmental Agency

Introduction (2)

- The size, density and submergence of riparian patches found in nature varies significantly.
- Controlled laboratory studies allow for in-depth exploration of patchiness effects on flow resistance under various hydraulic conditions.

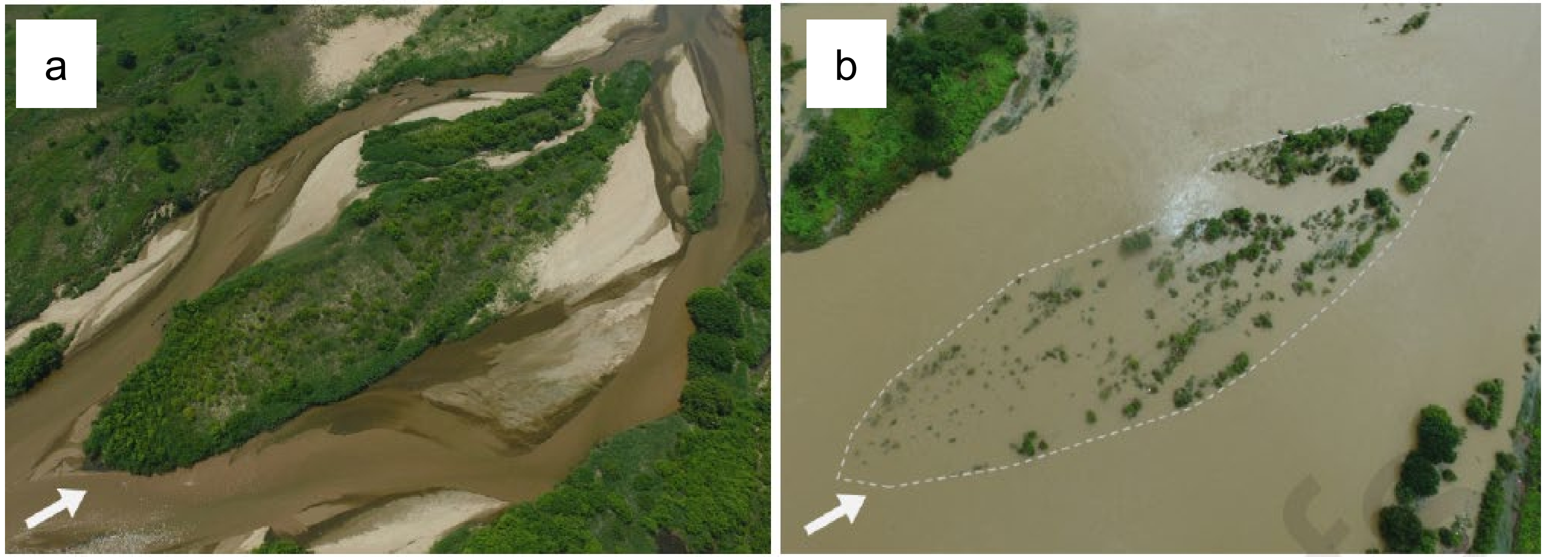

Figure: Woody riparian vegetation patch: 265m long, 80m wide, Naeseong-cheon Stream, South Korea during (a) low flow and (b) flooded condition (white arrow indicates flow direction)

Picture Source : Inhyeok Bae et al., 2023 Blockage effect of emergent riparian vegetation patches on river flow, https://doi.org/10.1016/j.jhydrol.2024.131197.

Research Objectives

❖ **Novelty of the research arises from the realistic representation of natural patchy vegetation for hydraulic experimentation**

❖ **Current knowledge is limited to aquatic vegetation & evenly distributed flexible riparian vegetation**

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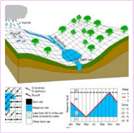

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Methodology – Flume Experiments Setup (1)

- Two reach scale LAI (1.0 and 2.4)
- 6 different patch shape (3 for each LAI case)
- 6 velocity conditions for each patch setup
- Two submergence levels for each velocity

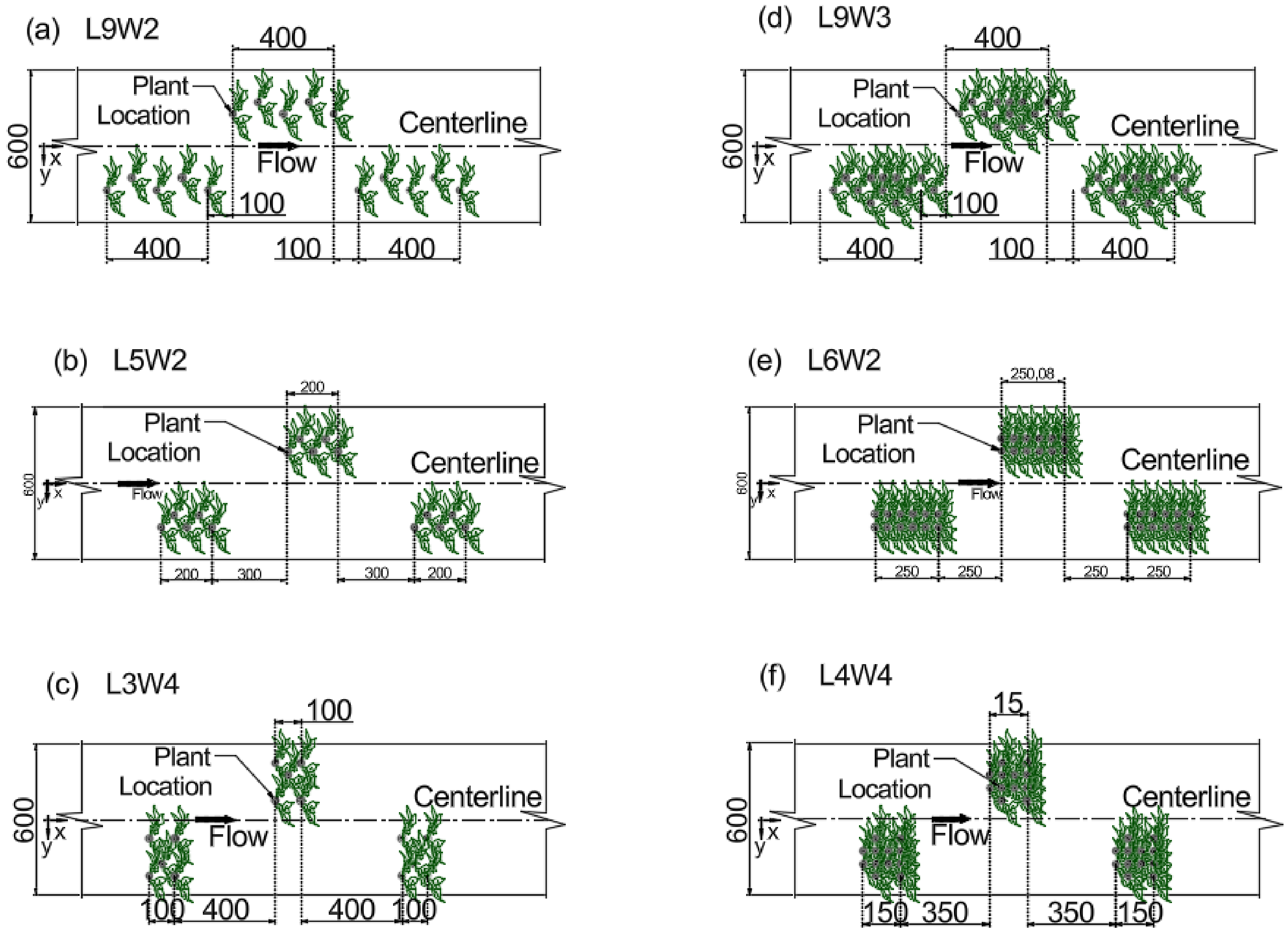
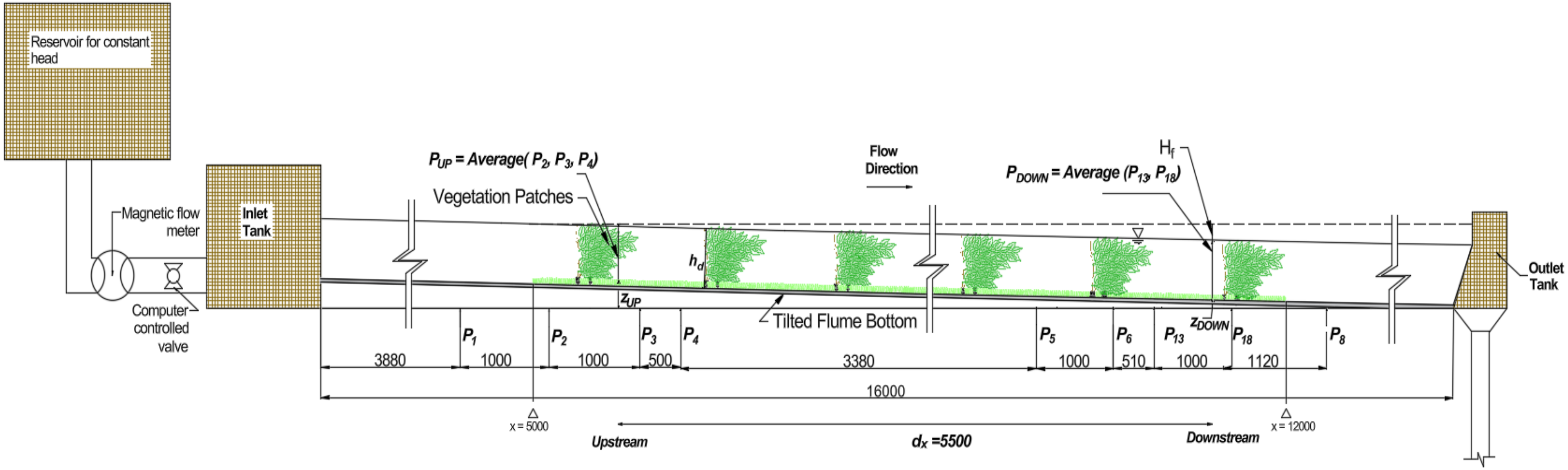


Figure: Khalid et al. (2025), Incorporating blockage effect of flexible woody vegetation patches in flow resistance analyses (accepted for publication)

Methodology – Flume Experiments Setup (2)

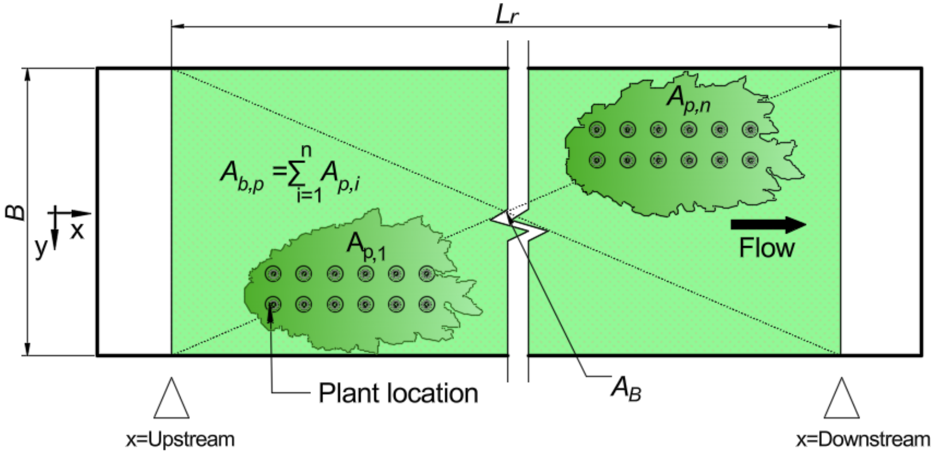
Quasi uniform flow conditions

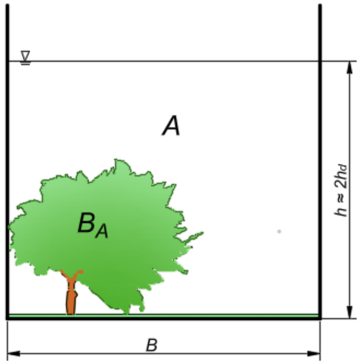
(Water level measurements)



(a)

(b)





Blockage factors estimation

(images from top-view and underwater perspectives)

$$B_{b,p} = \frac{A_{b,p}}{A_B} = \frac{A_{b,p}}{B L_r}$$

$$B_v = \frac{V_p}{V_w} = \frac{A_{b,p} h_d}{A_B h}$$

$$B_x = \frac{B_A}{A} = \frac{B_A}{Bh}$$

Results (1)

Vegetative friction factors *f"* as a function of mean velocity for two submergences

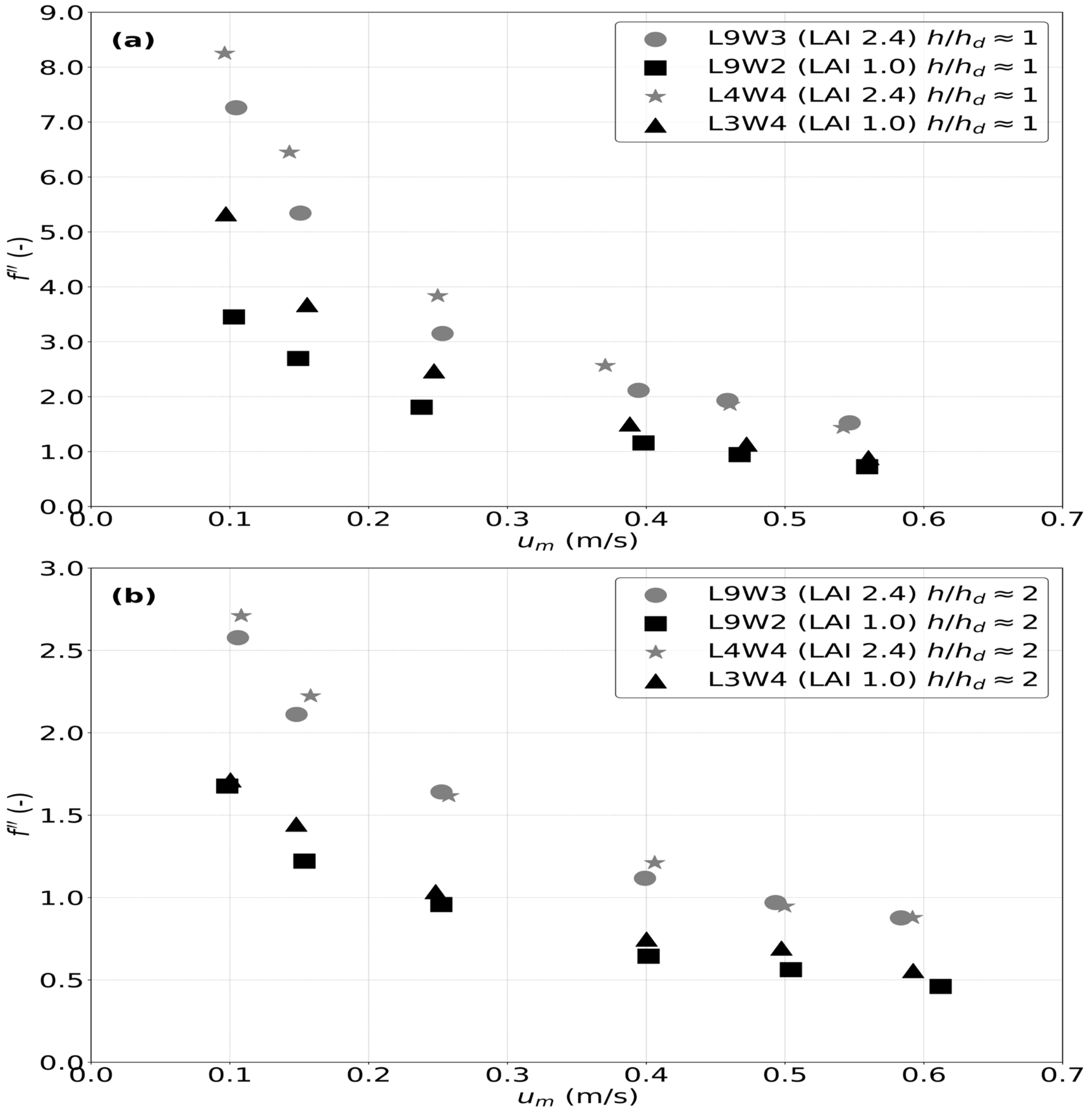


Figure: Khalid et al. (2025), Incorporating blockage effect of flexible woody vegetation patches in flow resistance analyses (accepted for publication)

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Results (2)

Ratio of *f”* of various patch setups categorized for similar patch shapes and two submergences

$$\boxed{\frac{f''_{(LAI\ 1.0)}}{f''_{(LAI\ 2.4)}}}$$

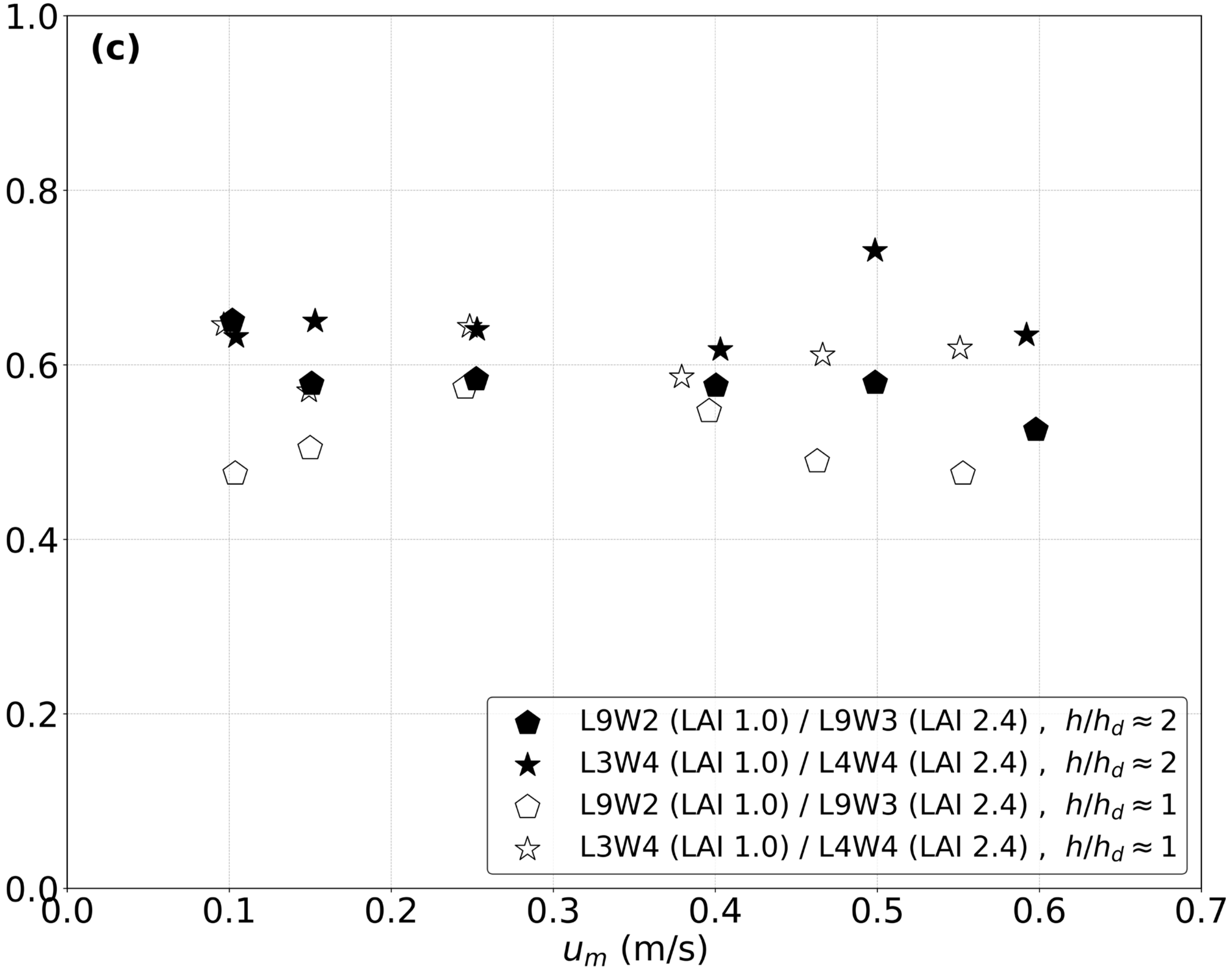

Figure: Khalid et al. (2025), Incorporating blockage effect of flexible woody vegetation patches in flow resistance analyses (accepted for publication)

Results (3)

Vegetated resistance *f''* as a function of static and dynamic planform $A_{b,p}$ area categorized by the two hydraulic submergences

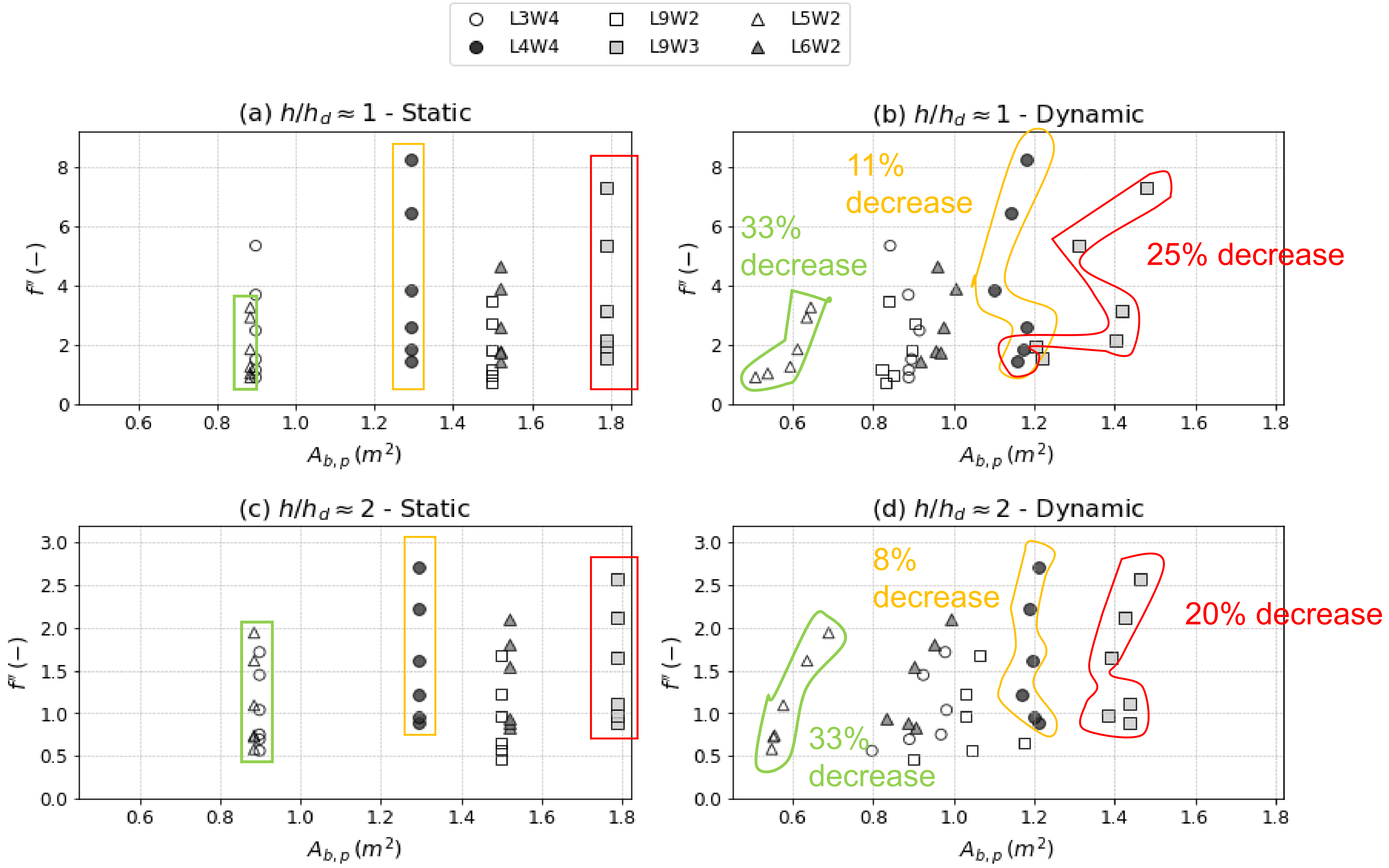

Figure: Khalid et al. (2025), Flume investigation of hydraulics of nature like patchy vegetation

Conclusion

Vegetative friction factor is controlled by LAI, but the relationship is not linear as previously reported for uniformly distributed vegetation.

The influence of LAI remains dominant, regardless of submergence level.

Patch projection areas are strongly influenced by flow velocity and shape, while the effect of submergence is comparatively minor.

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