



Agriculture and the Environment  
Aarhus, Denmark, 3-6 June 2025

# Examination of flow, sediment and phosphorus relationships using monitored storm event data from a multiscale research platform

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ROTHAMSTED  
RESEARCH



RESILIENT  
FARMING  
FUTURES

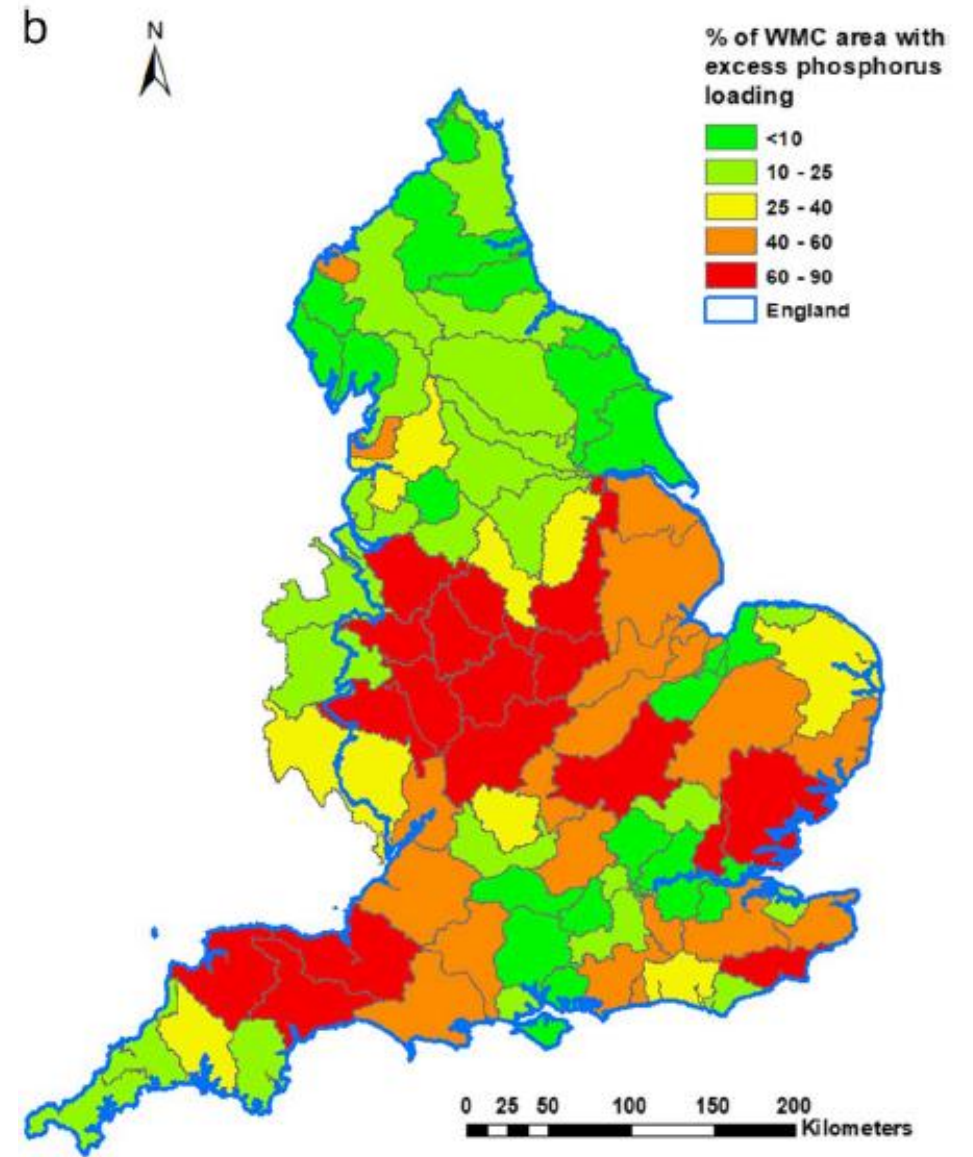


Biotechnology and  
Biological Sciences  
Research Council

# The challenge

## Environmental Improvement

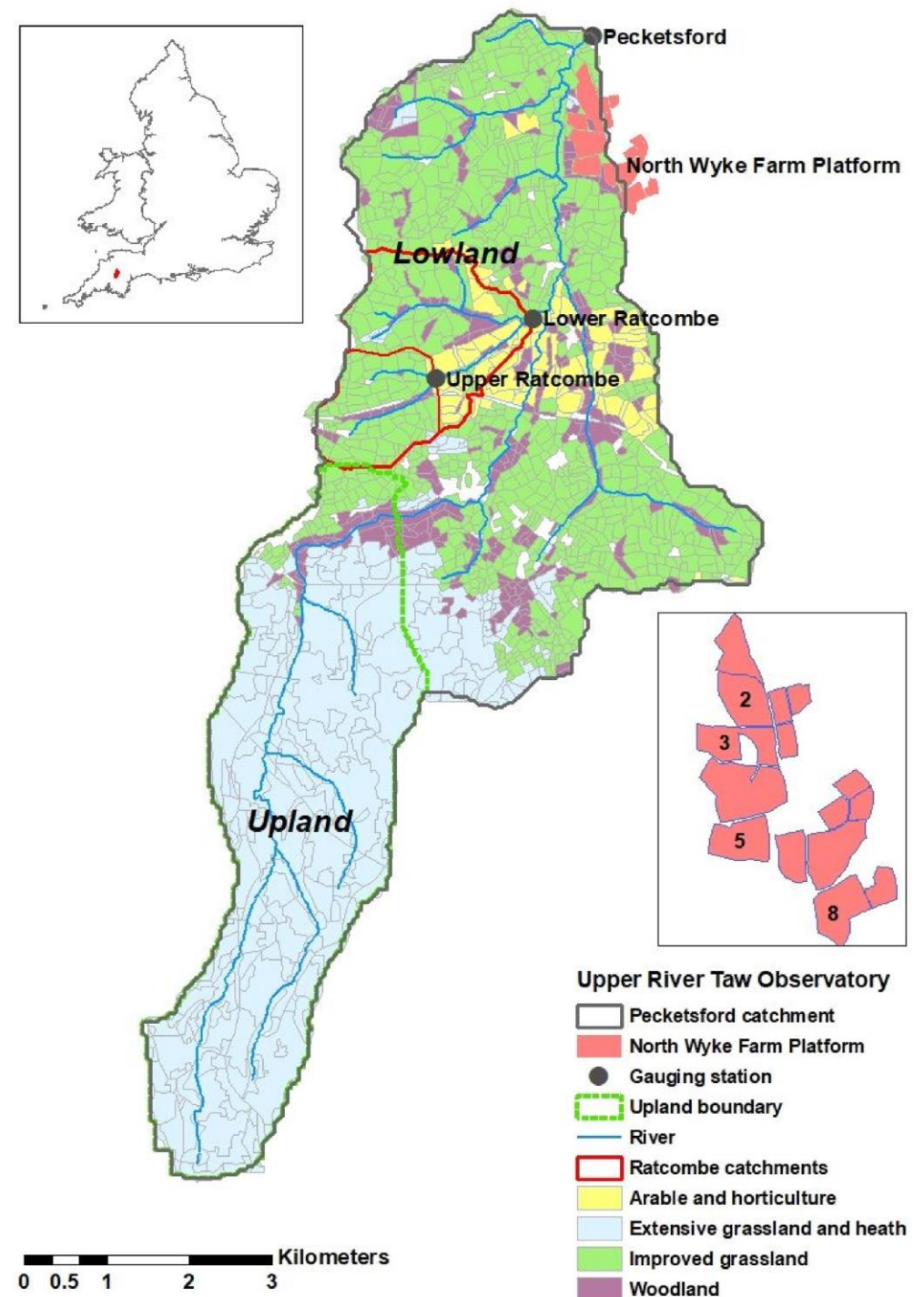
**Plan:** 40% reduction in sediment and nutrient loss from agricultural land by 2038 compared with a baseline in 2018



Source: <https://doi.org/10.1007/s13593-025-01015-4>

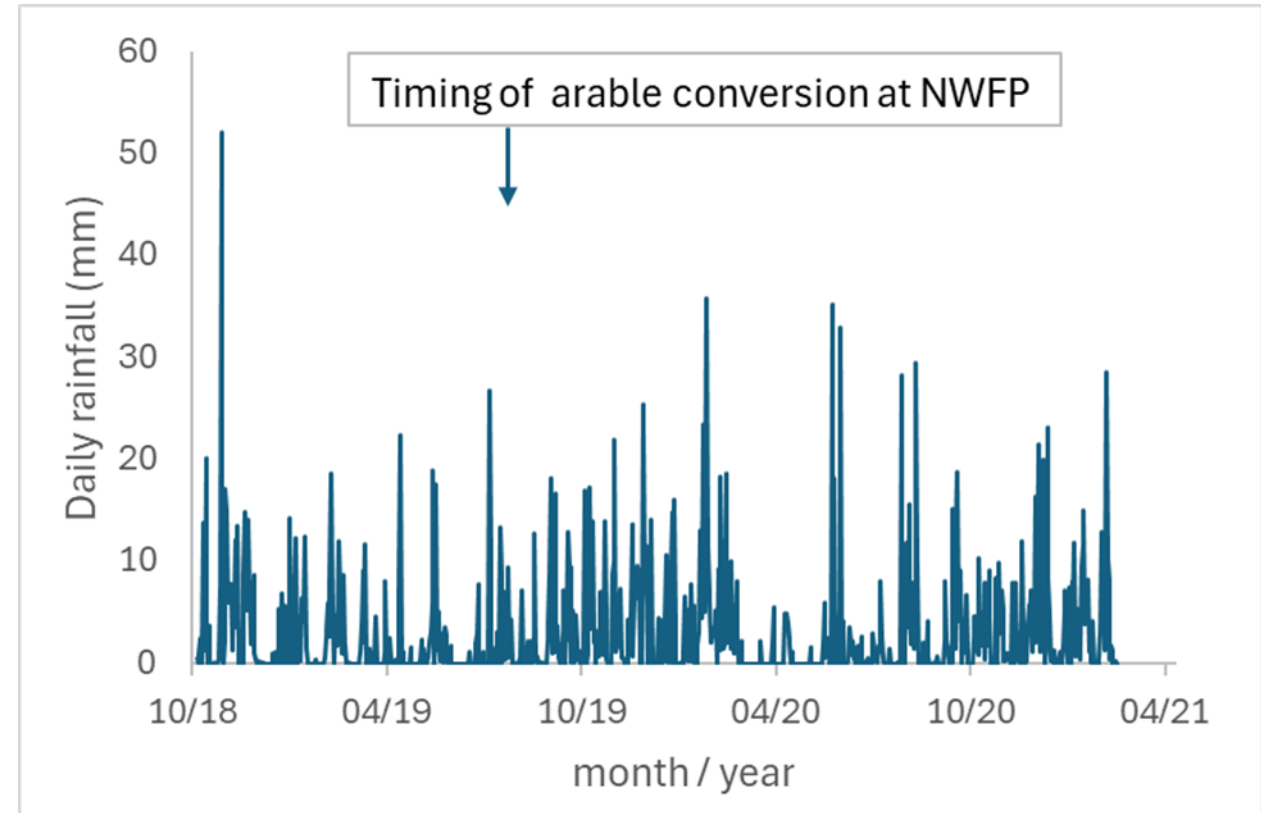
# BBSRC national capability

- North Wyke Farm Platform (NWFP): 15 hydrologically-isolated field scale catchments; 4 catchments were targeted.
- Upper River Taw Observatory (URTO): 3 nested catchments (Upper Ratcombe, Lower Ratcombe and Pecketsford) with contrasting land uses
- High resolution and continuous monitoring and recording of rainfall, flow rates, sediment and nutrients (nitrogen and phosphorus), etc.
- Focus on selected storm events where lab data for sediment and phosphorus are available for physical water samples



# Storm sampling and laboratory analyses

- Sampling period: Nov 2018 to Feb 2021.
- Number of events per catchment: 7 - 10
- NWFP: Flow-based sampling; 7 – 8 samples per event; cover both falling and rising limbs.
- URTO: Time-based sampling; 24 – 48 samples per event; cover whole hydrograph.
- All samples were analysed for suspend solids (SS) and total phosphorus (TP) concentrations (sodium hydroxide fusion)



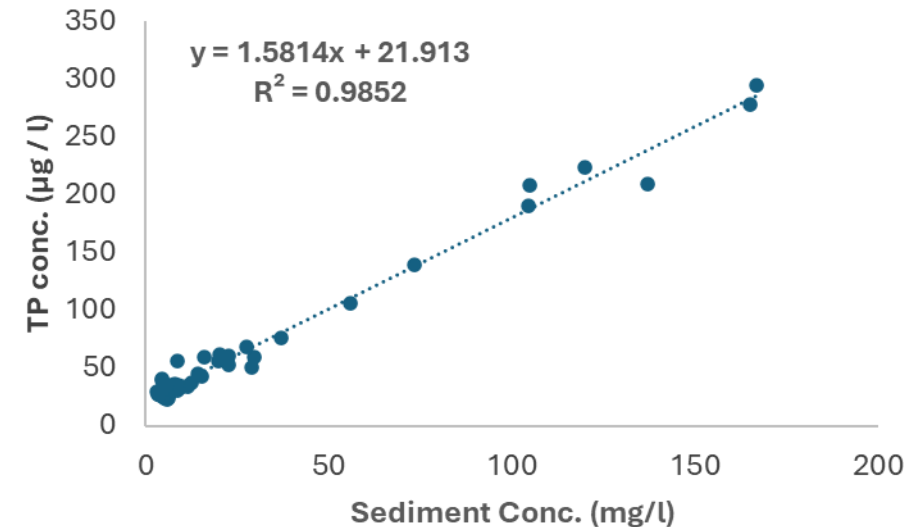
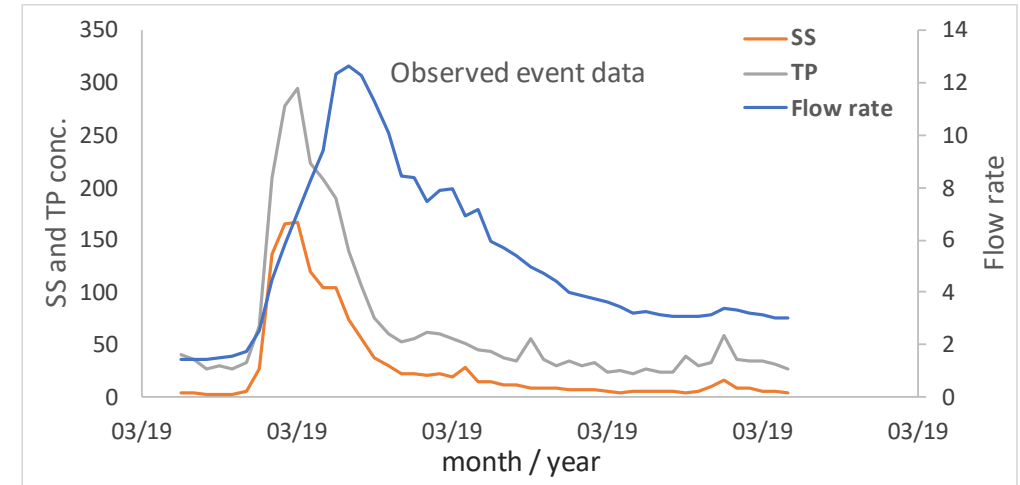
Sites experience designed arable conversion and extreme weather conditions.

# Maximum concentrations in the storm events

		<b>Catchment area (km<sup>2</sup>)</b>	<b>Land uses</b>	<b>Sediment conc. mg/l</b>	<b>TP conc. µg/l</b>
NWFP	Catchment 2	0.0673	grass and then converted to arable in Sep 2019	981	1413
	Catchment 3	0.0684	grass and then converted to arable in Sep 2019	1423	2905
	Catchment 5	0.0673	improved grass	206	699
	Catchment 8	0.0733	permanent grass	317	1073
UTRO	Upper	1.7	grass	172	282
	Lower	4.4	major area of arable	765	852
	Pecketsford	41.4	mixed	424	546

# Data processing and analysis

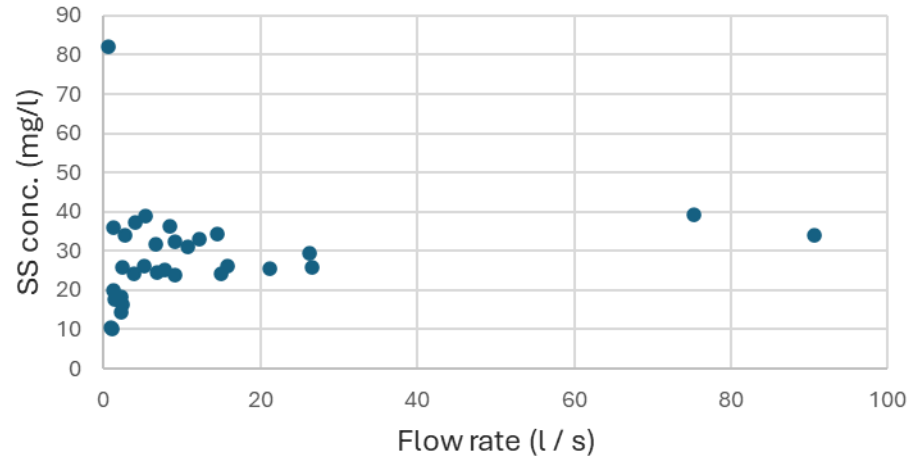
- Phosphorus content of sediment: total P concentration divided by sediment concentration. Mean values for each event were estimated
- Sediment and phosphorus relationship: simple linear regression to estimate slopes; correlation analysis to assess the strength of the relationship.
- Statistical tests to compare different land uses.
- Load estimates at UTRO: multiplication of flow rates and concentrations.



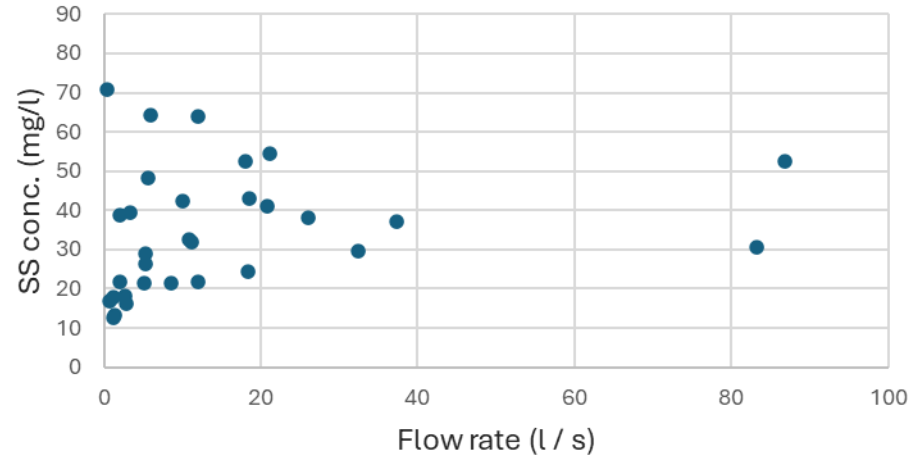
Example event data from Pecketsford -  
URTO

# Flow rates and SS concentrations on NWFP: land use change

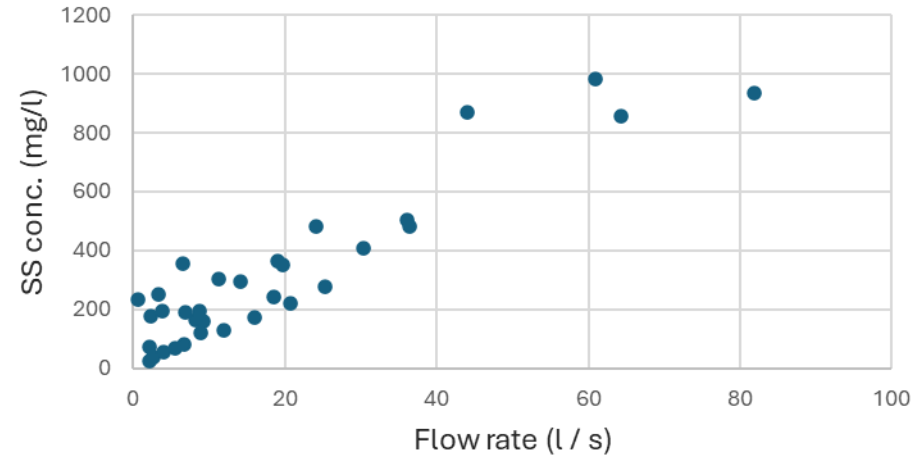
Prior to arable conversion at catchment 2(a)



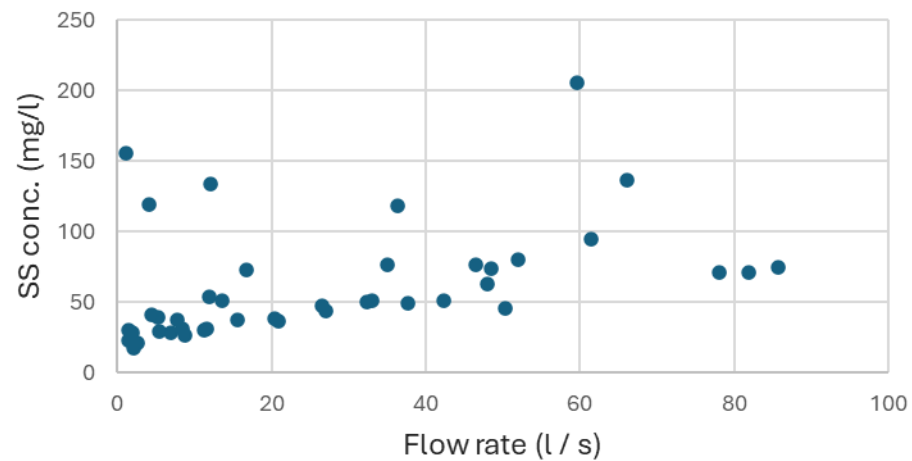
Catchment 5 a



Post arable conversion at catchment 2(b)

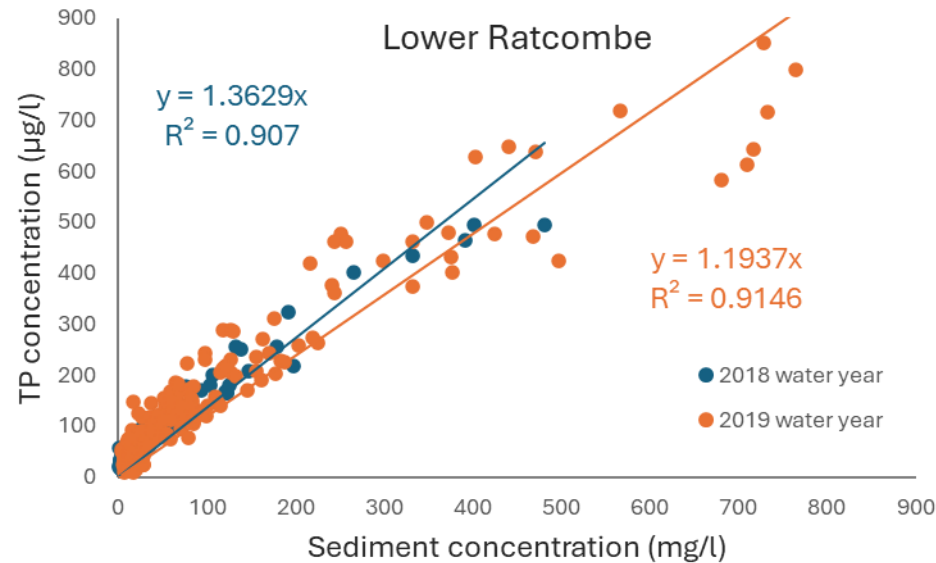
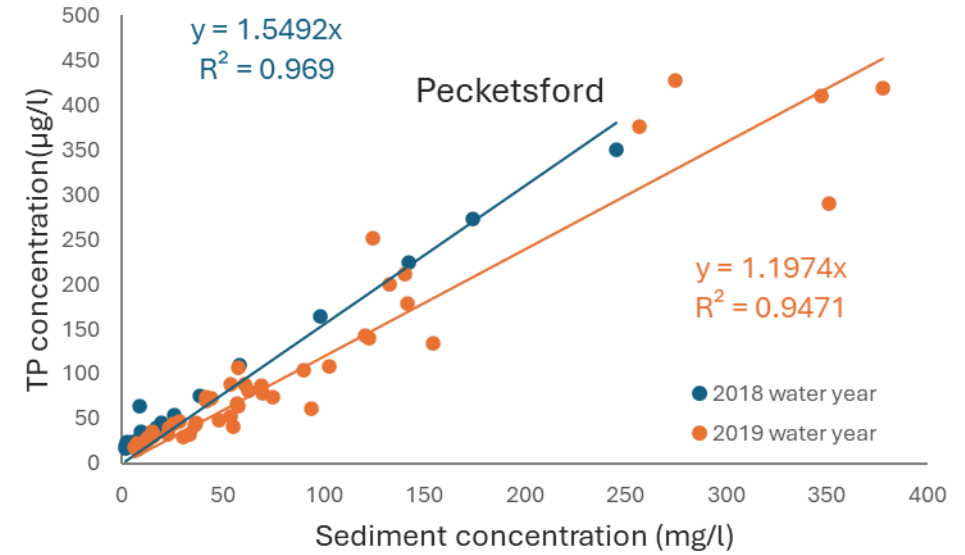
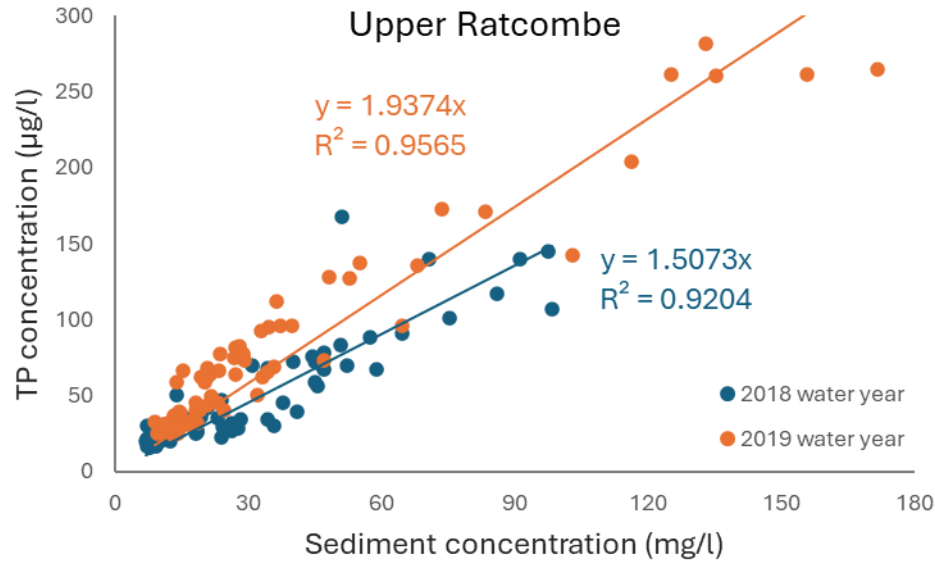


Catchment 5 b (no land use change)

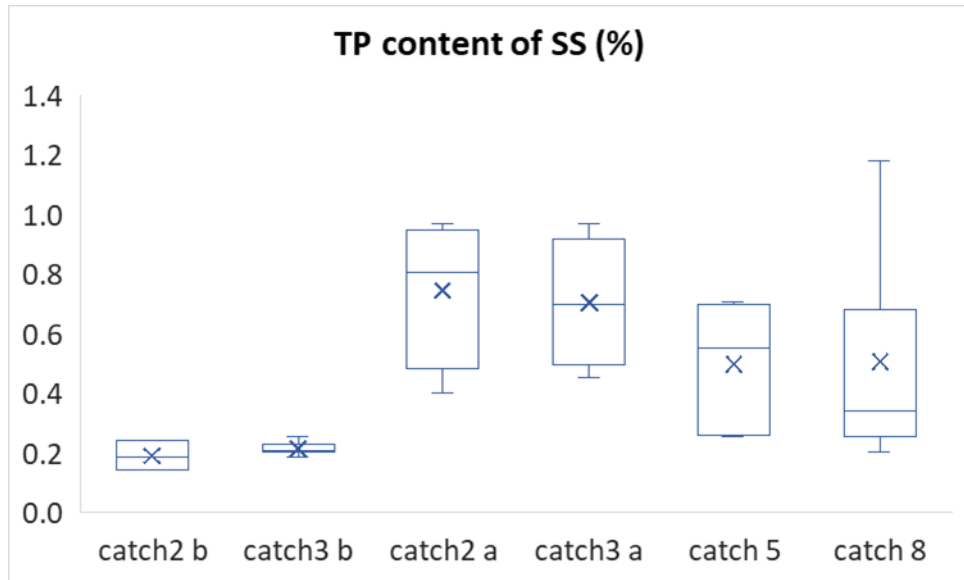
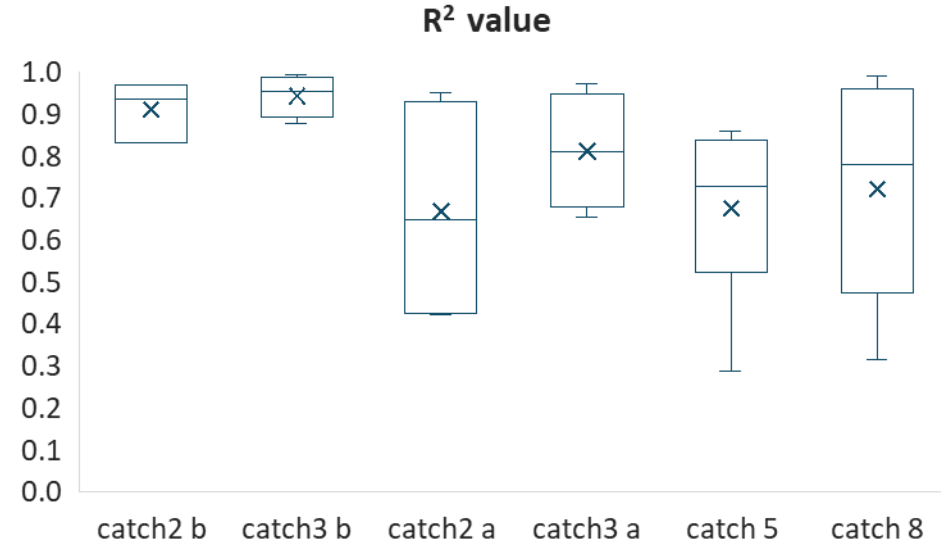
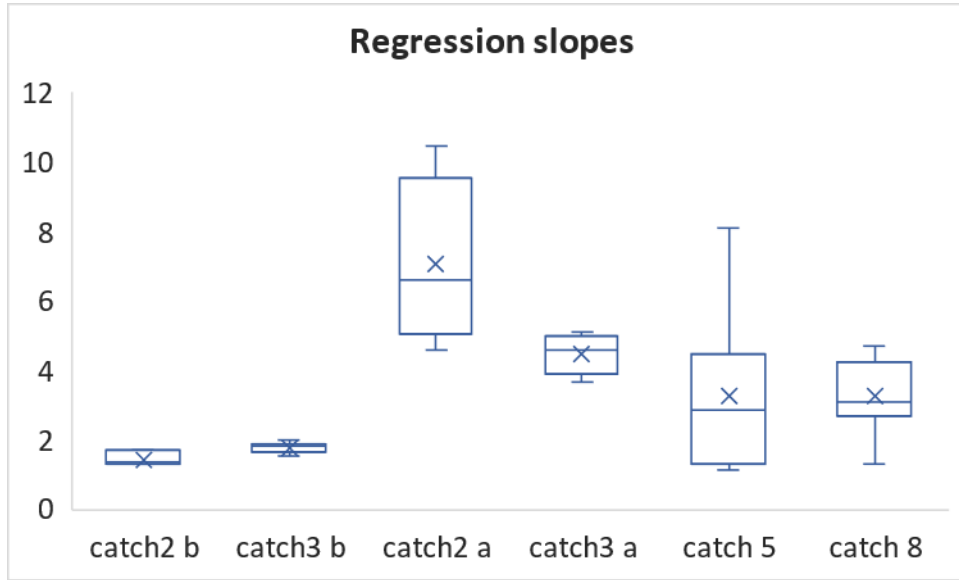


Source:  
<https://doi.org/10.1016/j.agee.2025.109713>

# SS and TP concentrations on UTR0: dry year vs wet year



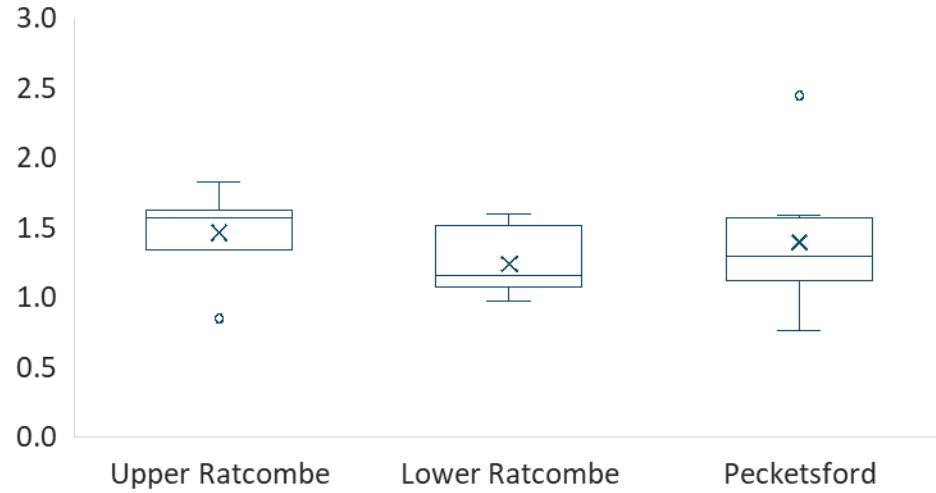
# SS and TP concentrations on NWFP



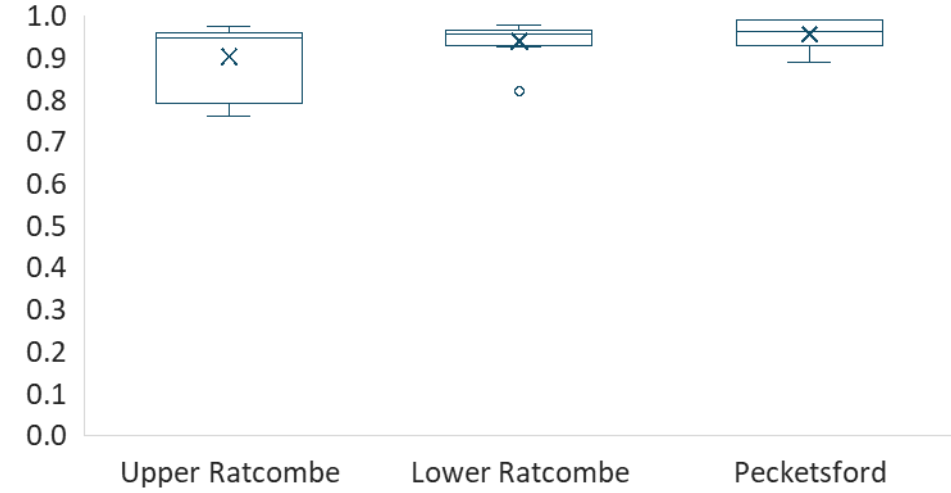
TP content of topsoil (down to 10 cm) was estimated to be around 0.09 to 0.14% based on soil survey undertaken in 2016.

# SS and TP concentrations on UTRO

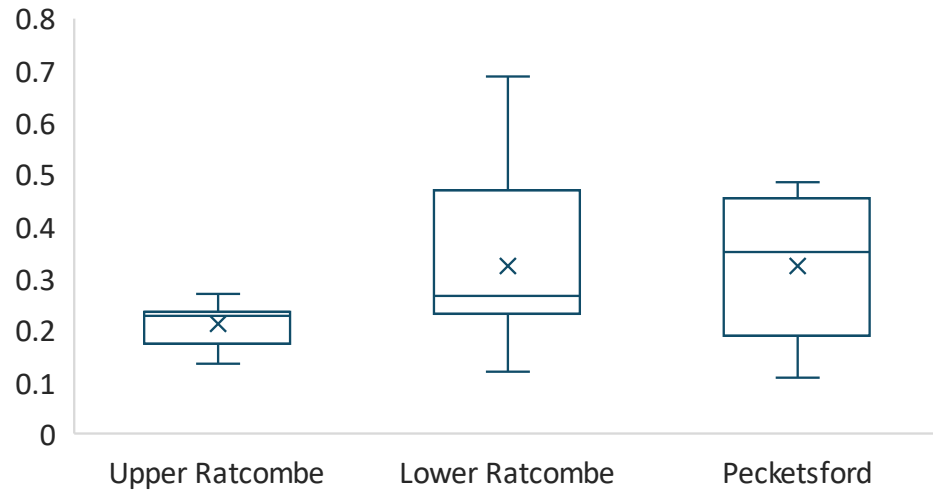
Regression slope



R<sup>2</sup> value

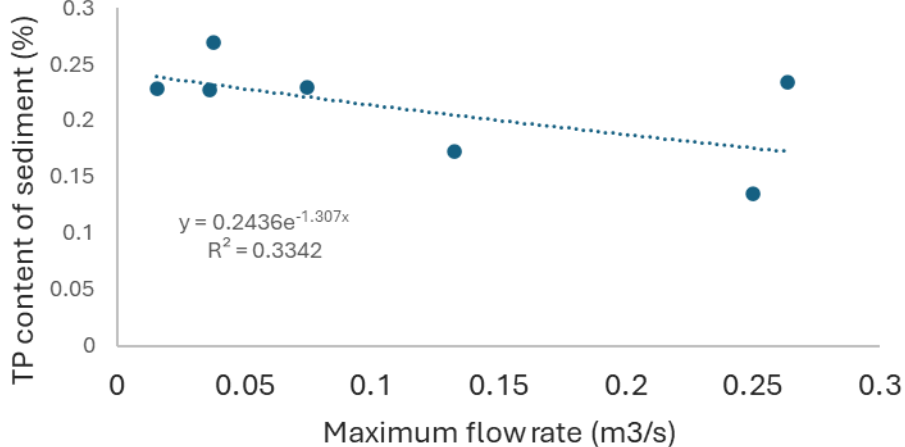


TP content of sediment (%)

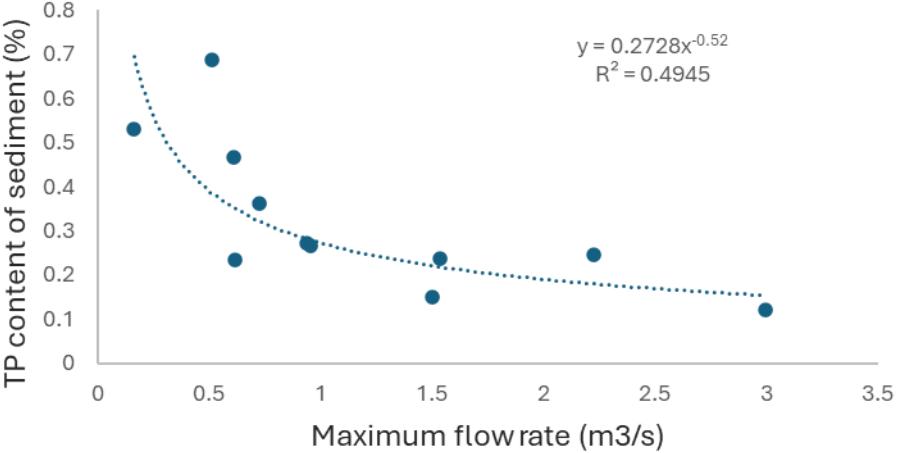


# Mean TP contents and maximum flow rates on UTR0

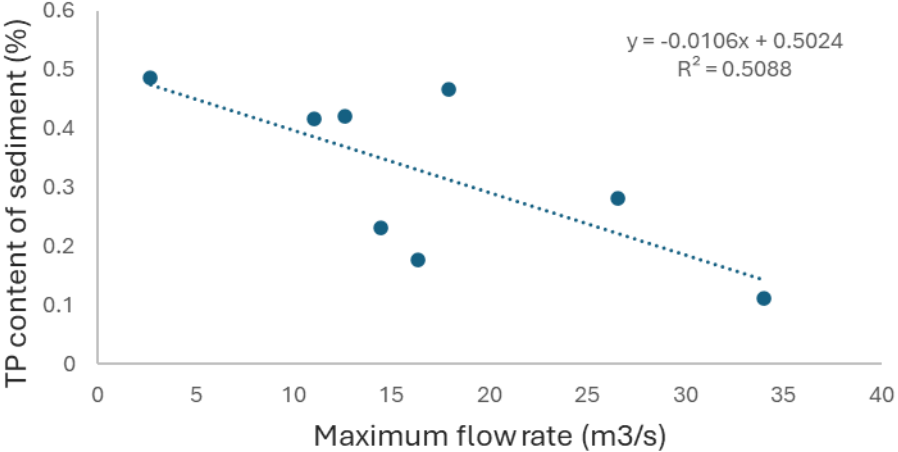
Upper Ratcombe



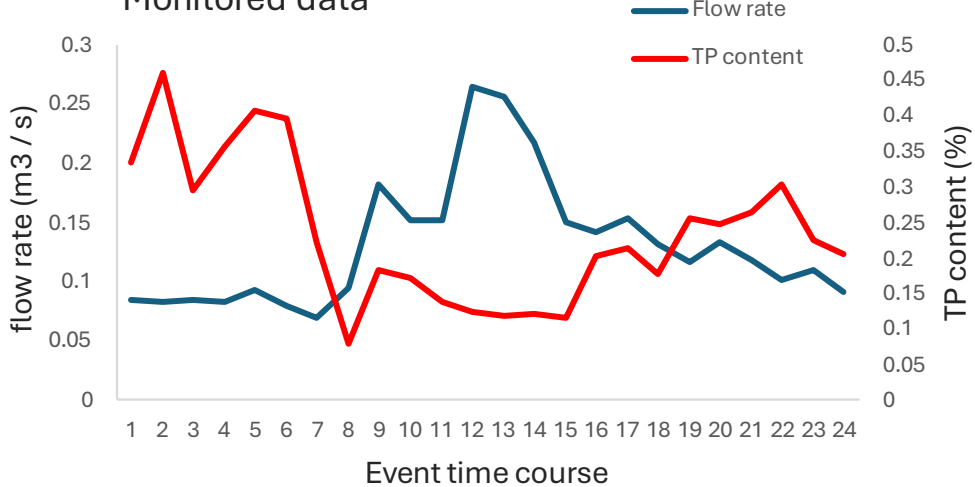
Lower Ratcombe



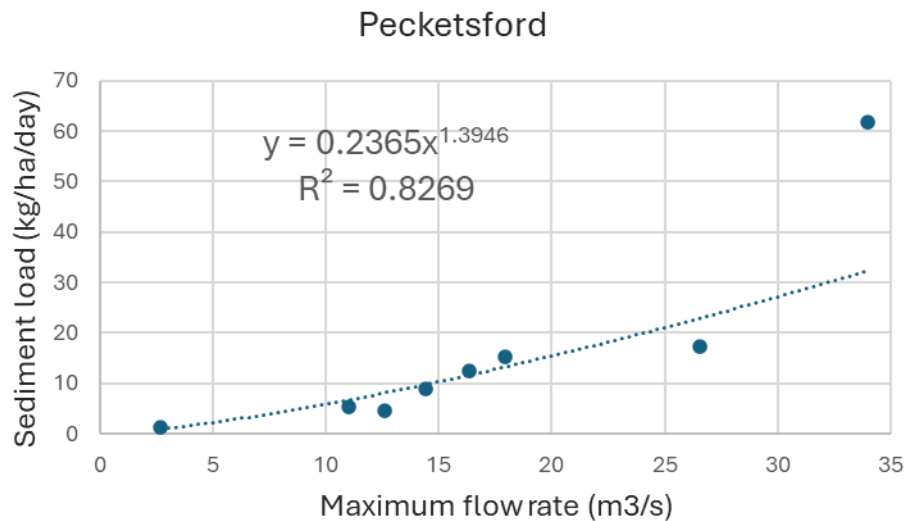
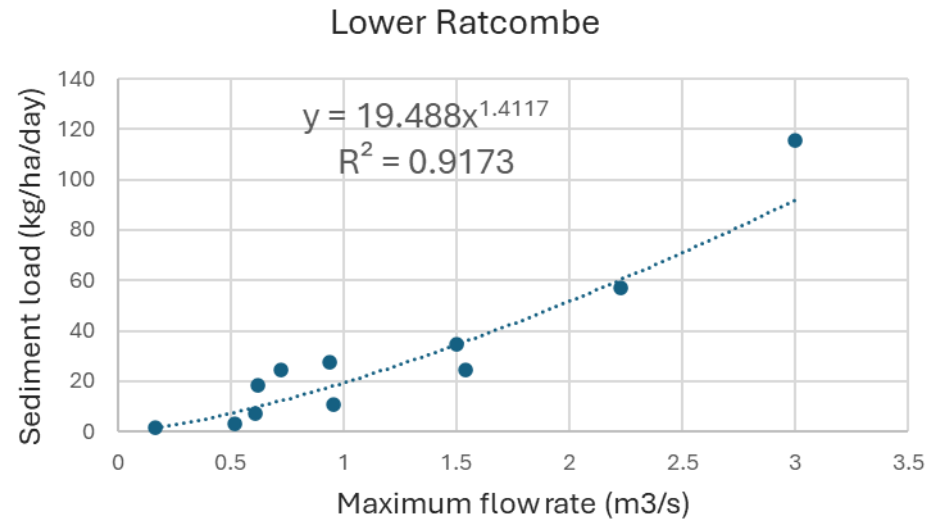
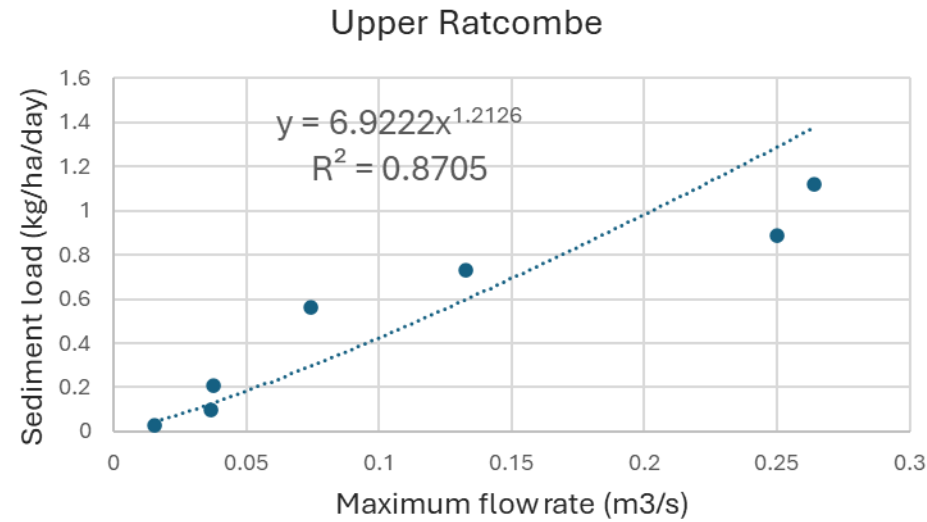
Pecketsford



Monitored data



# Maximum flow rates and sediment loads on UTR0



Similar relationships were also observed for TP loads

# Concluding remarks

- High-resolution flow monitoring, targeted storm sampling and laboratory analysis have provided valuable insights to examine different factors affecting sediment and TP delivery across scales.
- Conversion of grassland to arable will significantly change the TP contents and loads associated with the sediment delivered.
- Projected wetter and stormier winters and land use changes in the uncertain future climate conditions could worsen diffuse pollutions.

# Acknowledgements

- All technicians who work on the NWFP and deliver sample collection, instrumental maintenance, data curation and archiving and laboratory technicians who process physical water samples.
- UK Biotechnology and Biological Sciences Research Council which provides funding for The North Wyke Farm Platform UK National Capability by the (BBS/E/C/000J0100 / BBS/E/RH/23NB0008), Institute Strategic Programme Soil to Nutrition project 3 via grant (BBS/E/C/000I0330); Institute Strategic Programme Resilient Farming Futures (BBS/E/RH/230004B).

