Mapping the Plastic

Helping Communities Deal with the Global Plastic Waste Crisis

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Co-Chair FIG WORKING GROUP 4.3 – a joint Commission 4 (Hydrography) and Young Surveyors Network initiative

SUSTAINABLE DEVELOPMENT GOALS | International Federation of Surveyors supports the Sustainable Development Goals

Commission 4

Hydrography – working towards all SDGs, specifically 6, 13, 14 & 17

Serving Society for the Benefit of People and Planet

Photo credit: Christian Thompson / EPA

Some confronting statistics...

- Almost every piece of plastic ever made is still on our planet in one form or another
- 75% of all the plastic produced since 1950 is now waste, with most of it discarded into landfills or dumped into marine environments.
- 8 million tonnes of plastic ends up in our oceans every year
- This equates to 15 tonnes of plastic entering our oceans every minute.
- Eighty per cent of all litter in our oceans is now made of plastic, and…


By 2050 WWF estimates there will be more plastic in the ocean than fish, by weight

Top 10 river systems contributing to ocean plastic

- Yangtze River, Yellow Sea, Asia
- Indus River, Arabian Sea, Asia
- Yellow River (Huang He), Yellow Sea, Asia
- Hai River, Yellow Sea, Asia
- Nile, Mediterranean Sea, Africa
- Meghna/Bramaputra/Ganges, Bay of Bengal, Asia
- Pearl River (Zhujiang), South China Sea/East Sea, Asia
- Amur River (Heilong Jiang), Sea of Okhotsk, Asia
- Niger River, Gulf of Guinea, Africa
- Mekong River, South China Sea/East Sea, Asia

Export of plastic debris by rivers into the sea - Authors: Christian Schmidt, Tobias Krauth, Stephan Wagner, *Reprinted with permission from Environmental Science & Technology 2017, 51, 21, 12246-12253. Copyright 2017, American Chemical Society*.


95% Of Plastic Polluting The World's Oceans
Comes From These 10 Rivers
Amur
Hai He
Nile
Yellow
Indus
Yangtze
Ganges
Pearl
Niger
Mekong
Data source: Schmidt - Export of Plastic Debris by Rivers into the Sea (2017)

Export of plastic debris by rivers into the sea

- While ocean plastic remains a daunting problem, this could be good news for the quest to control it.
- A relatively few river catchments contributing the vast majority of the total load implies potential mitigation measures would be highly efficient when applied in the high-load rivers
- Reducing plastic loads by 50 percent in the 10 top-ranked rivers, would reduce the total river-based load to the sea by 45 percent.

Plastic waste transportation (waterways)

courtesy of the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia

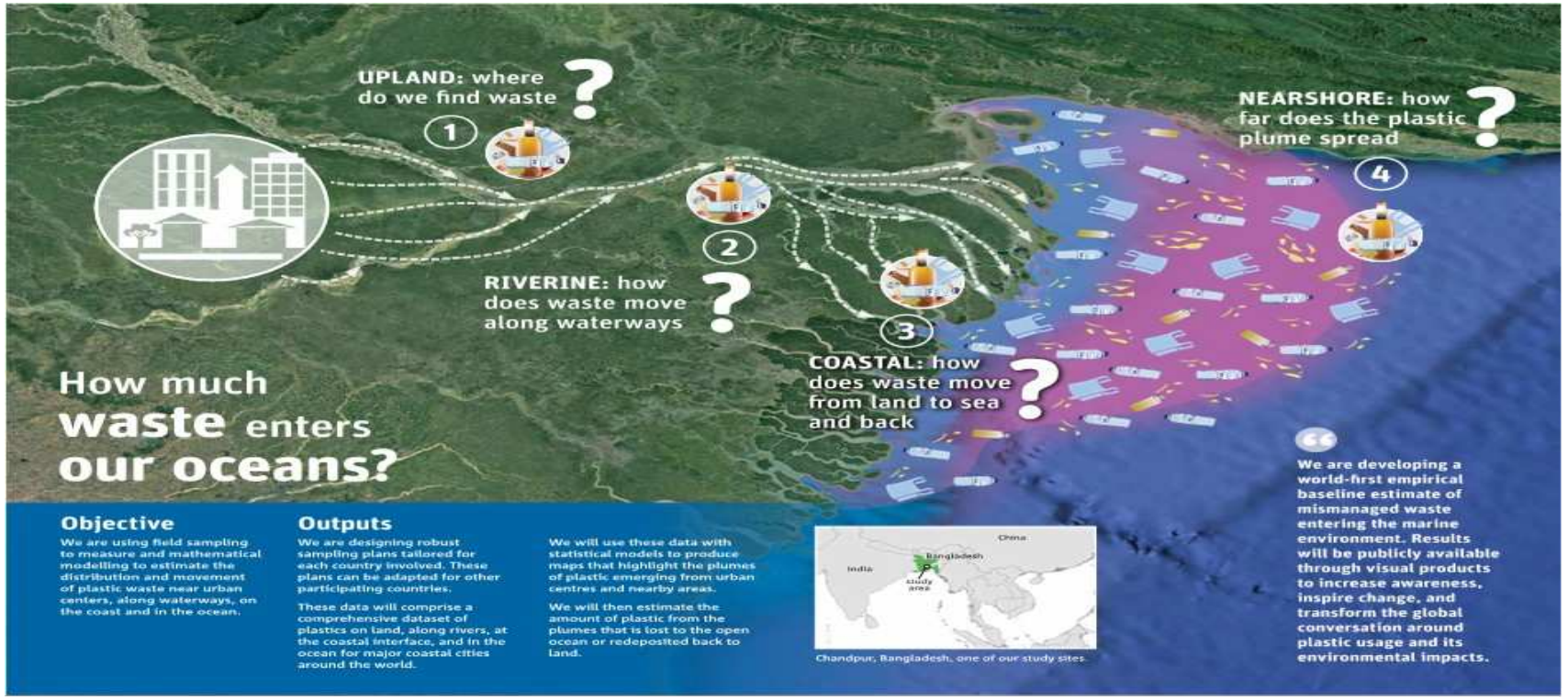

FIG Working Group 4.3 Mapping the Plastic

A joint initiative of
FIG Young Surveyors Network
FIG Commission 4 (Hydrography)

Academic Partners
University of Novi Sad (Serbia)
University of Banja Luka (Bosnia and Herzegovina)

With the support of
The FIG Foundation
Trimble

FIG YOUNG SURVEYORS

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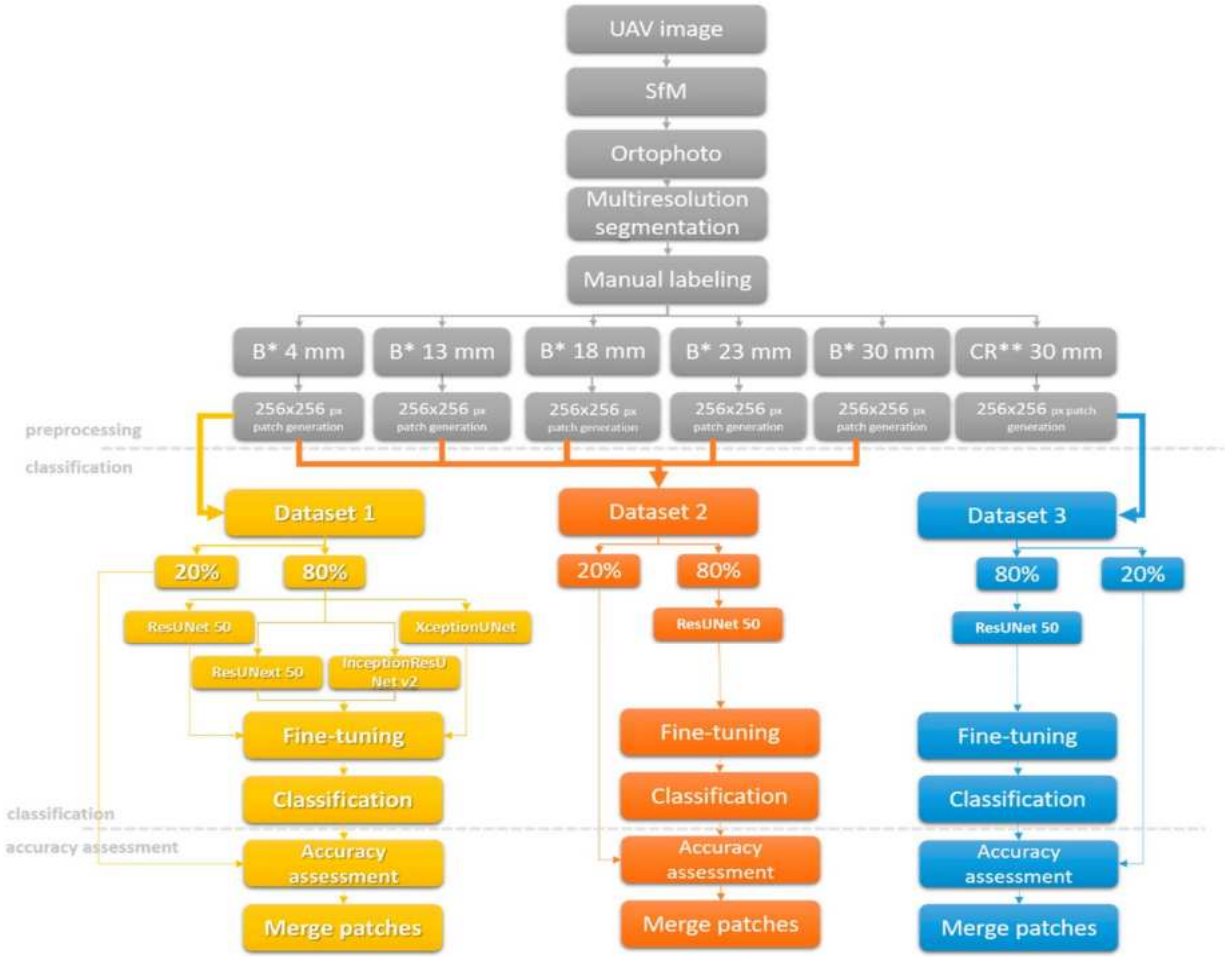
THE FIG FOUNDATION
Celebrating 20 years of Building a Sustainable Future 2001 - 2021

Pre-Processing methodology

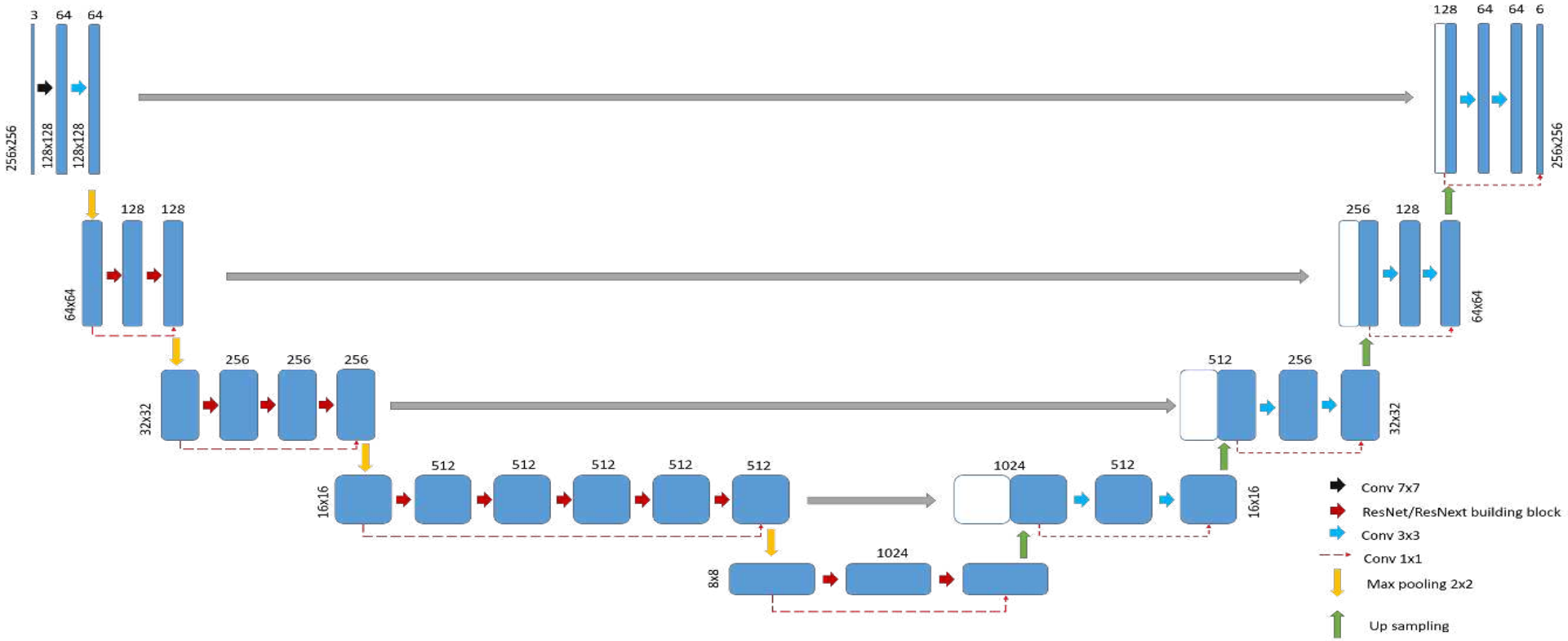
- Orthophotos are generated for each flight
- Lack of ground truthed data requires manual delineation and labelling of pixel classes
- Pixels then merged to obtain meaningful, non-overlapping polygons
- Each segment is manually labelled and classified
- Networks are trained using the cloud platform Google Colab
- Manual labelling will reduce over time as the plastic waste library grows


UAV image
SfM
Ortophoto
Multiresolution segmentation
Manual labeling
B* 4 mm
B* 13 mm
B* 18 mm
B* 23 mm
B* 30 mm
CR** 30 mm
256x256 px patch generation
preprocessing
classification
Dataset 1
Dataset 2
Dataset 3
20%
80%
ResUNet 50
XceptionUNet
ResUNext 50
InceptionResUNet v2
Fine-tuning
Classification
classification
accuracy assessment
Accuracy assessment
Merge patches

Classification process

- End to end semantic segmentation model used for plastic classification (floating and land based)
- Based on the U-Net deep learning architecture
- Widely used for the segmentation of remote sensing imagery, provides precise segmentation with little training data
- U-Net has a symmetrical encoder-decoder architecture
- The encoder extracts and abstracts the image pixel information
- The decoder extracts the plastic from the feature maps
- Four architecture models were tested for the extraction of plastic classifications during the trials
- ResUNet 50 architecture was found to have the highest detection accuracy of the classes tested

ResUNet 50 (deep learning) architecture

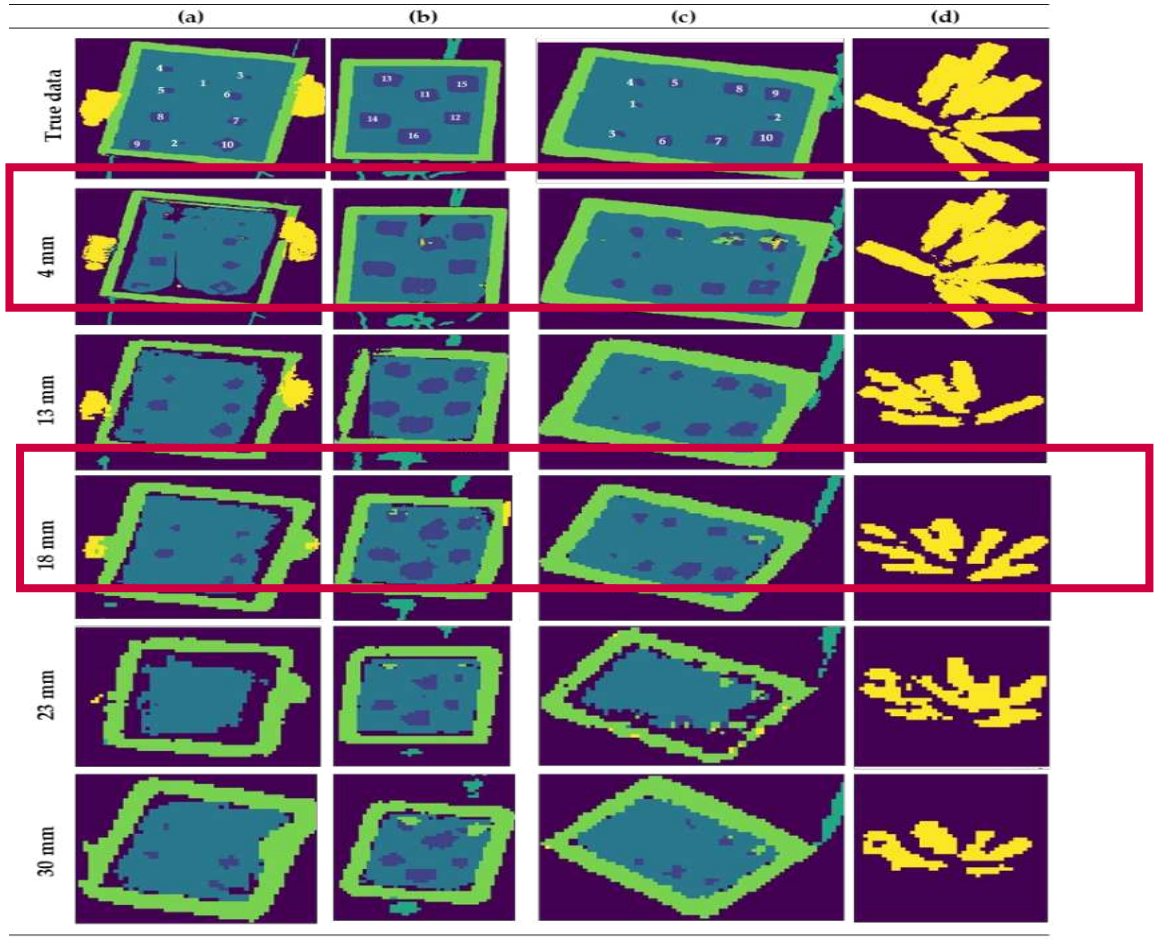


UAV plastic surveys – height vs spatial resolution

Flying height (m)	Spatial resolution (mm)	
	Balkana	Crna Rijeka
12	4	*
40	13	*
55	18	*
70	23	*
90	30	30

DJI mavic pro

Visual inspection of results – Area 1

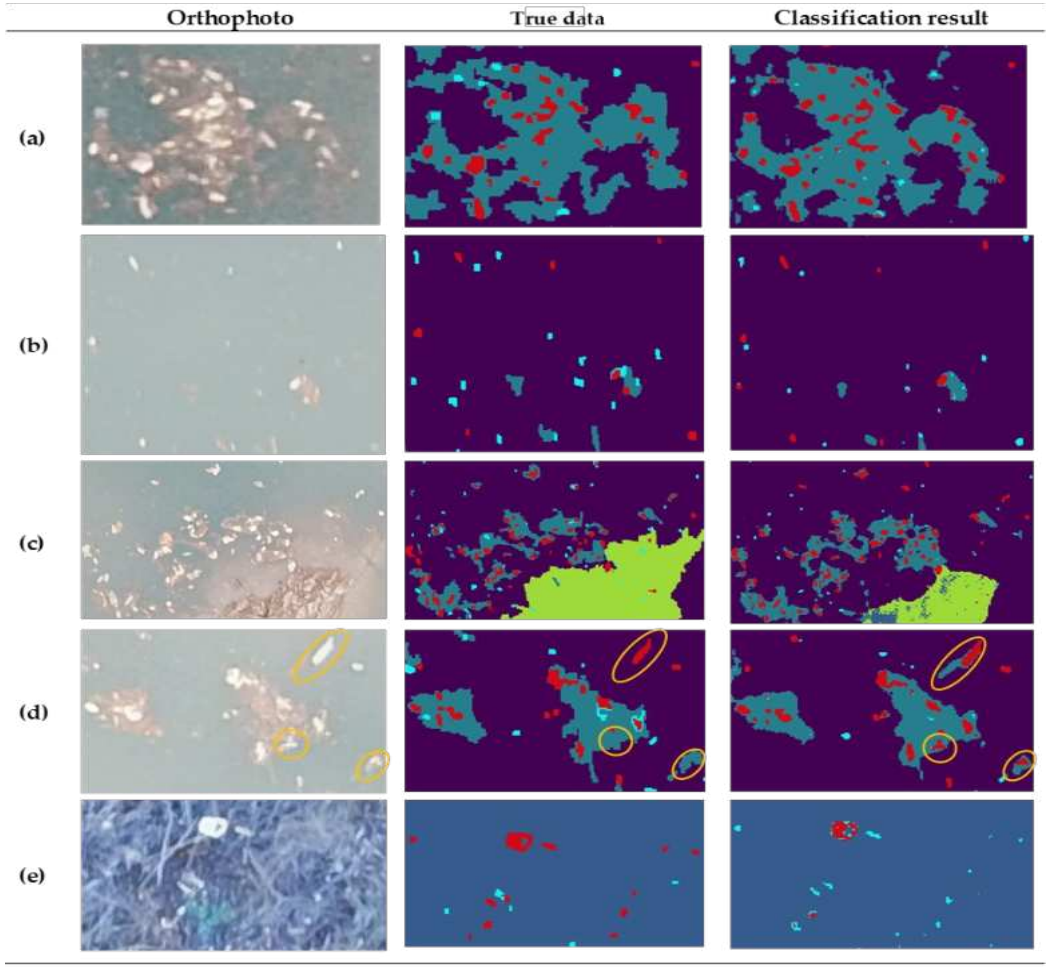


CSIRO
(1 cm²)

NOAA, OSPAR
(2.5 cm²)

Legend: water OPS gauze nylone wood PET

Visual inspection of results – Area 2



Legend: water OPS gauze nylone wood PET


plastic
wood


bootle
food containers
food packaging
other

The Plastics Problem in Ghana…

- > 2.5 million tonnes of raw plastic is imported into Ghana each year
- Ghanaians generate over a million tons of plastic waste each year
- Of which, < 5% is properly recycled
- A lack of the infrastructure to safely dispose of plastic waste means that the rest accumulates in the environment or ends up in landfill
- Approx. 30% of plastic waste ends up in the oceans
- Ghana ranks among the top 10 most polluted countries on earth, largely as a consequence of plastic waste

Source: Earth Care Ghana (https://earthcareghana.org/index.php/2022/03/23/plastic-waste-in-ghana/)

https://ctlinewsroom.com/wp-content/uploads/2019/05/Credit-fairplanet.jpg

© Thomas Müller/Greenpeace

Ghana's response…

Ghana has committed to tackling its plastics 'pandemic'

- In October 2019, it became the first African nation to join the Global Plastic Action Partnership
- Establishment of the Ghana National Plastic Action Partnership (NPAP) under MESTI
- In March 2022, Ghana endorsed the UN Environment Assembly resolution for a legally binding international agreement to end plastic pollution, including the marine environment, by the end of 2024
- The response work is ongoing, a 'citizen science' approach has been encouraged.

Korle Lagoon can be made clean in 5 years, says the Or Foundation

Thanks to YFM Ghana, April 18, 2023

National Plastic Action Partnership

An innovative collaboration between government agencies, experts, civil society, community organisations and the private sector to

- **Incentivise changes in material use**
- **Build capacity in waste management and recycling**
- **Enable innovation and technology transfer**
- **Raise awareness and changing behaviours to reduce the consumption of single-use plastics**
- **Promote gender equality and meaningful work, and**
- **Ensure transparent governance and accountability in the transition to a circular plastics economy.**

A Roadmap for Radical Reduction of Plastic Pollution in Ghana

Adopted on 6 December 2021, implemented under the NPAP. It envisages five key system change scenarios

1. **Reduce (30%) and substitute (10%) plastic usage year on year by 2040**
2. **Redesign plastic products and packaging for re-use or high value recycling - 5% of plastic produced to come recycled material by 2040**
3. **Increase plastic waste collection to 85% (realistic scenario) by 2040**
4. **Expand the recycling rate to 32% (realistic) by 2040**
5. **Build and expand controlled waste disposal facilities to control leaching of plastic waste**

NPAP - Enabling innovation and technology transfer…

- Working Group 4.3 Mapping the Plastic is FIG's response to the overwhelming and potentially catastrophic global plastic waste problem.
- We have successfully developed a method to detect, extract and classify floating and land-based plastic as small as 1cm^2 from UAV orthophotos using deep learning AI algorithms.
- The algorithms detect and differentiate plastic types found in oceans, waterways, riverbanks, coastlines, estuarine areas and on land.
- Waste classification can align with international marine litter assessment frameworks and can be adapted to meet other criteria.

NPAP - Enabling innovation and technology transfer…

- Plastic waste data is currently obtained from large-scale probability estimates or plastic litter surveys at localized coastal sites or along river banks
- Our solution enables comprehensive assessment of plastic waste at specific 'hot spot' locations quickly, accurately and relatively cheaply
- Repeat surveys offer effective monitoring of remediation work
- The plastics survey scope can be adapted to meet other environmental requirements.
- Requires a survey spec'd UAV (GNSS RTK, CMOS & RGB cameras) and suitably licenced pilot(s).
- DJI Phantom 4 RTK approx. cost NZ$ 10,000/GH₵ 80,273.

Korle Gono Beach Plastic Waste Survey 1 – preliminary results

- Undertaken by students from University of Mines and Technology, Tarkwa
- 18-23mm resolution range, giving a minimum plastic detection size approx. 3 cm^2
- Waste classification - Plastic and Non-plastic
- Initial plastic waste sub-classes – plastic bottles, food wrapping, food containers, plastic bags
- Extensive non-plastic waste classes detected including tyres and construction materials.
- This presents problems with training data – algorithms have not been trained on much of the waste surveyed.

Suggested considerations for UAV surveys to map plastic waste

1. High altitude, low resolution passes to identify the extent of the 'hot spot' location
2. Then low altitude, high resolution passes of the survey area to achieve optimal processing resolution
3. Delineation of an accurate algorthim training dataset. Research shows that a 12m flying height will enable detection of plastic waste as small as 1 cm^2
4. Analysis of the high resolution data (orthophotos) results
5. Back analysis of the low resolution data enables a better understanding of the accuracy of the low resolution 'hot spot' identification,
6. Thus, reducing future survey time.

Policy enablement through accurate mapping and ongoing monitoring

Oceans

- Marine debris (e.g., plastic)
- Coastal conservation and restoration
- Ocean governance and policy
- Climate change solutions with oceans benefits

Waste

- Phasing out single use and non-recycled plastics
- Waste management networks
- Water

Climate Change

- Land use
- Policy and Regulatory
- Adaptation and resilience for vulnerable communities/countries

remote sensing

an Open Access Journal by MDPI

CiteScore 4.89 SCOPUS

Impact Factor 4.118

CERTIFICATE OF ACCEPTANCE

Certificate of acceptance for the manuscript (**remotesensing-776433**) titled:
A Deep Learning Model for Automatic Plastic Mapping using UAV data

Authored by:
Gordana Jakovljevic; Miro Govedarica; Flor Alvarez-Taboada

has been accepted in *Remote Sens.* (ISSN 2072-4292) on 07 May 2020

MDPI Academic Open Access Publishing

Basel, May 2020

Available online: https://www.mdpi.com/2072-4292/12/9/1515