

# Coastal Ocean Environment School in Western Indian Ocean (COES-WIO)



COES-WIO 2025: 21<sup>st</sup> – 27<sup>th</sup> September in Mombasa, Kenya

A training report by Gabriel Akoko Juma



## Acknowledgement

The COES-WIO 2025 brought together experts in various facets of oceanography to enhance regional capacity among ocean professionals, early career researchers and students, following the successful implementation of COESSING in West Africa. It was funded by the USA National Science Foundation, with additional funds from the Capacity Development Facility (CDF) of the UN Decade of Ocean Science. The Ocean Teacher Global Academy of the IOC UNESCO provided the teaching platform for online sessions. In Kenya, the training was co-hosted by Technical University of Mombasa (TUM), Pwani University and the Kenya Marine and Fisheries Research Institute (KMFRI). Other partners included the Western Indian Ocean Marine Science Association (WIOMSA), Ocean Teacher Global Academy, Early Career Ocean Professionals (ECOP) Programme and Western Indian Ocean Early Career Scientist Network. As a result of this involvement with partners in the WIO region, COES-WIO has become a regional school drawing participants and resource persons across the WIO region and beyond. We express our appreciation to the organizers, the technical team and all the collaborators for their contribution, enabling the successful implementation of the activity.

## Funding agencies



## Collaborating partners



## 1. Introduction

Crosscutting learning and research is critical in the assessment and observation of the ocean environment. In depth knowledge on key topics such as coastal oceanographic processes, marine pollution, fisheries and data management help in gathering essential information for the conservation of marine biodiversity, navigation safety, marine spatial planning and the ocean resource management. Capacity development and training on use of simple sensors and machines has been identified as a tool to enhance ocean observation. Serving as the first COES-WIO training activity, this training was designed for Early Career Ocean Professionals (ECOPs), students and other oceanographers who intend to pursue different facets of oceanography and marine ecology. Different approaches were used including field work, interactive classroom lectures, group exercises, lab work, coding and presentations, which were used during the training, making it easy to relate, understand and apply the course concepts.

### Objectives of the training

- To enhance regional capacity in ocean science, especially among early-career professionals;
- To provide hands-on, practical training in key thematic areas of coastal and marine environmental research;
- To foster interdisciplinary collaboration and networking among ocean scientists, researchers, and policymakers across Africa;
- To promote the exchange of knowledge and best practices in sustainable marine resource management,
- To attract professionals from across the globe to work in partnership with the rich network in the WIO region, and
- To strengthen partnerships among academic institutions and research organizations within the WIO region.

To enhance content delivery among the various participant, the summer school had 5 hands-on project training tracks including:

- 1) Small-scale Fisheries, Mariculture and Post-harvest Management;
- 2) Chemical and Physical Oceanography;
- 3) Climate Change and Physical Processes;
- 4) Marine pollution and Plastics, and
- 5) Ecological Survey Techniques and Data Management.

These project tracks were designed and facilitated by both regional and international subject matter experts who were carefully identified during the planning phase. The project training tracks were selected to build the needed capacity in the WIO region amongst early career professionals, post-graduate and undergraduate participants.

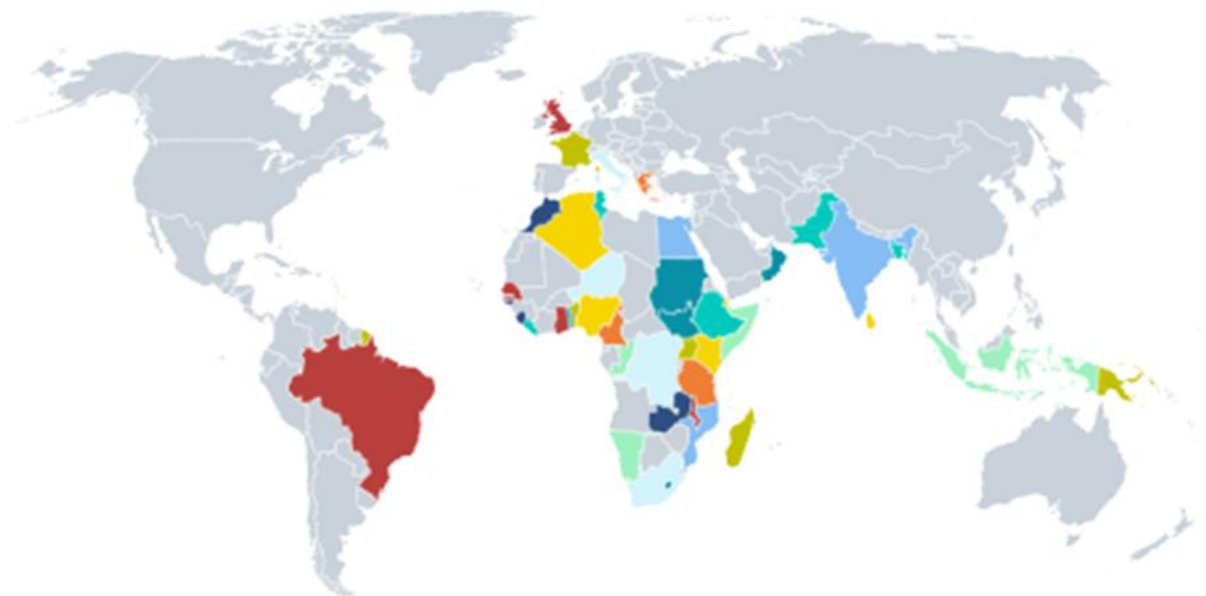
## Participants' demographics

### Target region

The training targeted students (Bachelors, masters, PhD), early-career researchers, and professionals in marine science and oceanography related fields including sectoral stakeholders and government officials from the WIO region. It targeted candidates from or studying/working in Somalia, Kenya, Tanzania, Mozambique, South Africa, Comoros, Madagascar, Seychelles, Mauritius and Reunion.

### Applicants' demographics

The application period was open for 15 days from 1st to 15th July 2025. Although we targeted 75 participants from the WIO region, we received 812 applications from over 45 countries (Fig1) globally. This reflected the growing demand for capacity development initiatives in ocean science. Among the applicants, 39% were female while 61% were males. Most of the applicants had obtained a Bachelors degree. Other levels of education obtained included Masters degree and PhD, while only less than 5% were undergraduates.



*Figure 1: Global map showing the distribution of applicants by country*

During the selection process, the applications were divided into five, based on the most preferred project track. The instructors for the respective tracks then evaluated and selected 15 participants based on the quality of the application. An additional 5 candidates were selected to the waiting list. The selection factored in a balance in the level of education, gender, and regional representation.

## Participants' demographics

A total of 78 participants were confirmed for the training. 48% were females while 52% of the participants were males. Although the 78 participants came from or worked in

the WIO countries (Fig. 2a), a greater proportion (58%) of the participants came from Kenya. This was due to the limited funding opportunities for travel. 15% of the participants came from Tanzania, 6% from Mauritius, 5% from Madagascar and the rest from the other countries (Fig. 2b). Apart from the WIO countries, we had a participant from France and Italy whose research activities had been conducted in the WIO region. 70 participants attended all the sessions and attained the requirements for obtaining the certificate. This reflected a 90% completion rate, likely due to the in-person approach.

Apart from the learners, the instructors were experts from the USA, Kenya, France, Ghana, Japan, Nigeria, Tanzania and Canada.

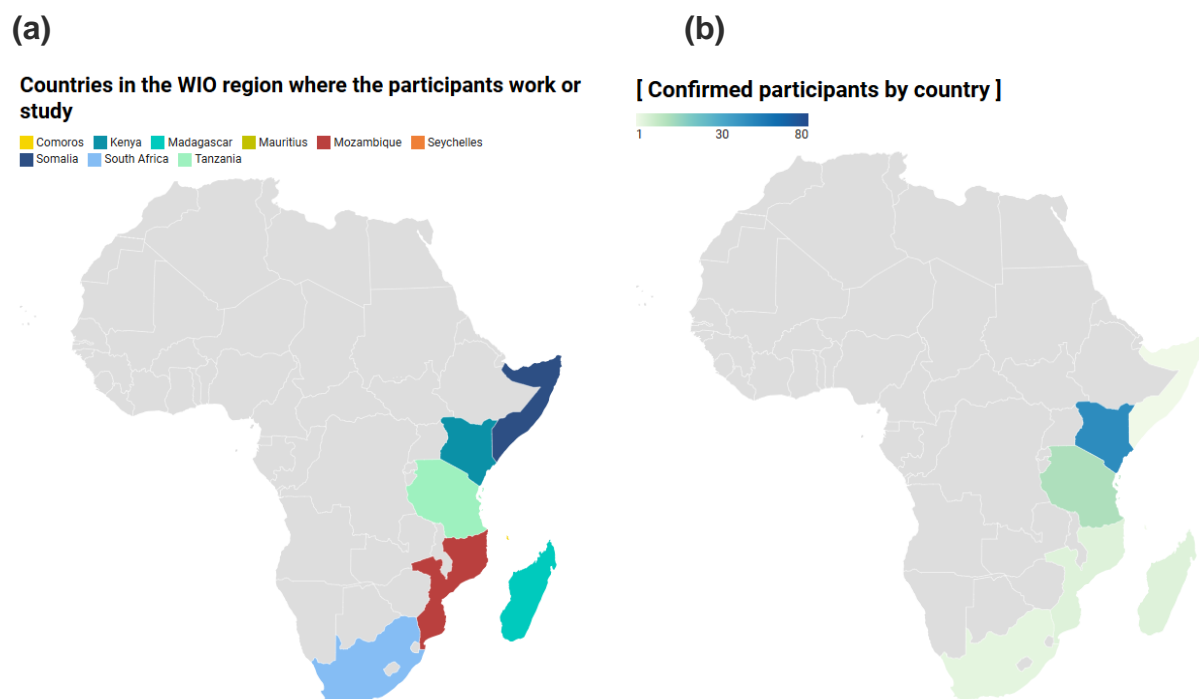


Figure 2: Map of Africa, showing the countries in the WIO region. (a) shows the target countries while (b) shows the distribution of participants. Most participants came from Kenya.

## 2. Key achievements/outcomes

The training was divided into five project tracks, each designed to progressively build participants' skills on the subject. The overview and learning outcomes of each project track is explained in the following sections:

### **Project track 1: Small-scale Fisheries, Mariculture and Post-harvest Management**

#### Overview

The Western Indian Ocean (WIO) region's coastal population is rapidly growing, with over 60 million people living along its coastlines, dependent on marine ecosystems for

their livelihoods and food security. This growing population is putting increasing pressure on the region's valuable coastal and marine ecosystems, such as coral reefs and mangroves. Most of the coastal population in the WIO rely on small-scale fisheries (SSFs) in addition to aquaculture/mariculture for livelihood, income, and food. SSFs create employment for many people involved in fishing, trading, and processing, particularly women. This sector however, experiences management challenges leading to overfishing and degradation of mangroves, seagrass beds and corals as critical habitats. In addition, SSFs face post harvest losses due to lack of appropriate fish handling and storage infrastructure. This course therefore, provided participants with an overview of the SSFs and aquaculture from production, sustainability and post harvest management focusing on the Kenyan experience.

Under small scale fisheries, the learners were taken through fisheries potential in Kenya, current status, challenges and threats as well as existing management strategies. In groups, the learners also described and grouped various fish species by habitat types and trophic level, using the FishBase. Under mariculture, the students were taken through global and regional mariculture production statistics, mariculture classification, culture systems and species and seaweed farming systems. The students were also taken through hands-on practical sessions on finfish culture techniques, crustacean culture techniques, live feed production and seaweed cultivation. Under post-harvest management, the learners were taken through post-harvest intervention, status of fish landing sites and value chain improvement, using the Kenyan coast as a case study.



*Figure 3: Participants in the Small-scale Fisheries, Mariculture and Post-harvest Management project track taking part in field practical session*

## Learning outcomes

By the end of the module, participants were able to:

- Understand the composition of SSFs and mariculture types in Kenya and the WIO region at large
- Understand post harvest management in the SSFs production
- Experience technological advances in mariculture production
- Apply scientific techniques in sustainability assessment of SSFs, mariculture production and post harvest management.



Figure 4: Participants learning about post-harvest management at KMFRI laboratory

## Project track 2: Physical and Chemical Oceanography

### Overview

This course introduced participants to the physical and chemical processes shaping estuaries and coastal systems, combining lectures, fieldwork, laboratory analysis, and ocean modelling. Using the Mkurumuji River estuary as a case study, participants learnt how tides, river flow, and mixing influence nutrient cycling, oxygen variability, and turbidity. The course also integrated field sampling with hands-on modelling using ROMS/CROCO and Python. It was designed to build capacity among Early Career Ocean Professionals (ECOPs) and students in the Western Indian Ocean (WIO) region to study, monitor, and manage estuarine and coastal environments.

## Learning outcomes

By the end of the module, participants were able to:

- Describe key physical processes (tides, river flow, mixing) shaping estuaries and coastal systems.
- Explain chemical and biogeochemical dynamics, including nutrient cycling, oxygen variability, and turbidity.
- Apply field sampling techniques to measure water quality parameters (salinity, pH, oxygen, nutrients).
- Analyze, interpret, and visualize estuarine field data.
- Run and visualize outputs from an ocean circulation model (ROMS/CROCO).
- Present group research findings linking field observations to model simulations.



*Figure 5: Participants in the physical and chemical oceanography project track at KMFRI Gazi Substation, during a field visit*

## Project track 3: Climate and Physical Processes

The Western Indian Ocean (WIO) region's shoreline is rapidly changing owing to the increase in coastal development and impact of climate change. With over 60 million people living along its coastlines dependent on marine ecosystems for their livelihoods and food security. This growing population on the coastline has put increasing pressure on the region's valuable coastal and marine ecosystems by converting coastal ecosystems into residential, industrial and port development among other developments, destroying coastal vegetation and exposing the coastline to tidal

surges and flooding. This has consequently enhanced erosion of the shoreline, destroying the coastal investment and affected the marine ecosystems with increased sediment loads. Anthropogenic factors such as construction of unsustainable engineering structures have altered sediment budgets, thus accelerating shoreline erosion rates. Climate change has exacerbated shoreline instability due to the increasing sea level rise and tidal surges. However, shoreline instability has received the least attention due to lack of data and information on the causes and sustainable interventions on the ever-changing shoreline. There are weak enforcement policies and regulations as well as conflicting policies on the shoreline management.

This module provided participants with an overview of the status of the shoreline change in the WIO region, with example case studies from Kenya, the causes and intervention in the wake of climate change impacts on the shoreline. It also provided first-hand experience of the shoreline and appreciated the need to provide data for sustainable management of the shorelines.

### **Learning outcomes**

By the end of the module, participants were able to:

- Understand type and nature of data and information that informs sustainable protection and management of the shoreline
- Establish the impact of the nearshore hydrodynamics due to climate change on exacerbating shoreline erosion in Kenya
- Experience and learn the effects of climate change and shoreline erosion through site visits to vulnerable shorelines in Kenya

### **Project track 4: Marine pollution and Plastics**

#### Overview

Marine pollution has emerged as a major environmental challenge in the 21st century, threatening ocean health, aquatic biodiversity, and human well-being. Covering over 70% of the Earth's surface, oceans play a crucial role in regulating the global climate, supporting fisheries, and maintaining biodiversity. However, increasing human activities have led to a significant rise in marine pollution, putting ecosystems and coastal communities at risk. This course introduced ECOPs, and other professionals involved in pollution management. The learners explored what marine pollution is, its main causes and effects, and the strategies to prevent it.

The different lessons taught in the project track include:

- Introduction to pollution
- General overview of plastic pollution
- Marine plastic pollution
- Non-plastic sources of marine pollution
- Field visits

During the field visits, in Diani beach, the students were able to collect macro plastic samples and characterize them according to types and potential sources.



*Figure 6: Participants of Marine and Plastic Pollution Project track participating in data collection in Diani beach*

## Learning outcomes

By the end of the course, the learners were able to:

- Familiarize with the scope of plastic pollution
- Understand how marine plastic pollution occurs and its effects
- Familiarize with strategies that can be adopted to prevent marine plastic pollution

## Project track 5: Ecological Survey Techniques and Data Management

### Overview

This specialized course served as an introduction to ecological data collection techniques, data processing, and analysis. Relevant biological, biogeochemical and environmental parameters were measured during field work. During the first online session, participants were introduced to various oceanographic parameters: temperature, salinity, turbidity, depth oxygen and chlorophyll. They were also taught how to develop research questions, sampling design and field work checklist. Additionally, they were taken through safety measures during field work. The participants were then introduced to R and Python during the remaining online

sessions, and were prepared to be able to undertake data analyses in the in-person part of the training.

During the in-person phase, the students were taken on a field excursion in Gazi bay and trained on seagrass carbon assessment, measurement of water quality parameters including salinity, turbidity, oxygen, conductivity, etc. and sample collection for determination of phytoplankton species diversity and abundance. In the lab, students were trained on sample processing, nutrient analysis and phytoplankton species identification. The participants then proceeded with data analysis using R and Python. They analysed OBIS data, own data or the data that was generated from the field sampling. Additionally, the participants were introduced to data from satellites and autonomous platforms such as the new array of Biogeochemical Argo floats. These datasets are freely available and open source, and the participants learnt to download and process the large datasets using Python. The results were presented during the closing day.

## **Learning outcomes**

By the end of the course, the learners were able to:

- Identify key coastal oceanographic parameters - Describe essential parameters like temperature, salinity, turbidity, depth, dissolved oxygen, and chlorophyll, and explain why they are essential in coastal studies
- Understand field sampling techniques - Familiarize with the methods and tools used to measure the parameters in a coastal environment, such as CTD devices, turbidity meters, and oxygen sensors.
- Prepare land and cruise expedition checklists - Develop data collection sheets, safety information sheets, and other logistical planning for field sampling.
- Get an introduction to the R and Python environment - Install and set the R and RStudio and Python environment, install the important packages, and understand the software environment
- Visualize data in R or Python software using the various packages - Learned how to build different plots and produce informative graphs from raw data.
- Conduct Simple analysis using R or python - In this lesson, the learners were taught to conduct normality tests on data, choose different significance tests, perform data transformations, and report results. The tests included univariate and multivariate statistics.
- Download and process large datasets from NASA Ocean Color and Biogeochemical Argo floats
- Arrange, store, export and share the data and figures
- Conduct results interpretation and discussion for scientific communication and writing



*Figure 7: Participants of Ecological Survey Techniques project track participating in a field training on seagrass carbon assessment in Gazi bay*

### 3. Challenges encountered

During the preparation and training phases, a few challenges were encountered including:

#### Logistical challenges

- Price fluctuation during flight booking for participants led to additional costs incurred and budget adjustments
- Very high number of applicants, requiring more time to conclude the selection process.
- Slight delays occasionally experienced during movement from TUM to KMFRI due to traffic
- Occasionally lower internet bandwidth at the training site
- Last minute cancellation of some participants calling for last minute invitations of participants in the waiting list.

#### Content related challenges

- Some students changed the project tracks leading to re-organization of the groups for practicals.
- The trainers for the Climate and Physical Processes Project track were not available for some of the sessions.

## **Coordination/administrative challenge**

- Change of the field site due to travel advisory

## **4. Impacts**

### **Short term impacts**

- Improved technical and analytical skills including the use of the various software and models among the students
- Increased scientific awareness and literacy, and enabling the learners to comfortably participate in field campaigns and internships.
- Collaboration and network built among the participating learners and instructors
- Improved confidence among learners, enabling continued knowledge sharing
- Generation of new data and information through the field surveys, practicals and modelling activities

### **Anticipated medium term to long-term**

1. Improved quality of research in the WIO region
2. Increased observation and field campaigns due to improved methodologies
3. New projects from collaborative funding mobilization

## **5. Lessons learned**

### What worked well and should be repeated

The scheduling of the training prior to the 13th WIOMSA Symposium worked well for a number of participants who had planned to attend the symposium. They proceeded to the symposium without having to incur additional travel expenses.

Inviting learners from the larger WIO region and experts from various institutions globally enhanced regional and international collaboration and networking. Discussions on potential research collaborations and capacity development activities were initiated.

### What did not work as expected and why

The OTGA platform was not adequately used by the different project tracks although it was expected that materials would be uploaded on the platform before the course commenced. This was partly due to the practical nature of some courses and content, supporting the in-person format.

### Recommendations for improving content design, logistics, facilitation and participant engagement

In the course feedback survey, the learners generally appreciated that their expectations were met, and that the course organization was good. Some students also highlighted the following recommendations:

Question: Do you have any recommendations for improving the content and the organization of the summer school?

“It would have been nice to have the course contents before the day of physical classes, not after. This is just a preference, not a critique on how it was done.”

“The theory session could have been further broken up into more days.”

“Maybe there be some prior online session more so on required software and packages installation”

“Small scale fisheries and Post harvest to be a single thematic area and Mariculture to be a stand a lone thematic area”

“More days need to be allocated to my project track, it is so huge in terms of content and should be divided into two. Fisheries and post harvest should be merged. Aquaculture should stand alone due since it is also huge in content and requires more time to deliver to the participants”

## 6. Next Steps/follow ups

### **Suggested actions for organizers, trainers at regional, national or thematic level**

The organizers agreed to submit the summer school activity for endorsement as Ocean Decade Activity. This will enhance visibility, collaboration and mobilization of financial resources.

The trainers also agreed to add the course materials on the OTGA platform for continued learning and referencing by the students.

### **Suggested actions for participants to increase their competencies**

- Continued application and practice using the software, methodologies and the techniques learnt during the training
- Continued teacher-learner and learner-learner discussions through the OTGA course forum and email.
- Organize similar training activities at the institutional level for other ECOPs and students, thereby enhancing their understanding of the subject.
- Participate in policy-focused initiatives about waste management, circular economy, and plastics policy frameworks.
- Join or collaborate with groups conducting beach surveys, microplastics sampling, and water column analyses.
- Apply and participate in research cruises, oceanographic surveys, fisheries sampling, data analysis workshops, or marine debris monitoring.
- Create outreach materials: infographics, videos, short articles to enhance science communication in the region and beyond.
- Apply for research project or collaborate in calls for research funding

- Join the COES-WIO alumni group for updates, announcements and mentorship opportunities

### **Plans for monitoring application of skills learned**

Through the alumni group, and the OTGA course forum, participants interact and share their insights and questions. There are also plans to on-board some of the learners to be instructors in the future training opportunities.

### **Future training opportunities**

1. COES-2026 in Tanzania with support from the US National Science Foundation.
2. COESSING 2026 in Nigeria with support from Schmidt Sciences
3. Research cruise training on-board RV Polastern from Mindelo in Carbon verde to Bremerhaven in Germany.
4. A training for ECOPs in Bruges, Belgium ahead of the WBMC in November 2026.

## **7. Annexes**

### **List of instructors**

1	Cosmas Munga	TUM
2	Ali Maarifa	PU
3	Brian Arbic	U-Michigan
4	Janae' Collier	U-Michigan
5	Eben Nyadjro	Mississippi State University
6	Richmond Q.	Plastic Punch, Ghana
7	John Walter	UNILAG
8	Audrey Delpech	CNRS France
9	Chenzhu (William) Xu	Oregon State University
10	Peter Knoop	U-Michigan
11	Tracey Schafer	U-Michigan
12	Gabriel Akoko Juma	Alfred Wegener Institute
13	Joseph Tunje	PU
14	Francis Mutuku	TUM
15	Saeed Mwanguni	TUM
16	David Mirera	KMFRI

- 17 John Mbugani UDOM
- 18 Clara R. Vives JAMSTEC (Japan), BioGeoSCAPES
- 19 Anthony Nzioka KMFRI
- 20 Peter Odote KMFRI-Associate
- 21 Frank Mirobo UDOM
- 22. Amon Kimeli KMFRI
- 23. Mariam Swaleh TUM

**COES-WIO 2025 Program Schedule**

Dates: 21st – 27th September 2025  
 Location: Mombasa, Kenya

Day	Time	Activity	Facilitator/Moderator
Sunday, 21st September	All Day	Participant arrivals and hotel check-in	All
Sunday, 21st September	6:30 PM – 9:00 PM	Welcome Dinner and Networking	Organizing Committee, TUM

Monday, 22nd September	9:00 AM – 11:00 AM	Official Opening Ceremony	Remarks by VC  DVC ARE (TUM) Partner speeches University of Michigan  Pwani University  KMFRI  WIOMSA  IOC UNESCO  ECOP
		Entertainment	Opening cultural performance (student choir or local group)
	11:00 AM – 11:30 AM	Tea/Coffee Break	All
	11:30 AM – 11:45 AM	History of the school	Brian
	11:45 AM – 12:30 PM	Meet the Facilitators & Track Introductions - Lightning talks from instructors - Course overview and logistics	Track Leads (All Instructors)
	12:30 PM – 2:00 PM	Lunch	All

	2:00 PM – 5:00 PM	Classroom Session 1	Track Facilitators
	5:00 PM – 5:30 PM	Tea/Coffee Break	All
Tuesday, 23rd September	9:00 AM – 12:30 PM	Field Excursion 1 - Site visits based on project tracks  - Data collection, community interviews, field observations	Track Facilitators
	12:30 PM – 2:00 PM	Lunch	All
	2:00 PM – 5:00 PM	Field Excursion 1 - Site visits based on project tracks - Data collection, community interviews, field observations	Track Facilitators
	5:00 PM – 5:30 PM	Tea/Coffee Break	All
Wednesday, 24th September	8:00 AM – 4:00 PM	Field Excursion 1 - Site visits based on project tracks - Data collection, community interviews, field observations	Track Facilitators

	5:00 PM – 6:00 PM	Group Reflection and Debrief	Facilitators
		Dinner at accommodation	All
Thursday, 25th September	8:00 AM – 2:00 PM	- lab  -data analysis	Track Facilitators
	4:00 PM – 6:00 PM	Classroom Session 4  Data analysis and reporting	All
	Evening	Dinner at accommodation	All
Friday, 26th September –	8:00 AM – 10:00 AM	Presentations	Students
	10:00 AM – 10:30 AM	Tea/Coffee Break	All
	10:30 AM – 12:30 PM	Closing Ceremony / feedback  Certificates awarded	
	12:30 PM – 2:00 PM	Lunch	All
	2:00 PM – 5:00 PM	Wrap up/ graduate school	

	7:00 PM – 12:00 AM	Farewell Dinner	TUM & Partners
Saturday, 27th September – Departure	All Day	Participant check-out and departure	—