PILOTING A REGIONAL EARLY WARNING SYSTEM FOR INCREASED RESILIENCE IN THE LAKE VICTORIA REGION
Stories of success

PILOTING A REGIONAL EARLY WARNING SYSTEM FOR INCREASED RESILIENCE IN THE LAKE VICTORIA REGION
FOREWORD

The Lake Victoria Basin is the lifeblood of East Africa, supporting approximately 25% of the region’s population. Lake Victoria hosts Africa’s largest inland fishery; it produces about 1 million tonnes of fish annually, employs over 200,000 fisherfolk and generates over US$ 500 million annually in exports. Over 30 million people live near the lakeside, with 1,400 landing sites or beaches from which 50,000 boats operate. Before the HIGH impact Weather Lake System (HIGHWAY) project, on average, 3,000–5,000 deaths occurred on the lake each year due to marine accidents caused by strong winds and waves. No regional, operational early warning systems existed to protect the health and safety of those navigating and exploiting the natural resources of the Lake Victoria Basin.

The HIGHWAY project supported regional cooperation among the National Meteorological and Hydrological Services (NMHSs) of Kenya, Rwanda, Uganda and the United Republic of Tanzania. The project strengthened professional relationships and trust among key NMHS staff in the countries through a shared sense of common purpose. The enhanced collaboration has resulted in a regionally harmonized set of marine weather forecasts covering the whole of Lake Victoria. The forecasts are issued twice daily, at the same time, and are easy for fishing communities to understand and use.

This document comprises stories of success from the HIGHWAY project and its partners. The stories highlight activities that have led to improved livelihoods of those in lakeside communities, and that have high potential for replication and scale-up. The stories demonstrate strengthened institutional frameworks, improved access to data sources, strengthened integration between producers and users, and strengthened capacities of NMHSs. This endeavour adds value to fieldwork by capturing and disseminating knowledge that promotes, targets and optimizes public investments in early warning systems for vulnerable communities.
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MEETING THE FORECASTING NEEDS OF FISHING COMMUNITIES

Fishing communities on Lake Victoria need to receive accurate and timely weather forecasts prior to fisherfolk heading out onto the water. Such forecasts can help to reduce loss of life and economic losses due to boat damage.

The HIGHWAY project assisted NMHSs in the Lake Victoria Basin to develop forecasts for fisherfolk based on user needs identified. A co-design method was used to create accurate, timely and understandable forecasts to ensure uptake from local communities around the lake.

CO-DESIGNING FORECASTS

Interviews and focus group discussions were held with local fishing communities. Government officials responsible for fisheries and marine safety were also interviewed, and talks held with radio stations popular in lake shore and island communities.

These revealed fisherfolk need daily forecasts with accurate weather information such as wind speed and direction that highlight when severe weather is expected. The consultations also made clear that fisherfolk need weather information in their local language before the start of each fishing trip in order to plan their route and decide what precautions to adopt.

Initial templates developed were refined in conjunction with fisherfolk and government and media representatives at a series of co-design workshops.

The workshops developed simple impact-based definitions of the terms used to describe marine weather that fishing communities could relate to easily. For example, “strong wind”, defined in meteorological terms as 41–60 km per hour, was described as: “The wind causes large trees to sway. It is strong enough to cause large waves and makes navigation conditions difficult for small boats.”

The workshops also finalized the design of visual weather icons used to illustrate the forecasts. A list of practical advice messages for small boat users was drafted. These messages are often published alongside severe weather warnings.

PRODUCING FORECASTS AND HELPING TO SAVE LIVES

The co-design process led to similar marine weather forecasts appearing in areas of Kenya, Uganda and the United Republic of Tanzania. Each country divides its part of the lake into different marine forecasting zones. Their NMHSs divide their forecasts for each zone into 6 hour time periods. In all three countries, the marine forecast gives information about wind speed and direction, wave height, rainfall, visibility and high-impact weather expected.

The first forecast of the day goes out in early morning before the day fisherfolk and transport canoes leave their landing sites. The second forecast is published in mid-afternoon before the night fisherfolk depart.

Field research shows high levels of awareness and use of the forecasts in fishing communities – particularly in Kenya and Uganda, where they are widely broadcast by radio stations.

Robert Bakaaki, a national fisherfolk leader in Uganda, who operates fishing boats and fuel supply boats on Lake Victoria, said: “The forecasts are always timely, accurate, reliable and easily understood. They help me plan my daily activities... minimizing fuel costs and eliminating potential risks and dangers to both my crew and my boats.”

A 24-hour forecast for the Buvuma and Northeast marine zone in Uganda with an orange “be prepared” warning. The weather icons and colour shading enable fishermen to understand the forecast information easily, even if they cannot read English.

Across Lake Victoria as a whole, the forecasts produced have helped to reduce drownings by about 30%, thus saving hundreds of lives each year. They have also led to an estimated US$ 44 million of financial benefits from money earned or saved by taking action in response to weather forecast information.
The radio stations, keen to attract strong audiences, ensure listeners get vital information about weather conditions on the lake when they need it most – before the boats leave their landing sites in the early morning and late afternoon.

**Presenter Benjamin Benda Okoch on Bulala FM in Kenya airs the forecast bulletin for fishing communities. Photo: Samuel Gatei**

**WORKING TOGETHER WITH RADIO STATIONS**

Right from the start, the HIGHWAY project identified the most popular local radio stations in fishing communities and involved them in the co-design process of the forecast bulletins. Radio station participation ensured the forecast bulletins were easy for radio journalists to understand and interpret. HIGHWAY also trained radio station personnel how to use the bulletins most effectively.

Such media training workshops were held in Kenya and Uganda for 20 radio stations that broadcast to Lake Victoria fishing communities. At each workshop, weather forecasters and fisherfolk leaders joined the journalists to help create concise bulletins in local languages that contained all the essential weather information needed by listeners.

**REACHING FISHING COMMUNITIES**

More than 50 local and regional radio stations now broadcast to lakeside and island communities in Kenya, Uganda and United Republic of Tanzania. As the HIGHWAY project was drawing to a close, half of them were carrying the twice-daily forecast bulletins for fisherfolk.

Field research in Kenya and Uganda showed more people are receiving the marine forecast bulletins by local radio than any other means. It found strong awareness of the forecasts in nearly all fishing communities in those countries.

Kenyan and Ugandan fishing communities know the forecast bulletins are available at fixed times on at least two or three local radio stations that they can listen to clearly. They also know the weather information will be delivered in local languages such as Dholuo, Kinyala, Luganda, Lusoga and Suba.

David Agangu, a presenter on Nam Lolwe FM in Kisumu, Kenya, said: “The information that is being sent to us by the Kenya Meteorological Department ... is in simple language. This makes it easy for us to understand and for me as a presenter to do the translation in order to transmit it in my local language. The illustrations which accompany the text ... help us to broaden our explanation to the listener.”

Agangu also said large companies that target farmers and fisherfolk now insist their adverts on the station are aired a few seconds before or after each weather forecast. “This has added some revenue to our station,” he said.

Translation of the forecasts into local languages was not required in the United Republic of Tanzania since TMA publishes its forecasts in Swahili, the language spoken fluently by nearly all Tanzanians.

Jimmy Kagaruki, a presenter on Jembe FM in Mwanza, United Republic of Tanzania, said listeners often comment on the high accuracy of TMA forecast bulletins for fishing communities. “Many of our listeners conduct their daily activities on the lake and this kind of information is very crucial as it saves their lives,” Kagaruki said.

Radio stations are happy to broadcast the forecast bulletins twice a day or even more frequently, because they know accurate weather information is important for their listeners and will attract strong audiences. At least two HIGHWAY partner stations have managed to attract commercial sponsorship for their marine weather bulletins.

NMHSs can disseminate their forecasts through radio station broadcasts. This is done free of charge, to millions of people in lakeside and island communities, in local languages and in a timely manner.
Ownership of smartphones within the fishing communities on Lake Victoria is increasing rapidly. At each landing site, there are at least two or three people who own a smartphone and often several dozen. Many fishing communities now have their own WhatsApp groups, which provide a valuable way of disseminating weather information to friends, colleagues and neighbours.

The HIGHWAY project harnessed the Internet to send marine weather forecasts and severe weather warnings directly to the smartphones of interested individuals and fisherfolk in the Lake Victoria region by WhatsApp.

**USING SOCIAL MESSAGING**

Many development projects have used SMS text messages since the early 2000s to communicate important information to mobile phone users. But WhatsApp allows more information to be sent in each message, and it is much cheaper to operate. These factors make WhatsApp more attractive than SMS and more financially sustainable.

In addition, PDF files attached to a WhatsApp message can communicate much more weather information than a 160-character SMS. They can also convey information using images such as weather icons and maps. And there are no transmission charges. Senders and receivers of WhatsApp messages simply need an active Internet connection on their phones to exchange information.

The HIGHWAY project therefore chose East Africa’s most widely used social messaging app – WhatsApp – to send marine weather forecasts for Lake Victoria to fishing leaders, community intermediaries at landing sites, radio journalists, government officials and other interested individuals.

**COMMUNICATING INFORMATION**

As well as receiving the information themselves, many recipients instantly forward the forecasts to dozens of people in other WhatsApp groups to which they belong. This cascades the weather information rapidly to thousands more people.

For example, whenever UNMA issues a severe weather warning for Lake Victoria, Willy Lugoloobi, the Chair of Kalangala District Council, forwards the message immediately to more than 500 people in the Ssese Islands through his own WhatsApp groups.

Some people who receive forecasts by WhatsApp also pass on the information by other means. Radio journalists broadcast weather forecast bulletins at fixed times on the radio. Community intermediaries call meetings to share the latest forecast with their neighbours. In some cases, they raise a warning flag if severe weather is expected.

Forecast recipients often send short text and voice messages back to the forecasting office. They also send in photos and video clips of the weather and ask questions. This lively dialogue has proved highly motivating for forecasters. Most had never previously spoken directly with people who use their bulletins. It also helps enormously with forecast verification.

Julius Kiprop, a HIGHWAY project focal point said: “The use of WhatsApp has increased user confidence in the weather information. Users can tell us what they think and know they will get an instant response. People even call us to request bulletins they have missed. The feedback on WhatsApp has meanwhile given UNMA forecasters a better understanding of the fishing community and how it uses the forecasts.”

NMHSs have also found WhatsApp useful for disseminating many other types of information of interest to lakeside communities. These include national severe weather warnings, seasonal forecasts, information about the movement of locust swarms and even advice on how to keep safe from Covid-19.

David Birimuye is a community intermediary on Buvu Island in Uganda who receives the Lake Victoria forecasts by WhatsApp on his smartphone. David owns and operates a loudspeaker system at the landing site known as the “community radio”, and broadcasts each bulletin loud and clear to all 3 000 people in the village.

David earns money by charging other people to use his loudspeaker system to make announcements, but he broadcasts the forecasts for free as a public service.

Using WhatsApp helps fishing communities to receive weather forecast information in a timely manner. In return, forecast users also give immediate and spontaneous feedback, which aids verification.
Being Africa’s largest lake by area, Lake Victoria is divided among three countries: Kenya, Uganda and United Republic of Tanzania.

The HIGHWAY project helped these three countries to produce a regionally harmonized set of marine weather forecasts covering the whole of Lake Victoria. These are issued at the same time, twice a day, and are easy for all fishing communities to understand and use.

**CO-DESIGNING REGIONAL FORECASTS**

Frequent consultation among NMHSs of the three countries led to a natural convergence in the format and content of the forecasts developed and the timing of their dissemination.

At a HIGHWAY regional meeting in 2019, the three NMHSs agreed to divide Lake Victoria into 10 standard marine forecasting zones. Most of these are cube-shaped areas of coastline, islands and open water measuring roughly 100 km by 60 km, although some are much smaller.

Kenya was the first of the three countries to design a forecast for fishing communities. KMD revived and enhanced a pilot forecast for Kenyan fisherfolk on Lake Victoria that was published between 2016 and 2017, and increased its frequency of publication to twice daily.

Kenya’s experience subsequently informed the co-design of a similar forecast in Uganda. The United Republic of Tanzania then benefited from the experience of both its neighbours when designing its forecast for fisherfolk.

As a result, all three countries use the same standard terms to describe marine weather conditions on Lake Victoria and the same set of visual weather icons.

**PRODUCING AND COMMUNICATING FORECASTS**

Each country issues two marine forecasts per day: one in the early morning for day fisherfolk and transport craft, and one in the afternoon for night fisherfolk. These bulletins forecast wind speed and direction, wave height, sky conditions and visibility for each zone of the lake.

All the forecasts carry severe weather warnings when appropriate. These are highlighted by a three-colour traffic light system that describes the conditions expected during each 6 hour period.

Green means “business as usual”, no severe weather expected. Orange means “be prepared”, severe weather is likely. Take special precautions if you go out on the lake and seriously consider postponing your voyage. Red indicates “extreme danger”, very severe weather. It warns boats to remain onshore or head immediately for shelter.

A daily teleconference involving forecasters at KMD, TMA and UNMA ensures these warnings are mutually agreed and well coordinated.

The forecasting offices of all three NMHSs then share their published forecasts for Lake Victoria through a WhatsApp group. The Lake Victoria forecasts are also shared across borders at the user level. Nearly 100 fisherfolk in Kenya’s Busia County on the Ugandan border receive UNMA marine forecasts for the Ugandan sector of the lake. KMD forwards UNMA bulletins to them through the same WhatsApp group that it uses to disseminate its own marine forecasts to Busia County.

Regional harmonization of the marine forecasts for the Lake Victoria Basin has made it easier for fishing communities to understand and follow them.
Lakeside and island communities around Lake Victoria widely trust the marine forecasts for Lake Victoria created through the HIGHWAY project.

This is because the communities regard the forecasts as being locally accurate for the waters around each landing site.

ENSURING THE FORECASTS ARE LOCALLY ACCURATE

Three factors have helped to ensure the forecasts are locally accurate.

First, the three countries surrounding the lake divide it into 10 marine forecasting zones. Detailed forecasts are issued for each zone.

Second, the 24 hour forecast for each zone is divided into four 6 hour periods. This enables forecasters to predict with a strong degree of confidence when weather conditions are likely to change during the course of the day. If strong winds, high waves, heavy rain or widespread thunderstorms are expected, the forecasts say precisely where and when such high-impact conditions are likely to occur.

Third, Kenya, Uganda and United Republic of Tanzania NMHSs all update their marine forecasts at 12 hour intervals. This ensures fishing communities can always get the most up-to-date weather information before boats leave the landing site in the early morning and late afternoon.

TRUSTING THE FORECASTS

Focus group discussions at landing sites in all three countries found most participants consider the marine forecasts are accurate on about 5 days out of 7 in a week. This gives a perceived accuracy rate of about 70%.

Field research showed that if rough weather is forecast, people venturing out onto the lake in small boats often take special precautions. These include wearing life jackets from the moment they leave the landing site, staying close to the shore and carrying extra fuel for outboard motors in case of problems. In many cases, forecast users simply postpone their trip to await calmer and safer conditions. These factors have helped to reduce the number of drownings.

The forecasts are appreciated by those who travel in boats on the lake. They have also proved useful to people engaged in many other kinds of activity. For example, fish traders who buy and dry silver fish (Rastrineobola Argentea) are keen to know whether any rain is coming. Rain causes the small fish that they spread out in the sun to dry to get wet and rot.

Many fisherfolk are also subsistence farmers. Field research in Uganda found that some people in the Ssese Islands were also using the forecasts to help plan their farm work as well as their fishing trips.

Kalangala Infrastructure Services, the local electricity and water supply company on the Ssese Islands, regards the forecasts as so important that it disseminates them to all its 70 employees by WhatsApp. The company is particularly on the lookout for severe thunderstorms that may cause cuts in the electricity supply.

Several hotels in the Ssese Islands meanwhile use the Lake Victoria forecasts to help plan outdoor activities for their guests.

Fishing communities trust and use the marine forecasts for Lake Victoria because they are perceived as being locally accurate. This strong trust in the twice-daily forecasts has made people confident about using the weather information to plan fishing trips and other journeys in small boats.

The high level of trust in the forecasts also means users take severe weather warnings seriously whenever they are issued.
The HIGHWAY project helped to enhance meteorological observations in the Lake Victoria Basin and to develop new tools for improving the accuracy of severe weather forecasting in the region.

Together, these initiatives have improved the accuracy of marine forecasts for fisherfolk and other small boat users on Lake Victoria.

ENHANCING OBSERVATIONS
Several manual and automatic weather stations for recording observations situated around Africa’s largest lake have been rehabilitated and some new ones added.

In addition, HIGHWAY funded the resumption of regular weather balloon launches to conduct upper air soundings at Lodwar and Nairobi in Kenya. The project also made financial provision for regular balloon launches to resume at Dar es Salaam in the United Republic of Tanzania and Entebbe in Uganda.

A separate initiative optimized the use of weather radars at Kigali, Entebbe and Mwanza. This enabled Rwanda, Uganda and the United Republic of Tanzania to improve forecasting of thunderstorms and heavy rainfall over the Lake Victoria Basin.

The radars also help to verify the accuracy of forecasts after they have been issued. Subsequent scans show exactly which areas were affected by rain and thunderstorms and which were not.

HIGHWAY helped to recalibrate the weather radar at Kigali to improve the accuracy of data. It also financed repairs and the purchase of spare parts for the weather radar at Mwanza, at the southern end of Lake Victoria.

TRAINING FORECASTERS
The HIGHWAY project’s partner in the United States of America – UCAR – meanwhile provided weather radar training for forecasters from several NMHSs.

Its training for TMA in 2019 was combined with the creation of a data link with the TMA Central Forecasting Office in Dar es Salaam. This enabled TMA forecasters to use real-time data from the Mwanza radar for the first time.

UCAR subsequently trained forecasters of UNMA how to use data from the new weather radar at Entebbe, which was installed in 2020.

The Uganda training was delivered online because of travel restrictions imposed by the Covid-19 pandemic, so forecasters from Kenya, Rwanda and the United Republic of Tanzania were able to take part in it as well.

DEVELOPING NEW TOOLS
Several new forecasting and data visualization tools were developed or made available for deployment in East Africa with assistance from the HIGHWAY project. These were mostly aimed at improving the nowcasting forecasting of thunderstorms by tracking their formation and development. However, at the end of the HIGHWAY project, few were ready for deployment.

One initiative that had an immediate impact on forecasts for the Lake Victoria region was the enhancement of the Tropical Africa forecasting model of the Met Office, United Kingdom of Great Britain and Northern Ireland. Kenya, Uganda and United Republic of Tanzania NMHSs extensively use this model.

The Met Office improved the grid definition of its Tropical Africa model to squares of 4.4 km from squares of 10 km previously. This improved the model’s ability to pinpoint convection and forecast the development of thunderstorms. Paul Oloo, the HIGHWAY focal point at KMD, said this had been a big help to Kenyan forecasters.

The improvement of meteorological observations and the development of new forecasting tools has contributed to greater forecast accuracy in the Lake Victoria region.
Much of the practical collaboration among the East African countries surrounding Lake Victoria achieved through the HIGHWAY project was the result of informal voluntary cooperation. This gave immediate results, while new statutory arrangements were negotiated more slowly at the intergovernmental level.

**PROMOTING COLLABORATION AND COOPERATION**

The HIGHWAY project stimulated informal collaboration through the establishment of personal relationships and trust among key individuals in Kenya, Uganda and United Republic of Tanzania NMHSs.

The frequent regional meetings and trainings organized by HIGHWAY encouraged networking and the informal discussion of regional cooperation in practical terms. The project also fostered the establishment of institutional goodwill and a shared sense of common purpose.

Daily consultations were established involving KMD, TMA and UNMA to align the early warning service content of their marine forecasts for Lake Victoria. These discussions were conducted through an existing daily conference call to coordinate severe weather forecasting in East Africa as a whole.

**PRODUCING OUTCOMES**

Consultations between KMD, TMA and UNMA at a regional meeting in 2019 led to the division of Lake Victoria into 10 mutually agreed forecasting zones.

Another important outcome was that Kenya, Uganda and United Republic of Tanzania NMHSs learned from each other how best to develop and communicate marine forecasts for artisanal fisherfolk and other small boat users. The three NMHSs voluntarily coordinated the design, production and publication of their twice-daily marine forecasts for Lake Victoria.

UNMA learned from the KMD experience of co-designing a marine forecast with local fisherfolk. It produced a weather forecast bulletin similar in form and content to its Kenyan counterpart. TMA subsequently drew on the Kenyan and Ugandan templates when it re-versioned its daily forecast for commercial shipping on Lake Victoria into a twice-daily forecast for fisherfolk.

In return, TMA shared its wave height forecasting model for Lake Victoria with KMD and UNMA. This model is now used to forecast wave heights for fisherfolk and other small boat users on Lake Victoria in all three countries.

Together, these initiatives led to a seamless set of similar marine forecasts covering the whole of Lake Victoria. All three services use the same language and weather icons to describe weather and wave conditions. They also forecast the weather for each zone of the lake in 6 hour periods and use the same three-colour code to describe the weather conditions during each period.

Informal collaboration among the three NMHSs also took place at the technical level. When KMD received a first consignment of new radiosondes, it invited TMA technicians to Nairobi to learn how to use the equipment. Radiosondes are attached to balloons. They beam back measurements of weather conditions in the upper atmosphere as the balloon rises. Kenya was able to reactivate its use of radiosondes before the United Republic of Tanzania, and was happy to share its knowledge.

Links established through HIGHWAY also enabled meteorologists from Kenya, Rwanda, Uganda and United Republic of Tanzania to collaborate in writing a study of the socioeconomic impacts of extreme rainfall in East Africa, which was published online in 2020.1

The above successes were achieved smoothly and without fuss because they did not require any external authorization. Neither was there a requirement to overcome technical challenges or set aside special budgets.

**STORIES OF SUCCESS — 07**


NMHSs of the three countries surrounding Lake Victoria have enhanced regional cooperation through several voluntary and informal initiatives.
In addition to improving weather forecasting for the Lake Victoria Basin, the HIGHWAY project has also laid the foundations for an ambitious early warning service covering the whole of East Africa.

It has assisted EAC to shape Vision 2025 – a regional strategy for coordinating severe weather warnings throughout the six EAC member States.

VISION 2025

EAC ministers approved Vision 2025 in 2019, and all six EAC NMHSs endorsed an implementation plan in 2020.

Within five years, Vision 2025 aims to create a statutory framework for coordinating high-impact weather alerts to vulnerable communities throughout Burundi, Kenya, Rwanda, South Sudan, Uganda and United Republic of Tanzania. It will cover an area much wider than the Lake Victoria Basin.

The Democratic Republic of the Congo, whose eastern regions have strong economic and cultural links with East Africa, has applied to join EAC, so it may also become a participant in Vision 2025.

The HIGHWAY project helped EAC to draw up this £19.1 million (US$ 25 million) investment plan. Donor funding to finance it was still being sought as the project drew to a close in early 2021.

The investment plan provides for the installation of new automatic weather stations, on land and on weather buoys installed in East Africa’s Great Lakes.

It also foresees improved access to satellite information, greater use of numerical weather prediction in weather forecasting, better telecommunications links to share data and specialist training for forecasters.

Vision 2025 builds upon the enhanced regional cooperation among NMHSs in East Africa that was achieved through the HIGHWAY project.

It also follows a decade of regional cooperation in early warning services through the Severe Weather Forecasting Demonstration Project. The latter established a daily conference call among EAC NMHSs and Ethiopia to help them coordinate their responses to forecasts of high-impact weather.

The investment plan that underpins Vision 2025 will further improve the accuracy of marine forecasts for Lake Victoria by providing valuable new sources of meteorological data.

It provides for the installation of weather buoys in the Kenyan, Tanzanian and Ugandan sectors of the lake. These will provide water temperature and wave height information for the first time, as well as recordings of wind speed and direction over open water at surface level. There are also plans to install more automatic weather stations on islands in the lake.

In addition, Vision 2025 calls for the siting of a new weather radar near Kisumu, a lakeside city in western Kenya. This will provide better radar coverage of the north-east corner of Lake Victoria. It will complement radar coverage of the lake already provided by weather radars at Kigali in Rwanda, Entebbe in Uganda and Mwanza in the United Republic of Tanzania.

The strategy is backed by an ambitious plan to strengthen meteorological observations throughout the region, improve severe weather forecasting and the dissemination of weather information.
Forecasts and severe weather warnings need to be translated rapidly and accurately into a local language that all users can understand clearly. It is difficult to communicate weather information effectively to rural communities who do not speak the language in which it is written.

In the United Republic of Tanzania, there is no need to translate the forecasts as TMA produces all its information products in Swahili.

In Kenya and Uganda, all forecasts and severe weather warnings are produced in English, which is a language that few people in Lake Victoria fishing communities speak fluently. The HIGHWAY project tackled this problem in two innovative ways.

**VISUAL WEATHER ICONS AND COLOUR CODES UNDERSTOOD BY ALL**

The project helped to create a new set of weather icons to visually describe marine weather conditions for artisanal fisherfolk and other residents of lake shore and island communities. These icons show weather impacts such as tree bending and shedding twigs and leaves in strong wind.

![Wind speed icons showing conditions ranging from “calm” to “very strong wind”](image)

Such images ensure the forecasts are easy to understand, even if the user does not know English or does not think of wind speed in terms of knots or kilometres per hour.

A three-colour code to describe expected weather conditions in each forecast provided another useful visual aid to forecast users. This code, assigned to each marine zone and each 6 hour forecast period, helps small boat users to identify the location and timing of any high-impact weather quickly and easily. Severe weather is highlighted by an orange or red signal. Green indicates fair weather and business as usual.

**BILINGUAL REFERENCE GUIDES**

The project also developed a series of bilingual quick reference guides to help forecast users understand key terms used in weather forecast bulletins and translate them quickly and accurately into their local language.

These guides were co-designed by weather forecasters and fisherfolk leaders. They are constantly referred to by radio journalists racing to prepare the next weather bulletin. They are also used by community intermediaries who receive the forecasts by WhatsApp and share them with other people at their landing site.

The bilingual guides were used to help train more than 400 community intermediaries in Kenya and 120 in Uganda. Each trainee was also provided with a copy of the guide.

In Kenya, a bilingual guide was produced in English and Luo, the language spoken by more than 90% of fisherfolk in the Kenyan sector of Lake Victoria. Luo is also widely used by local radio stations. A second bilingual guide was produced later for Kinyala-speaking fisherfolk near the Ugandan border.

In Uganda, a bilingual guide was produced in English and Luganda, the main language spoken in the south of the country. Most Ugandan fishing communities speak either Luganda or Lusoga, a closely related language, as their mother tongue. Both languages are widely used by local radio stations.

Henry Kizito, a non-governmental organization coordinator who organized the training of 120 community intermediaries in the Ssese Islands, Uganda, said, “People on remote Lujjaabwa Island told me that the reference guide, along with the local weather flag and noticeboard, have helped them to interpret the forecasts very accurately. They have saved lives.”

Bilingual reference guides, colour codes and visual weather icons assist the rapid and accurate translation of weather forecast information universally and into local languages.
The HIGHWAY project has supported the establishment of a regional centre to check the quality of weather observations that East Africa shares with the rest of the world. The regional WMO Integrated Global Observing System (WIGOS) Centre for East Africa monitors all weather data submitted electronically from the region to the WMO Global Telecommunication System (GTS). GTS receives weather observations from WMO Members and shares them with forecasters globally. HIGHWAY funded computer equipment and staff training for the new East African Regional WIGOS Centre (RWC), which is run jointly by Kenya and the United Republic of Tanzania. It began operating in July 2020, and monitors observations submitted to GTS by Burundi, Kenya, Rwanda, South Sudan, Uganda and United Republic of Tanzania.

**MONITORING DATA**

The data monitoring operation ensures any errors, distortions or anomalies in weather observations submitted to GTS by the six EAC member States are detected and followed up with a view to quick rectification. Individual countries remain responsible for feeding their observations directly into GTS. But these are now monitored closely by technical experts at the East African RWC. Whenever the experts detect suspicious characteristics in the data, they create an incident report using a WIGOS incident management system. This is logged and submitted to the NMHS that sent the suspect data. That organization must then investigate the malfunction and resolve it.

KMD monitors metadata from East Africa at its headquarters in Nairobi. It looks at (meta)data that describe and categorize the weather observations that flow electronically from the region into GTS. KMD proposes any corrections or updates that might be needed to OSCAR/Surface, the WMO global repository of observational metadata for surface-based stations. TMA meanwhile monitors the quality of the underlying weather observations from its offices in Dar es Salaam. TMA checks the data to ensure expected standards are met in terms of accuracy, regularity of submission and configuration.

**ENSURING THE QUALITY OF DATA**

Problems with data quality are commonly caused by the malfunction or breakdown of weather observation equipment and the disruption of telecommunications links. During its first seven months of operation, this binational operation opened 32 investigations into data anomalies. Eight of them were satisfactorily resolved. At the end of this period, 24 other investigations were still under way.

The East African RWC is one of several RWCs that are being established across Africa to detect and resolve problems with data flowing into GTS close to their source. The East African data are used by other NMHSs around the world for climate modelling and the production of automated global and regional forecasts. East Africa benefits directly from sharing weather information in this way because forecasting models are widely used by NMHSs in the region to help produce their own forecasts.

Mark Majodina, the WMO Regional Representative for Eastern and Southern Africa said: “The improvement in meteorological data inputs from the subregion will have a direct benefit on weather forecast quality... This is a significant milestone and will inspire the expansion of observations in other parts of the African continent.”

A regional centre has been established to monitor the quality of meteorological data from East Africa that are shared with the rest of the world. The creation of this East African Regional Centre was one of several HIGHWAY initiatives that fostered stronger formal cooperation among NMHSs in the region.
The HIGHWAY project has enabled Kenya to revive a pilot forecast for fisherfolk on Lake Victoria, improve its content and dramatically extend its dissemination.

The KMD forecast for fisherfolk is now broadcast twice daily, and is aired in local languages by eight radio stations that are popular with lake shore and island communities.

DEVELOPING AND RAISING AWARENESS OF THE FORECASTS

HIGHWAY helped KMD to work closely with fishing community leaders and local radio stations to enhance the format and content of the forecasts and the severe weather warnings they often contain.

The partners also collaborated to raise awareness of the forecasts in fishing communities.

County leaders of the Kenyan Beach Management Unit Network selected two volunteers with smartphones at each landing site to become community intermediaries. Joint teams of KMD staff, fishing leaders and fisheries department officials then trained the intermediaries how to receive the forecasts by WhatsApp, interpret them correctly and communicate relevant information from them to local people.

Over 400 community intermediaries were trained to receive the forecasts on their smartphones and to disseminate them to local people at about 200 landing sites.

Ten pilot landing sites were provided with weather information noticeboards and weather flags that are managed by the local intermediaries. This equipment has helped to communicate weather information to local people more easily. Whenever the latest KMD forecast contains a warming of high-impact weather, the intermediary raises an orange or red warning flag to replace the green flag that normally flies in fairweather conditions.

USE THE FORECASTS

Field research in 2020 showed that nearly everyone involved in fishing activities in the Kenyan sector of Lake Victoria was aware of the KMD forecasts and received them regularly. These people included fish traders and processors, as well as fishing crews and the crews and passengers of small transport vessels.

Focus group participants said the forecasts influenced the behaviour of between half and three quarters of all residents in Kenyan fishing communities.

Sylvester Kaywa, Chair of Beach Management Units in Busia County, said: “Fishermen are able to receive the forecast in time before leaving the landing site and this has assisted them to plan ahead… They are able to receive the forecast message in their local language and understand and interpret it well.”

EXTENDING FORECAST REACH

Paul Oloo, KMD focal point for the HIGHWAY project, had previously worked with fishing leaders in 2016 to co-design a daily forecast for small craft users on Lake Victoria.

Broadcast of that pilot forecast lapsed after less than a year, but fisherfolk liked the product, and Oloo played a key role in reviving and improving it.

When he detected some unused HIGHWAY funds that had been allocated to Kenya, Oloo had no hesitation in using the money to train 300 more community intermediaries than the project had originally planned.

That initiative extended the direct communication of KMD forecasts for fisherfolk to more than 100 additional landing sites.

Kenya has revived and improved its pilot forecast for fisherfolk on Lake Victoria. Weather forecasts now reach all landing sites and are widely used for decision-making.
UNMA follows closely the weather over Lake Victoria because it generates rainfall and thunderstorms throughout southern Uganda.

UNMA also studies the weather over Lake Victoria closely because it influences aeroplanes taking off and landing at Entebbe international airport. The main runway ends at the lake shore.

UNMA forecasters are physically close to the lake, as they work from an office in the airport control tower. Lake Victoria is a constant presence in their lives. They see the boats dotting its surface every day as they go to and from work.

However, Uganda is a landlocked country with little experience of marine weather forecasting. The HIGHWAY project helped it to produce a popular and influential forecast for fisherfolk and other small boat users on Lake Victoria.

IDENTIFYING FORECAST NEEDS

UNMA identified the weather information needs of Ugandan fishing communities through a forecast co-design process facilitated by HIGHWAY. Learning from Kenya, which had previously established a forecast for fisherfolk on Lake Victoria, was also helpful.

Ugandan forecasters found they already had the data, the analytical tools and the skills necessary to forecast wind, wave height, rainfall and visibility on Lake Victoria. Consultations with fishing community leaders during the co-design process made UNMA forecasters aware of key weather thresholds beyond which navigation conditions become difficult for small boats.

For example, wind speeds of more than 40 km per hour tend to generate waves over 1.5 m in height. These can cause fishing boats and small transport craft to capsize or sink. Such conditions now trigger the issue of severe weather warnings.

USING AND IMPROVING FORECASTS

The UNMA marine forecasts are widely used by lakeside and island communities because they are easy to access. At least 12 local radio stations popular in fishing communities broadcast the forecasts in local languages, particularly Luganda and Lusoga.

UNMA disseminates the forecasts to radio journalists, fishing community leaders and community intermediaries at landing sites via WhatsApp.

This messaging app has proved more popular than email. It prompts many forecast users to give instant feedback and report weather-related events they have observed. Often, fisherfolk send in photos and video clips to show local weather conditions. They also report weather-related boat accidents.

Julius Kiprop, the UNMA focal point for the HIGHWAY project, expects the accuracy of forecasts to improve further. Forecasters are now using the new weather radar at Entebbe to predict the weather. Soon, they will also receive observations from six weather buoys that the Ugandan Government is purchasing for deployment on Lake Victoria.

Kiprop said: “We are confident that the weather radar and the new weather buoys will enable UNMA to produce even better forecasts for fishermen and the island communities which rely on water transport.”

“The direct contact of forecasters with fishermen during the co-design process and through subsequent feedback from forecast users, has proved really motivational,” he added.

Landlocked Uganda produced a marine forecast for Lake Victoria that has proved popular and influential. Fisherfolk consulted a year after the forecast was launched said the bulletins were generally accurate on 5 out of 7 days. The success of this forecast has sparked demands for Uganda to produce similar bulletins for fisherfolk on Lakes Kyoga and Albert.
Before the HIGHWAY project, TMA was already producing marine forecasts for Lake Victoria. It had even developed a model for forecasting wave heights on the lake.

However, the TMA marine forecast for Lake Victoria was aimed exclusively at commercial shipping. It used meteorological terms that few artisanal fisherfolk could understand.

HIGHWAY helped TMA to engage with local fisherfolk to ascertain their weather information needs. It then helped TMA to develop simpler ways of expressing marine weather information to make it easier for people in fishing communities to understand.

DEVELOPING THE FORECASTS

On the technical side, HIGHWAY enabled TMA to optimize the use of its weather radar in Mwanza at the southern end of Lake Victoria for forecasting severe weather over the lake. The radar was repaired and serviced, and a data link to TMA headquarters in Dar es Salaam installed.

This enables TMA forecasters to obtain radar pictures of weather over the lake in real time. HIGHWAY also trained TMA forecasters how to interpret the radar data – particularly for forecasting heavy rainfall and thunderstorms.

The new TMA forecast for fisherfolk divides the Tanzanian sector of Lake Victoria into the same four marine forecasting zones used in its forecast for commercial shipping. The forecast for fisherfolk also contains the same types of marine weather information: wind speed and direction, wave height, sky conditions and visibility.

The format, language and visual features of the new bulletin were inspired by the forecasts for artisanal fisherfolk that HIGHWAY had already helped to develop in Kenya and Uganda.

TMA uses the same simple language to describe weather conditions, the same weather icons and the same colour code to warn of severe weather as its East African neighbours. It also adopted their practice of splitting each day into four forecast periods of 6 hours each.

The launch of the TMA twice-daily forecast for fisherfolk on Lake Victoria was preceded by three stakeholder engagement workshops held in important fishing districts along the lake shore. These helped identify about 100 people who now receive the forecast by WhatsApp and a further 350 who receive forecast summaries by SMS.

Initial feedback from users has been positive. Field research shows they find the forecast information timely, accurate and useful. There is strong potential for it to reach fisherfolk at all 642 landing sites in the Tanzanian sector of Lake Victoria via the many local and regional radio stations that broadcast to lake shore and island communities.

ADAPTING COMMERCIAL SHIPPING FORECASTS FOR FISHERFOLK IN UNITED REPUBLIC OF TANZANIA

The United Republic of Tanzania adapted its forecasts for commercial shipping on Lake Victoria into a product better suited to the needs of artisanal fisherfolk on the lake.

The day forecast for a marine zone in United Republic of Tanzania. The 12 hour forecast features an orange severe weather warning for the afternoon.
Although Rwanda lies 150 km from Lake Victoria, the weather of this landlocked country is strongly influenced by the rain clouds and thunderstorms that drift westward from the lake.

Rwanda was therefore an active partner in the HIGHWAY project and benefited from it in several different ways.

**IMPROVING OBSERVATIONAL DATA**

One of HIGHWAY’s first actions was to recalibrate a weather radar located near the capital Kigali. The radar detects weather systems drifting towards Rwanda from the western shores of Lake Victoria. It can also detect thunderstorms in the north-west corner of the lake.

HIGHWAY subsequently trained Rwandan forecasters how to use the radar more effectively to detect approaching thunderstorms and rain-bearing clouds, and to assess their impact.

Meteo Rwanda forecasters joined an online training course that had been organized primarily to help their Ugandan counterparts interpret data from the recently installed weather radar at Entebbe.

Meteo Rwanda used its own weather radar to compare radar images of heavy rain and thunderstorms with information from the ground about the damage caused by heavy rainfall, hail and strong winds associated with these high-impact weather events.

Meteo Rwanda developed a series of severe weather thresholds. These were agreed by consensus with representatives of affected communities and with technical experts. Meteo Rwanda has offered to share these thresholds with other NMHSs in East Africa.

**ENGAGING WITH USERS**

HIGHWAY also enabled Meteo Rwanda to explore new and more effective ways of communicating early warning messages and other types of weather information to Rwanda’s predominantly rural population.

It encouraged Meteo Rwanda to adopt similar approaches to stakeholder engagement to those used by Kenya, Uganda and United Republic of Tanzania in the development of marine weather forecasts for fisherfolk on Lake Victoria.

HIGHWAY funded three user engagement workshops that enabled Meteo Rwanda forecasters to consult with local media, farmers and agricultural experts in Eastern Province and fisherfolk on Lake Kivu. This is a large lake that Rwanda shares with the Democratic Republic of the Congo.

The workshops enabled forecast users to tell Meteo Rwanda what kind of weather information they needed most and how to express it in ways they could understand easily.

Acknowledging the increasingly widespread use of smartphones at all levels of society, Meteo Rwanda started to disseminate its forecasts and severe weather warnings by WhatsApp to individual subscribers. This was in step with the use of WhatsApp in Kenya, Uganda and United Republic of Tanzania to communicate forecasts to fisherfolk on Lake Victoria.

Joseph Ndakize Sebaziga, a senior forecaster at Meteo Rwanda, who served as a focal point for the HIGHWAY project, said: “The HIGHWAY project benefited Meteo Rwanda forecasters by increasing their ability to use weather radar products in nowcasting and interacting with fishermen and media houses to disseminate the weather forecast... Meteo Rwanda will continue to improve nowcasting.”

Rwanda improved its observational data, engaged closely with forecast users and developed severe weather thresholds for use in early warning messages.
Large waves caused by strong winds and waterspouts pose a grave danger to the safety of small boat users on Lake Victoria and the other Great Lakes of East Africa. The HIGHWAY project highlighted the need to find a way of forecasting the height of waves and the occurrence of waterspouts more accurately.

**MODELLING WAVE HEIGHT**

Waves more than 1.5 m in height from crest to trough are regarded as dangerous for the open canoes that catch fish and transport goods and passengers on Lake Victoria. Waves of this size can fill the boats with water or cause them to capsize. Large waves often lead to accidents that involve loss of life. In June and July, when strong steady winds blow from the south over the whole lake, the waves in open water can be up as high as 3.5 m.

The forecasts for fisherfolk and other small boat users developed by Kenya, Uganda and United Republic of Tanzania include predictions of wave height. But feedback from forecast users suggests they consistently underestimate the true height of waves in open water. In 2020, several serious accidents occurred in Kenya and Uganda that involved transport craft sinking in rough water at times when the local forecast had predicted small waves and fair weather.

The forecasts for fisherfolk on Lake Victoria use a wave forecasting model developed by TMA. This takes into account the depth of the lake and the shape of the lake bottom, as well as wind speed and direction. However, the model has not yet been scientifically verified.

Uganda also uses a wave forecasting model available through the European Centre for Medium-Range Weather Forecasts charts forecasting model. But this has not rectified the underestimation of wave heights.

The planned installation of automatic weather buoys in different parts of Lake Victoria should enable meteorologists to forecast wave height more accurately. Uganda is due to take delivery of nine weather buoys in 2021. These can measure wave height and wind speed and direction at surface level on the open lake. Most of the buoys will be installed on Lake Victoria, but some are also due to be placed on Lakes Albert and Kyoga.

**PREDICTING WATERSPOUTS**

The EAC Vision 2025 early warning strategy has called for weather buoys to be installed in the Kenyan and Tanzanian sectors of Lake Victoria and on Lakes Kivu and Tanganyika. Besides helping NMHSs to forecast wave heights more accurately, the weather buoys should help to resolve another forecasting problem – predicting the occurrence of waterspouts.

These twisting spirals of wind and water can lift boats into the air and smash them down on the lake surface, killing the people on board.

The weather buoys will be able to measure water temperature and relay the information straight to forecasters. Unusually warm surface water temperatures and strong convection of the type that causes thunderstorms are key pointers to the likelihood of these tornadoes appearing on the lake.

Specialist training could also help forecasters use the weather radars at Mwanza and Entebbe to detect waterspouts up to 80 km away and issue warnings.

Feedback from fisherfolk shows that accurately forecasting wave height and predicting the occurrence of waterspouts is of vital importance to their safety.
The HIGHWAY project created a comprehensive record of weather observations for the Lake Victoria Basin over a period of 12 months. This will help meteorologists to improve their forecasts and warnings for the region in coming years. HIGHWAY created an archive by aggregating surface-based weather observations from Kenya, Rwanda, Uganda and United Republic of Tanzania NMHSs, and several external sources.

COLLECTING OBSERVATIONAL DATA
In addition to routine observations from weather stations, NMHSs provided new sets of radar data from the Tanzanian weather radar at Mwanza, at the southern end of Lake Victoria, and Uganda’s new weather radar at Entebbe, at the northern end of the lake.

The field campaign also captured upper atmosphere weather recordings from twice-daily weather balloon launches by KMD at Nairobi and Lodwar. KMD resumed balloon launches at these sites in 2019 after a long break.

Weather observations from external sources included satellite data from the European Organisation for the Exploitation of Meteorological Satellites, the European agency that monitors world weather from a network of satellites. It provided a wide range of satellite data on weather in the Lake Victoria Basin.

The company Earth Networks, from the United States of America, meanwhile contributed lightning strike data from its East African network of lightning detectors.

In addition, the Trans Africa Hydro-Meteorological Observatory, an enterprise run by Dutch and United States universities, contributed observations from its network of 27 automatic weather stations in the Lake Victoria Basin.

STORING OBSERVATIONAL DATA
The field campaign was supervised by NCAR. The complete dataset is stored on NCAR computers and is freely available for future use by scientists studying the weather in East Africa.

NCAR is particularly excited about the prospects of using data from the field campaign to improve ways of forecasting thunderstorms over the Lake Victoria Basin up to 6 hours ahead.

PRODUCING NEW OBSERVATIONAL DATA
Informed by the findings of the field campaign, HIGHWAY recommended the installation of weather buoys on Lake Victoria to gather weather information from the lake surface and the siting of a new weather radar near Kisumu in western Kenya.

Both these proposals have been incorporated into the Vision 2025 early warning strategy of EAC, so there is a possibility they will be funded.

The weather buoys would transmit real-time recordings of wave height, wind conditions, rainfall and water temperatures on the surface of the lake to forecasters. There is no equipment in place at present that is able to provide such vital data.

The Kisumu weather radar would fill a gap in radar coverage in the north-east corner of the lake. Data from Kisumu and the existing weather radars at Entebbe, Kigali, and Mwanza could create a mosaic of radar images covering the whole of the Lake Victoria Basin.

However, HIGHWAY found that sustained additional spending would be required to bring about such improvements. More money is required to support data acquisition from new sources, improved telecommunications links, acquisition of spare parts, and recruitment and training of additional technicians and forecasters.

Rita Roberts, the NCAR scientist coordinating the field campaign said: “With these observations, forecasters will be able to provide precise severe storm warnings, never before possible over East Africa.”

A campaign of intensified meteorological observations is helping scientists to understand better how weather develops in the Lake Victoria Basin.
Small boat users on Lake Victoria are affected by wind and wave conditions, so even when the weather appears to be set fair, they still need a reliable forecast for the voyage ahead.

The HIGHWAY project helped NMHSs to communicate warnings of high-impact weather to fishing communities around the lake through regular forecasts issued twice daily at fixed times.

The forecasts and severe weather warnings are timed to reach boat crews and passengers before they leave the landing site. This means they are likely to have a significant impact on decision-making.

**TIMING THE BROADCASTING OF FORECASTS**

NMHSs of Kenya, Uganda and United Republic of Tanzania all developed special weather forecasts and severe weather warnings for fisherfolk and transport operators on Lake Victoria. The forecasts are updated at 12 hour intervals and are broadcast at fixed times by local and regional radio stations.

The first marine forecast of the day is timed to reach day fisherfolk and transporters in the early morning, shortly before they set out on the lake around dawn. The second goes out in the afternoon to catch night fisherfolk before they head out, an hour or two before sunset.

Once the wooden canoes are already on the water, it is more difficult to reach their crews and it is often too late for them to change their plans.

**REACHING THE TARGET AUDIENCE AND SAVING LIVES**

A socioeconomic benefits study carried out for the HIGHWAY project indicated that the marine forecasts and the severe weather alerts embedded in them help to prevent about 300 deaths per year in boat accidents.

The forecasts have also helped to generate an estimated US 44 million of economic benefits every year for fishing communities on Lake Victoria. Fisherfolk say they use weather information to save on outboard motor fuel and improve their catches. They also say they use forecasts to avoid damage to boats and nets.

Field research showed that occasional severe weather warnings reach a wide audience and are taken seriously because people in fishing communities trust the forecasts and follow them closely.

The HIGHWAY project’s experience suggests severe weather warnings carried in regular forecasts issued at set times are likely to reach more people than stand-alone warnings published at odd times when people may not be expecting to receive weather information.

Mary Namuddu Annet, a young entrepreneur on Funve Island in Uganda, takes the forecasts and the severe weather warnings embedded in them very seriously. The 24-year-old businesswoman owns two fishing boats. She listens to the marine forecasts for the Ugandan sector of Lake Victoria on the radio and also gets them on her smartphone via a local WhatsApp group. Namuddu Annet says she relies heavily on the afternoon forecast to plan her boat’s fishing activities for the coming night. If strong winds or high waves are expected, she ensures her boats carry extra fuel for the outboard motor. And if the forecast is bad and an orange warning is issued, she does not allow them to go out at all.
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