

Haleh Kootval, Alice Soares, David  
Rogers

# Hydrometeorological Services as “System of Systems”

# Overview



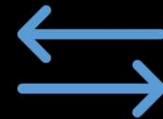
Road  
mapping




Service  
Delivery



Production  
and  
support  
systems



Change  
management

The background of the slide features three classical pillars standing on a dark, flat surface. Behind the pillars is a dark, moody landscape with a horizon line under a dark sky. The pillars are light-colored and have a fluted design. The text 'Pillars of modernization' is written in white, sans-serif font to the left of the pillars.

## Pillars of modernization

- Enhancement of service delivery system
- Institutional strengthening and Capacity Building
- Modernization of Observation and telecommunication infrastructures, modelling and forecasting systems

# Road mapping



# Purpose of a Road Map

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**Assess** the current capabilities

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**Assess** users' requirements

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**Identify gaps** and challenges in producing and delivering fit-for-purpose services

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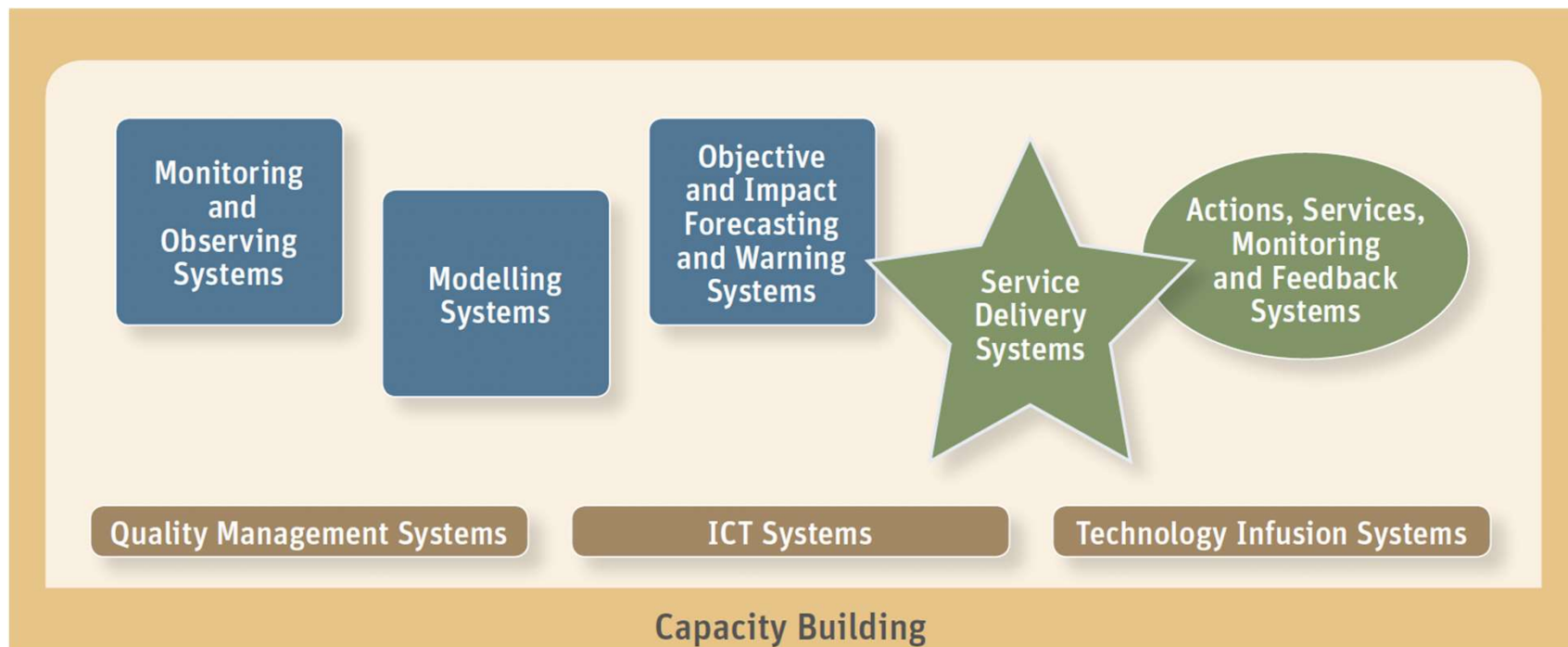
**Strategic Path** with achievable milestones

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**Not** detailed design features for the project's lifetime.

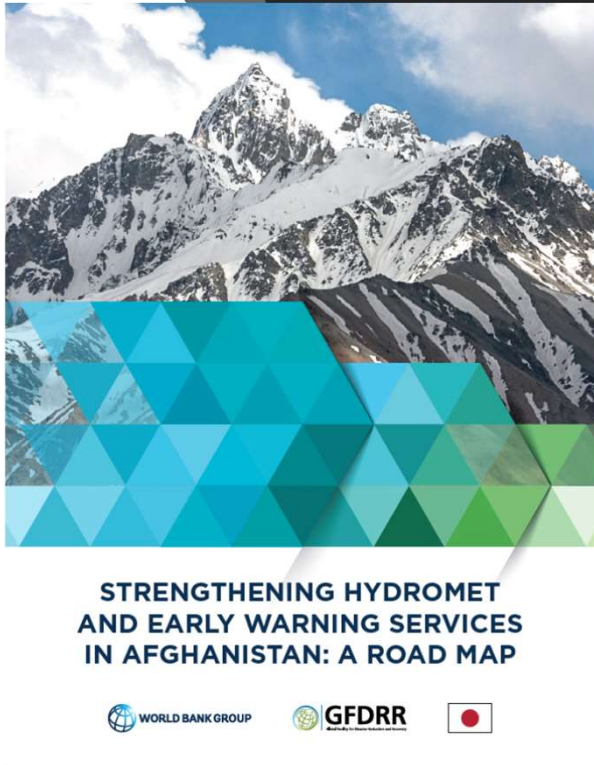
# A system of systems

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# Stages in a Roadmap

- Strategy – to achieve a goal
- Concept of Operations – existing and future system of systems
- Scenarios – alternatives depending on resources



# Outline of Road Map

## Modernizing Weather, Climate and Hydrological Services: A Road Map for Armenia



- Background to country and major hazards
- Current status
- Modernization overview
- Proposed roadmap for country
  - 3 pillars
- Scenarios
  - Technical assistance
  - Intermediate
  - Advanced



# Category 1: Delivery Systems

- Based on user needs
  - Available and timely
  - Dependable and reliable
  - Usable
  - Useful
  - Credible
  - Responsive and flexible
  - Sustainable
  - Expandable

New to most public service providers



**SEVERE WEATHER  
APPROACHING  
PLEASE  
EVACUATE  
NOW**

# Challenges for Service Delivery

## Forecasting component easier for staff:

- Familiar environment of forecast office
- Education and Training in Forecasting

## Service Delivery component more difficult:

- Requires knowledge and skills not taught
- Engagement with users: environment often not familiar or even hostile
- Requires understanding others' points of view and demands: often unfamiliar
- Feedback: Not always friendly

# Service Delivery Progress Model

## STRATEGY ELEMENT 1

### Evaluate user needs and decisions

Undeveloped	Development initiated	Development in progress	Developed	Advanced
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## STRATEGY ELEMENT 2

### Link service development and delivery to user needs

Undeveloped	Development initiated	Development in progress	Developed	Advanced
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## STRATEGY ELEMENT 3

### Evaluate and monitor service performance and outcomes

Undeveloped	Development initiated	Development in progress	Developed	Advanced
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## STRATEGY ELEMENT 4

### Sustain improved service delivery

## STRATEGY ELEMENT 5

### Develop skills needed to sustain service delivery

Undeveloped	Development initiated	Development in progress	Developed	Advanced
No concept or communication of service delivery principles exist.	No formal training in service delivery is provided, though service delivery principles are informally communicated.	Most members of NMHSs are aware of the importance of service delivery. Some formal training is provided.	All members of staff are fully aware. Formal training is provided. There is an ad hoc process for staff to offer ideas for improvements to service delivery.	There is a culture of providing best possible service delivery. Innovative ideas are routinely integrated into the continual service improvement process.

# Capacity Building

- User dialogue Skills
- Learning to develop services based on user requirements
- Learning communication and presentation skills
- Learning and applying QMS for services
- Training PWS advisors and liaison with users
- Twinning with advanced Weather Service providers

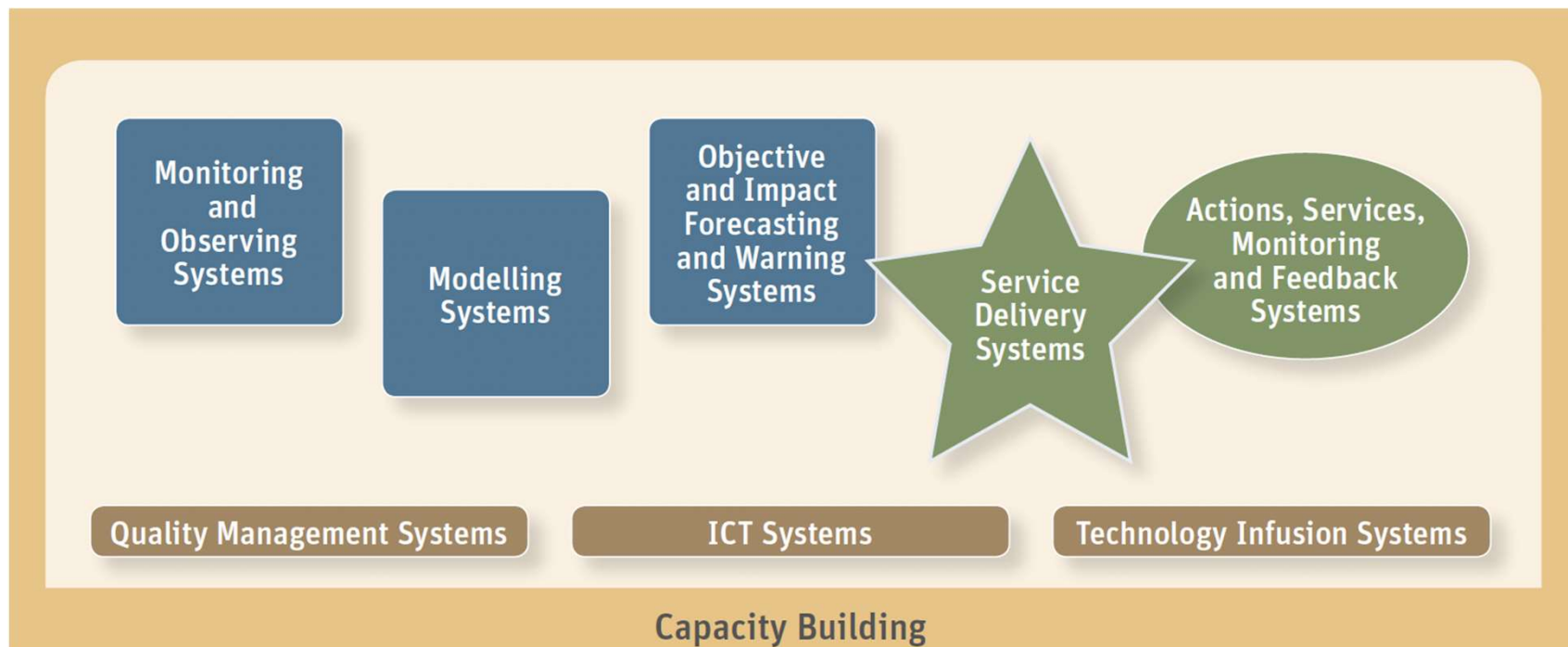


Capacity  
Building

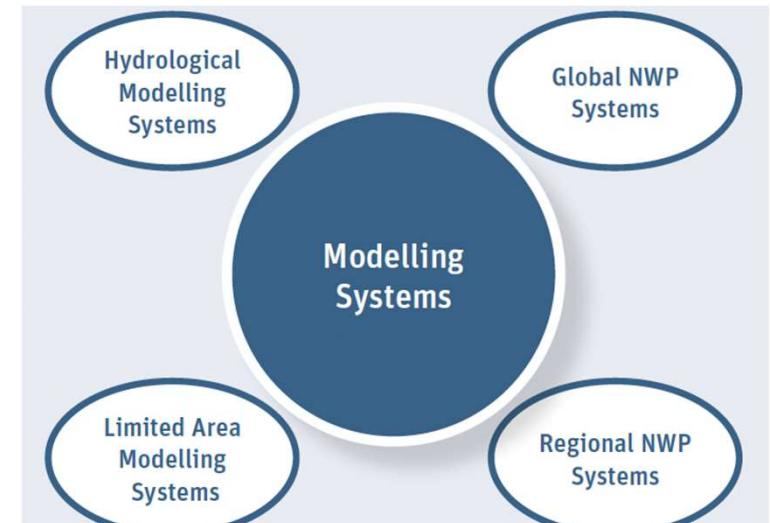
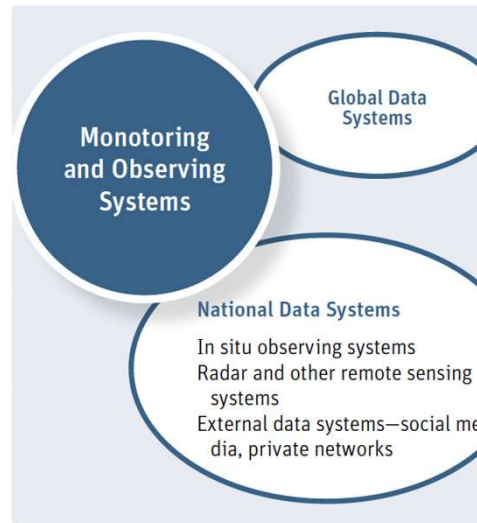
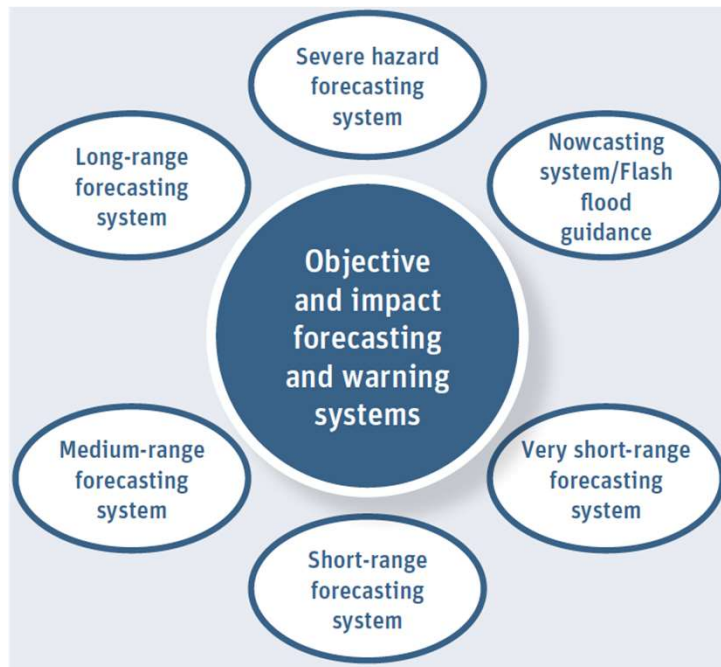
Stakeholder  
Institutional Training

# A system of systems

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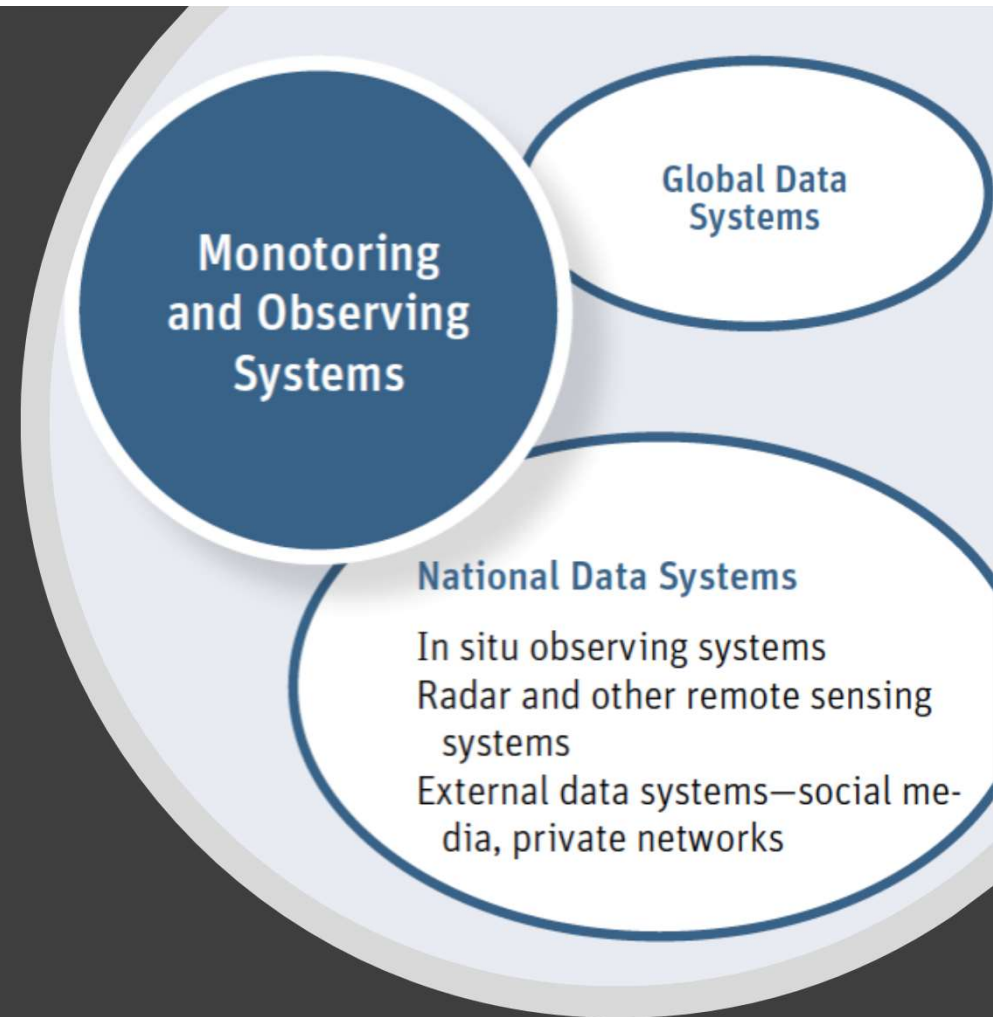


# Category 2: Production Systems

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# Monitoring and Observing Systems

- Fit-for-purpose observation networks
- Data-sharing
- QA/QC
- Forecast verification
- O&M of technical equipment



# Observation and telecommunication progress model

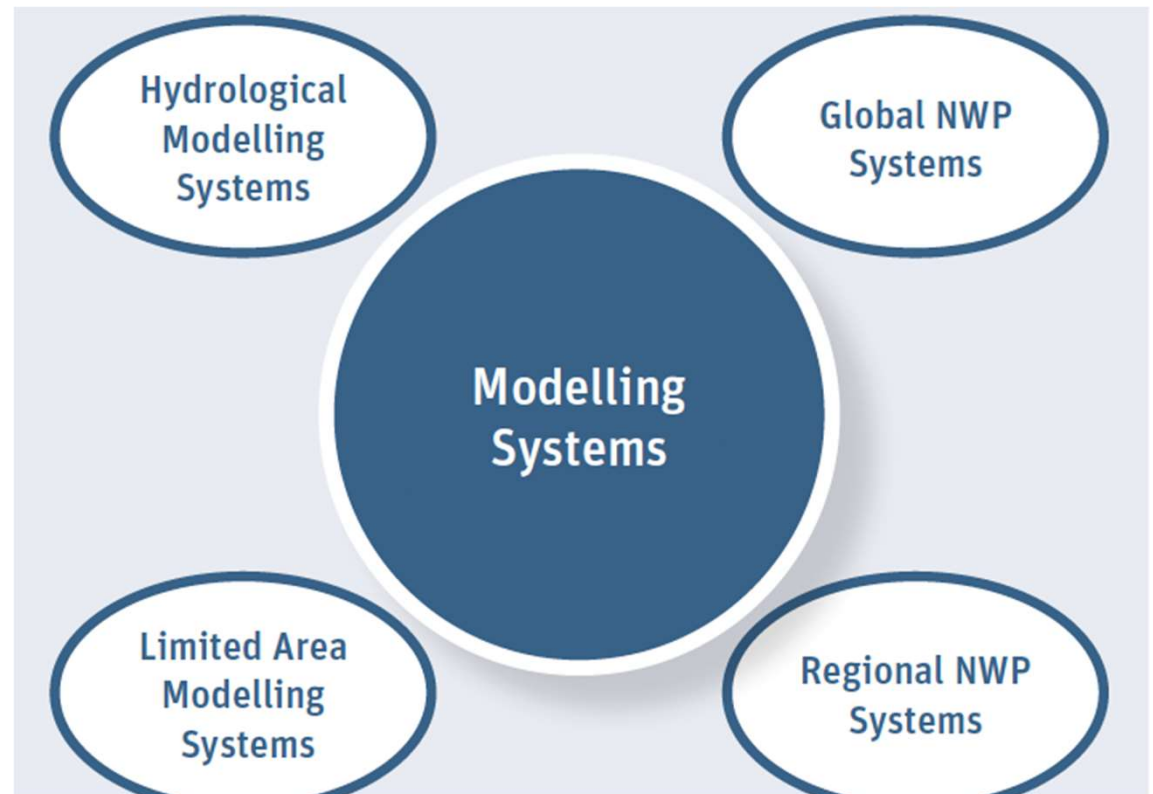
	Undeveloped	Development Initiated	Development in Progress	Developed	Advanced
Observations and Telecommunications	NMHS has very few manual synoptic stations and hydrological station. It does not share these data on the Global Telecommunication System (GTS).	NMHS has the capacity to support a synoptic meteorological network and hydrological network.; shares these data on the GTS; has sufficient staff to maintain its observing networks.	Automation of observing network with quality control is routine. NHMS accesses satellite data with e.g. the capacity to derive precipitation estimates. The observing network is sustainable with sufficient budget for operations and maintenance. The vertical structure of the atmosphere may be routinely measured.	Observations extend to smaller scales and include ground-based remote sensing techniques, such as radar. The NMHS may be able to take and integrate observations from other parties.  It may access observations by outsourcing its observing requirements	NMHS conducts research, introducing new observational technologies and techniques as needed. The observing network is comprehensive and sufficient to meet main user needs, incorporates external observations from other suppliers, for example, agro-meteorological network operated by a Ministry of Agriculture or hydrological network operated by a Ministry of Energy or Water Resources.

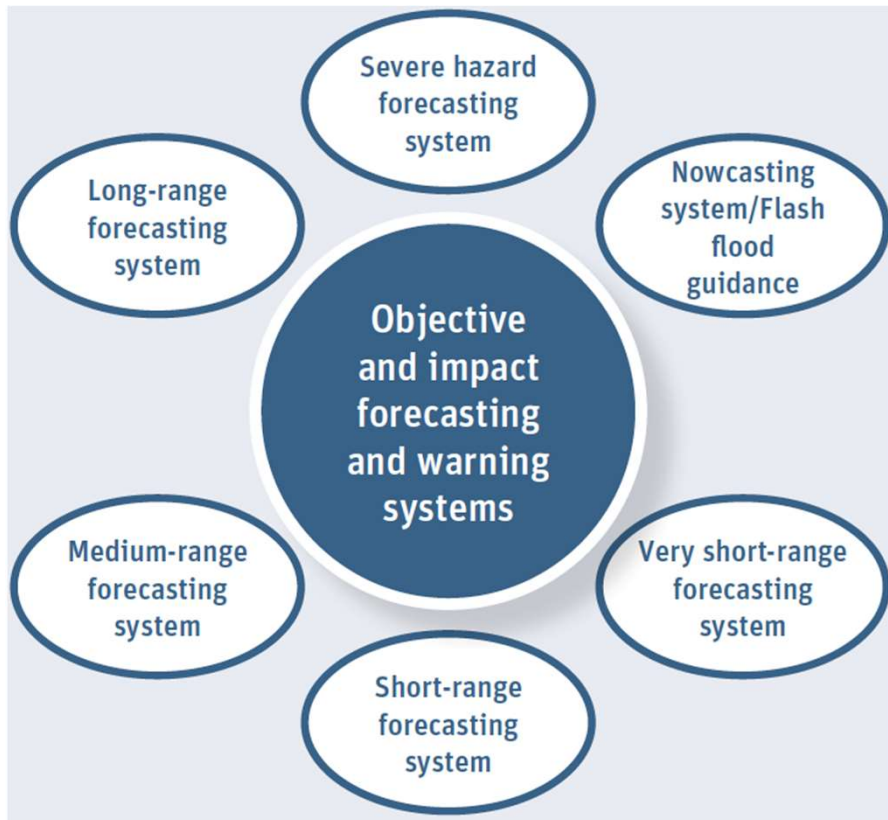


# Meteorological and Hydrological Modelling Systems

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- Global and regional models
- Use of Limited Area Models
- Use of «Ensemble Prediction Systems»





# Forecasting and Warning Systems

- All timescales, from nowcasting to climate
- Tailored forecasts to users' needs
- Forecaster environment
- Forecast process
- Impact-based forecasts

# Modelling and Forecasting progress model

	Undeveloped	Development Initiated	Development in Progress	Developed	Advanced
Forecasting Systems	<p>NMHS provides up to two-days deterministic forecast based on graphical forecast products retrieved from different web sources. There is no verification of forecasts. The NMHS does not operate forecasting on a 24-hour, seven-days-a-week basis; and warnings are not issued.</p>	<p>NMHS can provide at least three-days deterministic forecasts based on access to global and regional NWP data and products available on the GTS and/or graphical products available from WMO RSMCs; monitors the current weather and hydrological system; has basic data-processing and archiving systems; carries out subjective forecast verification. There is no research and development, and the quality management system is rudimentary. The NMHS may not operate forecasting on a 24-hour, seven-days-a-week basis. Warnings are limited.</p>	<p>The NMHS can provide 0 to 5 days forecasts using global and regional deterministic NWP and EPS data and products from GPCs; issues nowcasts and very-short-range forecasts up to 12 hours based on extrapolating NWP and blending remote-sensing observations.; is able to monitor major rivers and generate short-term flow and flood forecasts; has protocols for emergencies, back-up of data and products and offsite storage facilities; carries out verification and post-processing; has some R&amp;D and a QMS. The NMHS operates forecasting on a 24-hour, seven-days-a-week basis.</p>	<p>LAM systems are available locally or through regional centers. Using local data assimilation, high-resolution short-time scale forecasts are produced with emphasis on 0–6 hours for extreme events. The forecasting system extends from 0 to at least 7 days based on a combination of global, regional and national deterministic NWP and EPS data and products. The NMHS has the capacity to manipulate digital data and to tailor forecasts to specific users and operates a multi-hazard warning system; generates seasonal stream flow outlooks and specialized hydrology products; has full R&amp;D capability. There are well-established relationships with partner agencies.</p>	<p>NMHS has an extensive research program and introduces new forecasting technologies and techniques; has the capacity to support requirements of other NMHSs, is able to run global, regional and national NWP and EPS systems. Forecasts of weather and hydrological impacts on specific sectors are routine and generally developed with users of these forecasts. The NMHS has a well-developed education and training unit.</p>

# Climate Service progress model

	Undeveloped	Development Initiated	Development in Progress	Developed	Advanced
Climate Services	<p>NMHS may operate a limited national climate observing system; collects data in paper form; retrieves climate data from different sources to generate national climate products; participates in regional climate outlooks; and has very limited or no interaction with users. Typically, NMHSs in this category do not have staff dedicated to carry out climate services.</p>	<p>NMHS designs, operates and maintains national climate observing systems; manages data including QA/QC; develops and maintains data archives; monitors climate; oversees climate standards; performs climate diagnostics, climate analysis, climate assessment; disseminates climate products; participates in regional climate outlooks; and interacts with users; performs the functions of national climate centers providing basic climate services. Staff are proficient in climate statistics, homogeneity testing techniques and quality assurance techniques.</p>	<p>NMHS has the capacity to develop and/or provide monthly and longer climate predictions, including seasonal climate outlooks, both statistical and model-based; able to conduct or participate in regional and national climate outlook forums; interacts with users in various sectors; adds value from national perspectives on the products received from RCCs and in some cases GPCs for long-range forecasts, conducts climate watch programs and disseminates early warnings. Staff are proficient in developing and interpreting climate prediction products and in assisting users in the uptake of these products.</p>	<p>NMHS generates sub-seasonal to seasonal forecast products, develops specialised climate products; downscales long-term climate projections as well as interprets annual to decadal climate predictions; covers all the elements of Climate Risk management, from risk identification, risk assessment, planning and prevention, services for response and recovery from hazards, information relevant to climate variability and change, and information and advice related to adaptation; builds societal awareness to climate change issues and provides information relevant to policy development and a national action plan. Staff have knowledge in climate modeling and methods for downscaling/calibration, risk and risk management and financial tools for risk transfer.</p>	<p>NMHS has research capacities and runs global and regional climate models (sub-seasonal to decadal and longer); works with sector-based research teams and develops application models, software and products suites for customized climate products. Staff have multi-disciplinary modeling and statistical expertise and can downscale/calibrate global scale information to regional and national levels. The NMHS is able to receive and respond to user requirements for new products</p>



# Hydrological Services progress model

Undeveloped	Development initiated	Development in progress	Developed	Advanced
<p>The NHS may operate and maintain a very small hydrological observation network; collect data in paper format; and have very limited or no interaction with users. Typically, staff of NHSs in this category are not trained in hydrology.</p>	<p>Functions of NHS may include operation and maintenance of a small hydrological observation network; hydrological data management, with basic hydrological data-processing, archiving and communication system; little or no back-up / offsite storage; and some interaction with users of hydrology data and products. There is no research and development, and rudimentary quality management system. There are no relationships with partner agencies.</p>	<p>The NHS is able to operate and maintain a hydrological observational network to monitor major rivers, and take and integrate some hydrological observations from other parties. The NHS operates an interoperable hydrological data management system; and have well-established protocols for emergencies, backup of hydrological data and minimum offsite facilities. The NHS carries out water level and flow monitoring, and is able to generate short-term flow forecasts (low flows), flood forecasting, and hydrological data products for design and operation of water supply structures. There is a small research and development unit; and a quality management system. There are some relationships with partner agencies.</p>	<p>The NHS operates and maintain a comprehensive hydrological observational network to monitor major and some smaller rivers, and takes and integrates most of the hydrological observations from other parties. The NHS operates a well-developed interoperable hydrological data management system; and has well-established protocols for emergencies, backup of hydrological data and offsite facilities. The NHS carries out water level and flow monitoring, and is able to generate short-term flow forecasts (low flows), flood forecasting, and hydrological data products for design and operation of water supply structures. The NHS is also able to generate seasonal stream flow outlooks, and specialized hydrology products. There is a research and development unit; and a well-established quality management system. There are well-established relationships with partner agencies.</p>	<p>In addition to the foregoing capabilities, the NHS has an extensive research and development program; and strong relationships with partner agencies, taking a leading role in the advice and decision support. NHSs have the ability to generate customized hydrological products, and to develop hydrological application tools.</p>

# Capacity Building

- Core disciplines – WMO Basic Instruction Packages for Met, Hydro and Technicians
- On-the-job training
- “Dummy shifts” – Forecast Desks
- Training trainers
- Twinning with advanced NMHSs
- University education

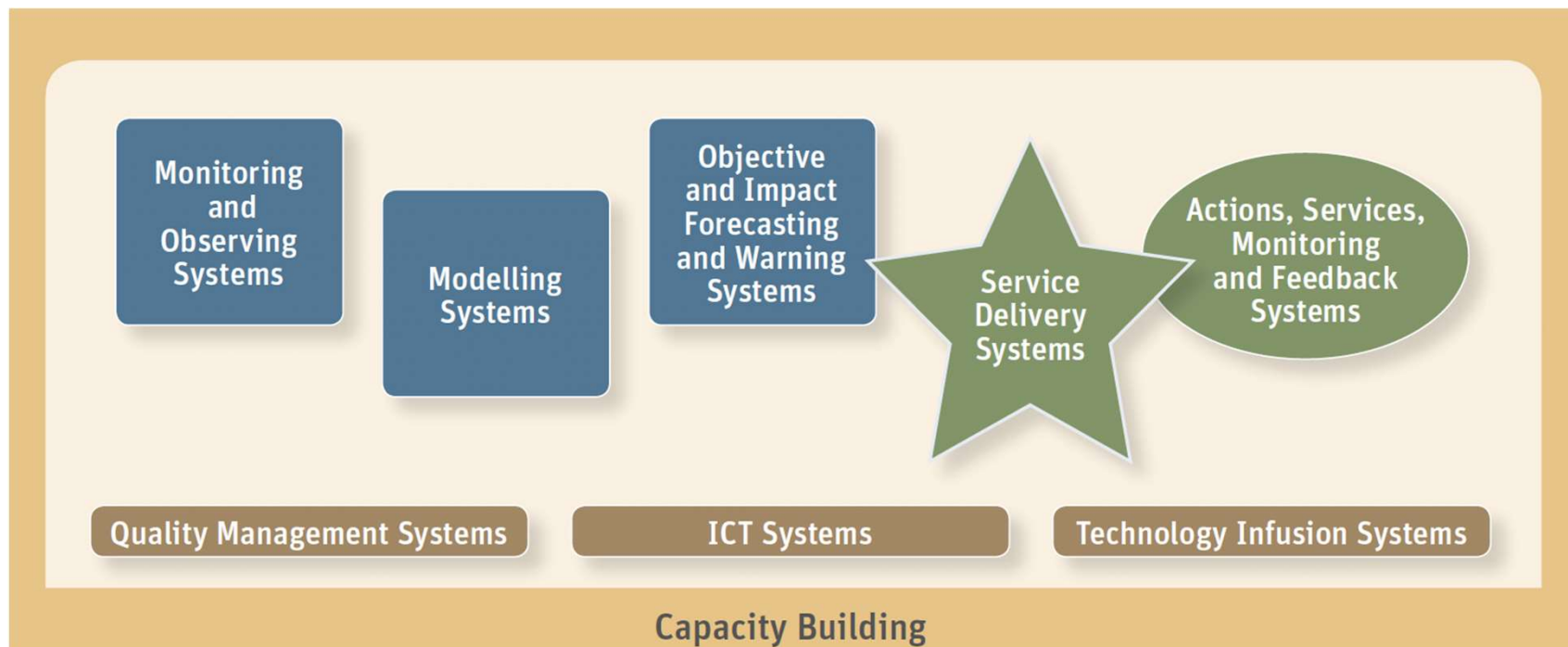


Capacity  
Building

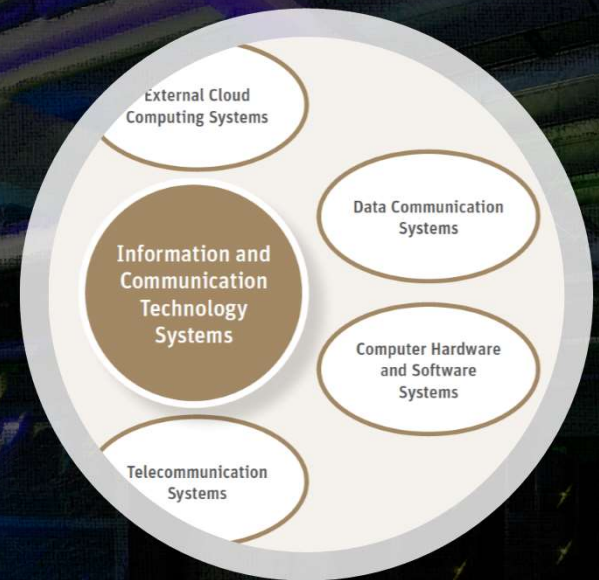
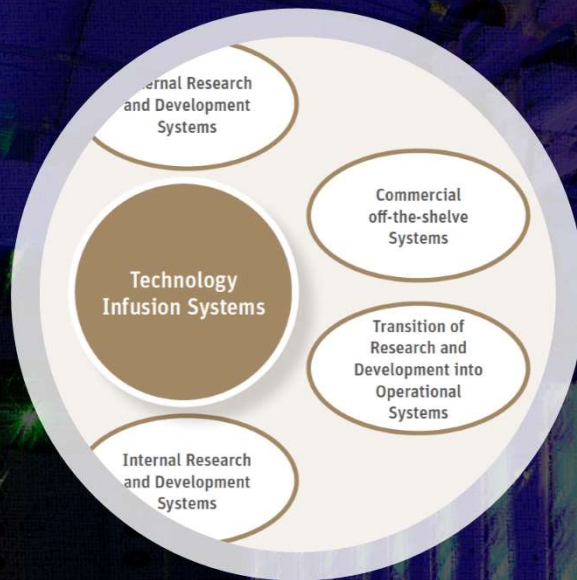
Stakeholder  
Institutional Training

# A system of systems

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## Category 3: Support systems



# Data Management

Global Surface Observations (Met)

GTS/MSS

National Surface Observations (Met)

MDAS

Satellite data

GEONetCast

Radar data

RDAS

Global and Regional NWP/EPS

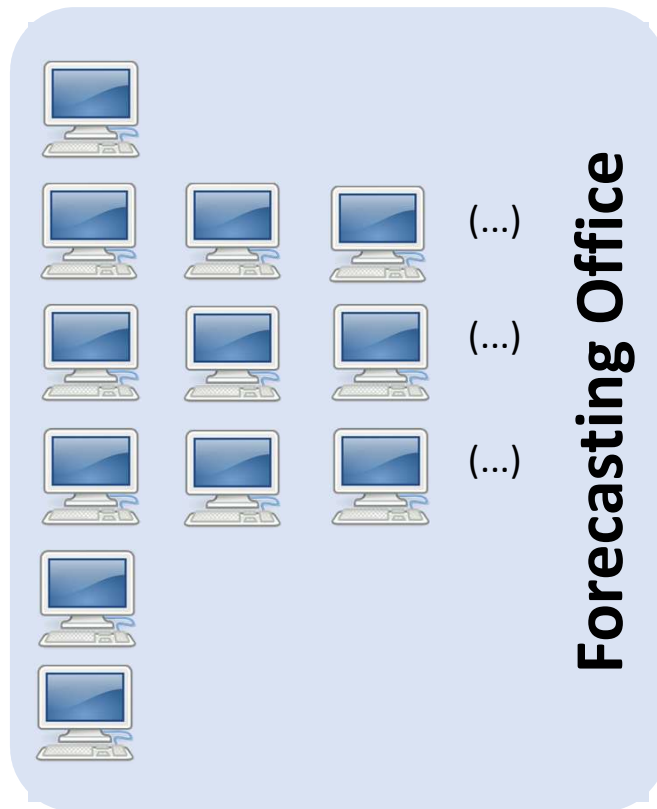
GTS

LAM

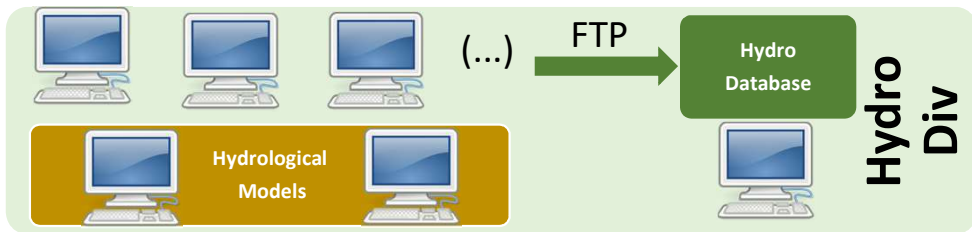
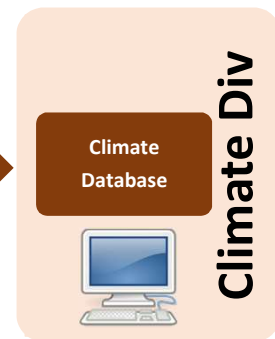
FTP

National Observations (Hydro)

HDAS



FTP





Global Surface  
Observations  
(Met)

GTS/MSS

National Surface  
Observations  
(Met)

MDAS

Satellite data

GEONetCast

Radar data

RDAS

Global and  
Regional  
NWP/EPS

GTS

LAM

FTP

National  
Observations  
(Hydro)

HDAS

## Centralized Datacenter



Clima DB

HydroDB

Forecast  
er WS

Operations

Models

SD  
Platform

(...)

Clima DB

HydroDB

Forecast  
er WS

Development &  
Backup

Models

SD  
Platform

(...)



Met Div



Hydro Div

Forecasting  
Office



# Capacity Building

- Core disciplines
- ICT skills
- On-the-job training
- Training trainers
- Twinning with advanced NMHSs
- University education

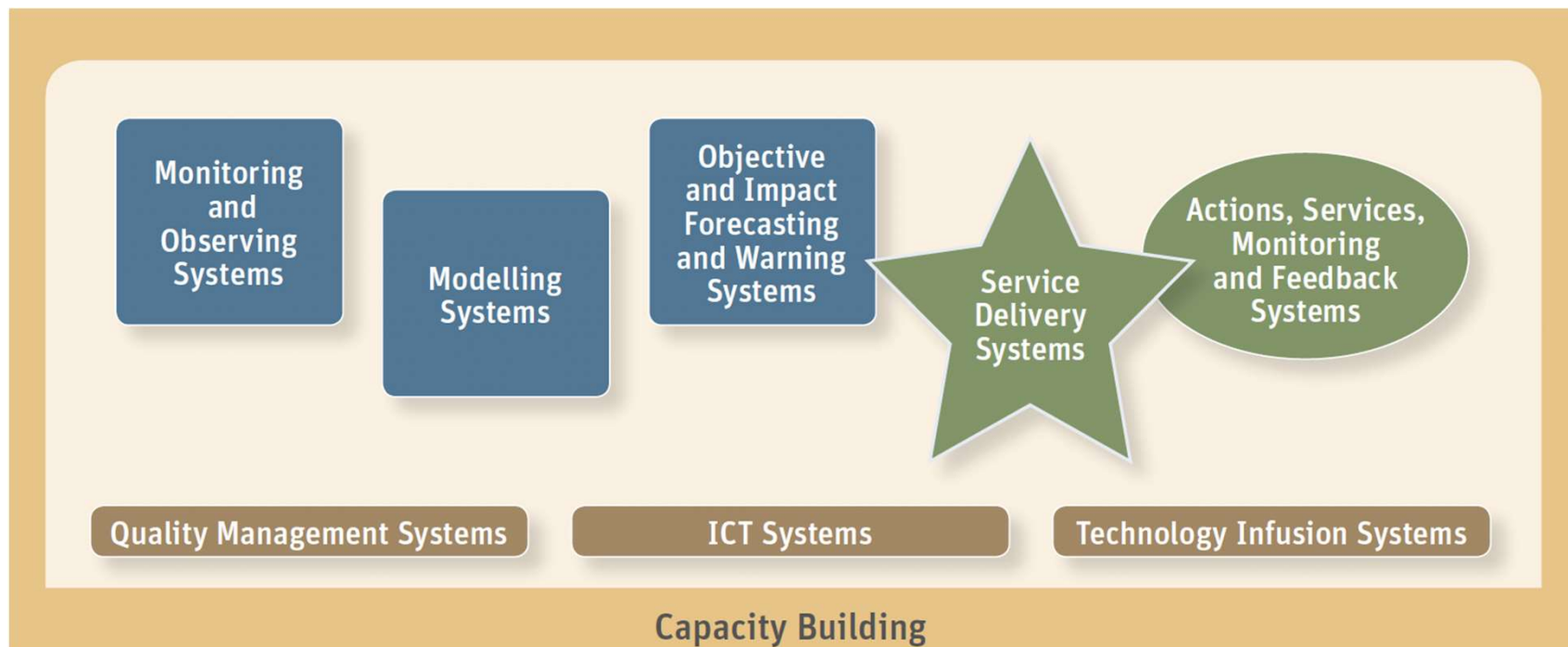


Capacity  
Building

Stakeholder  
Institutional Training

# A system of systems

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# Business Models

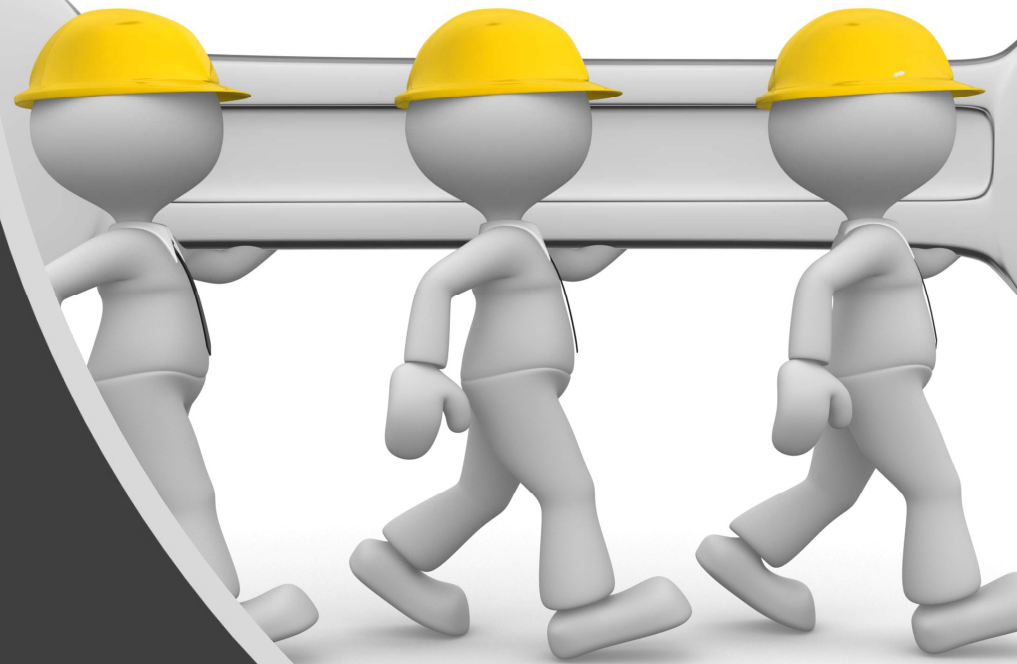
- Cost centers
- Own and operate Observational networks
- Observation networks as a service
- Data as a service
- Own and operate local area models
- Outsource NWP services
- Outsource ICT functions
- Infrastructure as service





# Concept of operations

- Consensus among all stakeholders, reduce risks, improve quality
- Who are the stakeholders?
- What are needs?
- Can we meet their needs?
- If not, what capabilities are required of the system?
- Who does what? where? and when?
- How will the system be resourced, designed built and maintained?



# Capacity Building

- Keeping up with rapidly evolving GWE skills
- Developing skill in business practices
- Twinning with advanced NMHSs and private sector
- Tertiary education in business practices



Capacity  
Building

Stakeholder  
Institutional Training



Thank you

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