LASER PULSE

Long-term Assistance and SErvices for Research (LASER)
Partners for University-Led Solutions Engine (PULSE)

EAST AFRICA WATER SECURITY PROJECT

TRAINING MANUAL: Introductory Training on the use of Data for Decision Making to Improve Water Security

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ABOUT LASER PULSE

LASER (Long-term Assistance and SErvices for Research) PULSE (Partners for University-Led Solutions Engine) is a five-year, $70M program funded through USAID's Innovation, Technology, and Research Hub, that delivers research-driven solutions to field-sourced development challenges in USAID partner countries.

A consortium led by Purdue University, with core partners Catholic Relief Services, Indiana University, Makerere University, and the University of Notre Dame, implements the LASER PULSE program through a growing network of 3,000 researchers and development practitioners in 61 countries.

LASER PULSE collaborates with USAID missions, bureaus, and independent offices, and other local stakeholders to identify research needs for critical development challenges, and funds and strengthens the capacity of researcher-practitioner teams to co-design solutions that translate into policy and practice.

CONTENTS

1 ABOUT THE MANUAL

This Manual has been developed as part of the LASER PULSE East Africa Water Security project. The project focuses on providing water information and data access for water resources decision making and management for the East African countries of Kenya, Tanzania, and Uganda to ultimately improve water security across the region. It is a collaboration between an academically oriented Research Team[1] and Translation Partners[2] who are development practitioners, aiming to ensure that "*research ultimately results in on-the-ground solutions to development challenges*."[3]

WHAT IS LASER PULSE?
LASER PULSE stands for Long-term Assistance and Services for Research, Partners for University-Led Solutions Engine. It is a USAID-funded consortium that convenes and catalyzes a global network of universities, government agencies, nongovernmental organizations and the private sector. The Consortium members are Purdue University, Catholic Relief Services, Indiana University, Makerere University, and the University of Notre Dame. Through collaboration between researchers and practitioners, LASER PULSE delivers research-driven, practical solutions to critical development challenges in low- and middle-income countries.

This Manual is intended for use in training water resources managers, policymakers, and other water resources personnel on the use of data for decision making to improve water security. It is designed for an introductory training (1−2 days) on the basics of watershed modeling, research/results translation, and data–policy relations. The Manual has limitations with respect to time; it focusses on the process whilst suggesting potential tools and techniques that interested Trainees may use for an in-depth look on the topics.

The Manual is organized in three parts:

Part A (Training Material) is based on three modules that build on each other, yet are individually complete and stand-alone such that a trainee who takes a module obtains its complete process-wise picture. *Module I* introduces the 'hard' science and application of watershed modeling, using three watersheds in East Africa (Sasumua; Kenya, Simiyu; Tanzania, and Murchison Bay; Uganda) as the starting point, infused with insights and lessons from other parts of the world. *Module II* introduces research/results translation including examples of translation products and their dissemination mechanisms based on stakeholder preferences, and technology compatibilities, among others. *Module III* explores the interdependence between data and policy. Each Module highlights the limitations and key considerations for success.

Part B (Facilitators' Guide) provides the Facilitator with adaptable tricks and approaches for delivering the training. This is by no means prescriptive. It is only a foundation for the Facilitator to contextualize the training based on an understanding of the prevailing circumstances such as Trainees' background and prior experiences, time availability for the training and available logistics, among other factors.

Part C (Annexes) comprises handouts of presentations made during the workshop, along with an exercise workbook with worksheets associated with each of the modules, and example consent and photo release forms.

[1] Purdue University, US Department of Agriculture (U.S.A), Makerere University (Uganda), University of Dar es Salaam (Tanzania)
[2] AidEnvironment (Uganda), Global Water Partnership Tanzania (Tanzania), Resource Plan (Kenya)
[3] LASER PULSE (2020). LASER PULSE Research Awards Manual, available at https://laserpulse.org/publication/laser-pulse-core-research-awards-manual/

2 MODULE I: MODELING

This Module aims at explaining the science and application of hydrological modeling. It covers the rationale and potential applications for modeling, explores challenges surrounding data needs for modeling and their resolution, and explains additional issues that may be encountered in applications.

2.1 Introduction

A model is a representation of something. In the context of water resources, the something is typically a watershed or watershed system. It could also be specific entities within the system, e.g. a reservoir, an urban area, etc. that are modelled as part of or apart from the watershed system. In modeling, we use existing concepts, equations, and numbers to describe the past, present, and/or anticipated future states of our water resource systems.

So why are we modeling? Oftentimes, we use modeling to understand underlying processes and patterns; for example, how pollutants move in the environment; watershed conditions that can result in flooding, etc. We can also use models to conduct assessments, such as to determine if there are specific areas in a watershed that are of particular concern. In areas where landscape or land use changes are planned or being contemplated, modeling helps provide insights into how the watershed will respond, should such changes be implemented; for example: would these cause more or less flooding downstream; would implementation lead to an increase or decrease in a particular pollutant of concern, etc.

Changes, occurrences, and systems that can be represented using modeling include (and are not limited to): land use responses and land use changes; climate changes and climate interactions; floods and flooding; management (pollutant control) practice effects (BMPs); ponds and reservoirs; etc.

2.2 Tools and Input

2.2.1 Modeling tools/software

Because a lot can be accomplished through modeling, there is a large number and great variety of modeling tools and software available. These models work at different spatial scales—ranging from plot to river basin—and may produce outputs at a variety of timesteps (average annual through daily or hourly) even while the model itself operates on a specific timestep (e.g. daily). The types of processes or components simulated vary across models and, therefore, so do the outputs produced. Thus, before selecting a model, it is important to ask yourself some key questions (Box at right).

CHOOSING A MODEL

1. Why are you modeling? What are you modeling?
2. What components are of interest? What level of output is desired?
3. What data do you have available? In what quantities? What is its quality?
4. How much computational power do you have? Do you have the base software?
5. Do you have time/capacity to work on modifications if needed?

2.2.2 Data

Data[4] are the basis for all modeling calculations and analyses. In this sense, they provide the foundation for decision-making and management. It is, therefore, critical that data be accessible and of good quality, such that resulting information is objective.

Baseline data used in modeling includes land use, climate, topography, soil map units, watershed boundaries, hydrography, and gaging station locations. Other inputs include management, crop parameters, soil properties, and features that are important for representing the watershed. Having detailed in-stream data including stream discharges, and sediment and nutrient loads or concentrations is important for in-depth model calibration and validation[5], which helps improve accuracy of modeling results. If other constituents are of concern, having measured values of the constituents is also important. Baseline spatial data can be obtained from open data repositories[6] such as the USGS Earth Explorer and ISRIC SOTER databases. Climate, and river gaging station locations and associated data are best obtained from country-specific entities that collect and curate the data.

In case of limited or no data, information can be obtained from secondary sources. This includes data already published in any form and that have not necessarily been collected by the researchers, for example: literature-based values of soil hydraulic conductivity summarized by broad soil classes and textures. Management operations data, such as planting and harvesting dates and fertilizer application dates and rates, can be obtained from standard recommendations with the underlying assumptions that landowners follow recommendations. It is good practice to verify the information at a local level by, for example, speaking with landowners, watershed managers, and other agents working in the area of interest. Parameter Regionalization[7] can be used in instances where in-stream data are either insufficient or unavailable for use with model calibrations. A soft-data approach can also be used, allowing simulated values to be compared with published data from the same or similar regions. Climate data can be generated using weather/climate generators. If using these, it is important to check that the generators are effective in simulating essential characteristics[8] in addition to basic statistical properties of the local climate.

2.3 Key Considerations for Modeling

2.3.1 The problem model divergence

Ideally, performance—especially performance statistics (Nash-Sutcliffe Efficiency, NSE and Coefficient of Determination, R^2)—obtained should not differ substantially between calibration and validation phases. Furthermore, values of these statistics should not differ substantially, i.e. values obtained for NSE should not differ substantially from those obtained

[4] Singular or plural? Both are acceptable; the plural construction is more common in published material.
[5] Moriasi et al (2015). Hydrologic and water quality models: Performance measures and evaluation criteria. doi: 10.13031/trans.58.10715
[6] https://earthexplorer.usgs.gov/; https://www.isric.org/projects/soil-and-terrain-soter-database-programme
[7] Gitau and Chaubey (2010). Regionalization of SWAT model parameters for use in ungauged watersheds. https://doi.org/10.3390/w2040849; Merz and Bloschl (1995). Regionalisation of catchment model parameters. https://doi.org/10.1016/j.jhydrol.2003.09.028
[8] Mehan et al. (2017). Comparative study of different stochastic weather generators for long-term climate data simulation. https://doi.org/10.3390/cli5020026

for R^2. When this happens, the phenomenon is known as model divergence[9] and is an indicator of inadequate or improper parameterization. This means that the model would need to be re-calibrated and re-validated.

2.3.2 The problem of equifinality

Similar to the problem of model divergence, is the problem of equifinality[10]. In this case, different parameter sets can give the same performance. This brings up the question as to which set provided suitable or the most suitable representation of watershed responses. Resolving this problem requires an in-depth knowledge of the system being studied.

2.3.3 Getting around data limitations

All in all, data unavailability, insufficiency, and quality present the biggest challenges for modeling. To get around data limitations, it is important to:

- Know your data (and its/their limitations): What data do you have? In what quantities? At what scales? What is its quality? What are the key characteristics?
- Know your watershed/the system that you are modeling: What goes on in the watershed/area? Have you visited the watershed? Spoken with residents or those working in the area?
- Use multiple methods of evaluating model performance[11]: graphical, statistical, soft-data, other.
- Document everything carefully.

2.3.4 Documentation and reporting

As with any other scientific endeavor, the reproducibility of modeling results is of utmost importance. This entails careful documentation and reporting of the modeling effort(s), and more so when working in data-scarce areas or contexts. Include a description of the methodology used in sufficient detail to allow someone else to reproduce the work. Include tables of default and calibrated parameter values along with acceptable parameter ranges. Include complete details on model performance including calibration, validation, and diagnosis along with supporting information. With the transition towards open information and open data, consider sharing your data files, model code, and supplemental materials. A major concern in this regard is ensure that you get credit for your work/products. Today, a variety of open data repositories exist that will provide a Digital Object Identifier (DOI) for products deposited at their sites, such that these products can be cited appropriately.

2.4 Watershed Model Applications & Results

2.4.1 The 3 example watersheds in East Africa

2.4.1.1 General Attributes

The three watersheds of focus in in East Africa are Sasumua (Kenya), Simiyu (Tanzania), and Murchison Bay (Uganda). These watersheds represent a variety of landscapes from mountainous to coastal; and threats to water security including urbanization, climate change,

[9] Sorooshian, S.; Gupta, V.K. Model Calibration. In Computer Models of Watershed Hydrology; Singh, V.P., Ed.; Water Resources Publications: Highlands Ranch, CO, USA, 1995.
[10] Beven, K. 1996. Equifinality and Uncertainty in Geomorphological Modeling. The Scientific Nature of Geomorphology: Proceedings of the 27th Binghamton Symposium
[11] Moriasi et al (2015). Hydrologic and water quality models: Performance measures and evaluation criteria. doi: 10.13031/trans.58.10715

and land degradation. The similarities and differences across watersheds make them ideal examples.

Table 1: Characteristics of the three watersheds

Watershed	Characteristics	Current threats
Murchison Bay Watershed, Uganda (Kiggundu et al., 2018)	▪ Area: 40.9 km2 ▪ Average annual rainfall: 1,290 mm ▪ Supports a variety of human activities ▪ Core changes: urban expansion (29%); decreases in agricultural areas (18%), forests (6%), and wetlands (7%)	▪ Anthropogenic perturbations particularly land use/land cover change ▪ Associated water quantity and quality impacts
Simiyu River Watershed, Tanzania (Mulungu and Munishi, 2007; Rwetabula et al., 2007)	▪ Area: 13,972 km2 ▪ Average annual rainfall: 700 mm–1,000 mm ▪ Simiyu River is ephemeral ▪ Waters discharged into Lake Victoria ▪ Primary land uses: Grassland, woodland, cultivated land ▪ Water uses: agriculture, fishing and livestock production.	▪ Water fluxes due to land use/land cover change ▪ Pollutants in water courses ▪ High rates of erosion
Sasumua River Watershed, Kenya (Mwangi et al., 2015)	▪ Area: 107 km2 ▪ Average annual rainfall: 1,000–1,600 mm. ▪ Land use: primarily agricultural and forested ▪ Provides 20% of the water supply for the City of Nairobi. ▪ Western and central parts characterized by poorly drained soils	▪ Erosion and flooding in the western and central parts ▪ Land degradation ▪ Associated water quality impacts

2.4.1.2 Modeling Approach

Why SWAT model: The Soil and Water Assessment Tool (SWAT)[12] is a continuous-simulation, daily time step, physically-based, watershed-scale model that can be used to predict land use, land management, and climate impacts on water, sediment, nutrients, and other chemical yields in complex watersheds over long periods of time. Some of the strengths of SWAT include that it is well supported with detailed web-based documentation, active user support groups, and regional and international conference offerings. The model package offers accessible databases, Geographic Information Systems (GIS) interface tools, pre- and post-processing tools, and open-source code. In addition, SWAT has been extensively used worldwide including in the study areas in the three East African countries by the project Co-Principal Investigators (Co-PIs)[13].

Building the model: As described earlier, the SWAT model requires a variety of datasets to simulate water quantity and water quality. The model simulates the watershed by delineating into sub-watersheds or subbasins, which are further sub-divided into homogeneous hydrologic response units (HRUs), which are a product of a unique combination of average slope, soil type, and land use. For the applications presented, the required data were obtained

[12] Arnold, J.G., Srinivasan, R., Muttiah, R.S., and Williams, J.R. (1998). Large area hydrologic modeling and assessment part I: Model Development. https://doi.org/10.1111/j.1752-1688.1998.tb05961.x

[13] Anaba, L.A., Banadda, N., Kiggundu, N., Wanyama, J., Engel, B., and Moriasi, D. (2017). Application of SWAT to assess the effects of land use change in the Murchison Bay catchment in Uganda. 10.4236/cweee.2017.61003; Mulungu, D.M.M. and Munishi, S.E. (2007). Simiyu River catchment parameterization using SWAT model. https://doi.org/10.1016/j.pce.2007.07.053; Mwangi, J.K., Shisanya, C.A., Gathenya, J.M., Namirembe S., and Moriasi, D.N. (2015). A modeling approach to evaluate the impact of conservation practices on runoff and sediments in Sasumua watershed, Kenya. DOI: https://doi.org/10.2489/jswc.70.2.75.

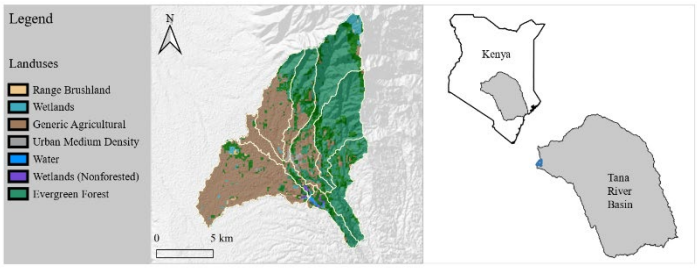
from available sources, processed, and used to build the SWAT model for each of the watersheds. Appropriate SWAT GIS-based user interfaces were used to build the SWAT model. Care was taken to ensure that the study areas were accurately represented in the model, including making sure that major physical features such as the presence of reservoirs/dams; river/stream channel network, management practices etc. were represented, so as to minimize chances of obtaining inaccurate final model outputs.

Model parameter adjustments: Due to limited or lack of information about important parameters, parameter values that are considered suitable for the use of a model in each study area were determined by adjusting parameters that are sensitive to the process of interest, that is, through calibration. Parameters to be adjusted for the important processes were determined through a process called sensitivity analysis that determined parameters that impacted the outputs of interest the most. Adjustment was stopped when model outputs compared reasonably well with available measured data. Subsequent simulated values were evaluated using pre-set performance criteria thresholds or compared with literature values for model outputs in which measured data was not available. We called this process model validation.

Defining and performing modeling scenarios: Once model outputs were validated, the model was deemed ready to be used for various applications, which we call modeling scenarios. In general, the scenarios consisted of quantifying the impacts of current concerns in each watershed and exploring possible solutions to the identified issues. This information is useful for decision and policy making. watershed-specific concerns, study objectives, model validation results, and the scenarios and the corresponding results are provided next.

2.4.1.3 Sasumua watershed

Location:



Size: ~136 km^2

Watershed is located within the Tana River Basin

Aqueduct connects Chania River to Sasumua River 5 km upstream of dam, and water is diverted from Kiburu River to reservoir

Primary landcover transitions from agriculture to forest as elevation increases

Problem statement: A major concern for Sasumua watershed is the encroachment of agricultural land in forested areas of the watershed that increases the likelihood of use of fertilizers that can affect the water quality for this important source of fresh water for the city of Nairobi. Another concern is limited information on the impacts of a changing climate on the watershed.

Study objectives: The overall goal was to demonstrate the use of data for water resources management decision-making. This was accomplished by using the SWAT model to quantify the impacts of various management practices on water quality and climate change on water resources.

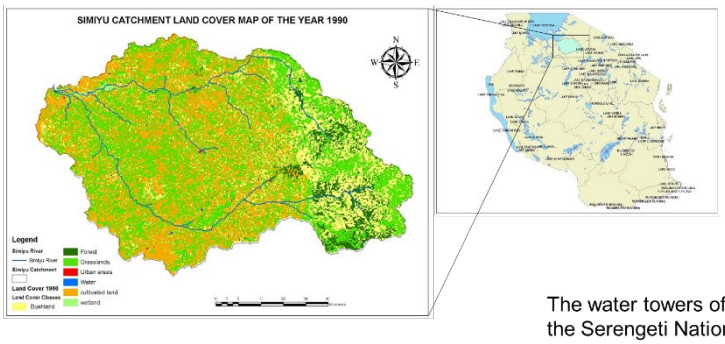
Validation of model outputs: There were no measured data available to validate model outputs for Sasumua watershed. However, model surface runoff and sediment outputs were within the reported values.

Scenarios & implications for policy & decision-making: The two overarching scenarios applied in Sasumua watershed were: quantifying the impacts of various management practices on water resources; and, the impact of future climate scenarios on water resources. The studied management practices were riparian buffers, filter stirps, terracing, field diversions, agricultural water harvesting ponds, and a combination of all of them. Four future climate scenarios were developed and used to determine their impact on water flows.

The results indicated that overall, for three of four future scenarios the water flows could be more than twice the values for the baseline period of 2011-2020. With respect to the impacts of management practices on water quality, results indicated that the filter strips reduced watershed sediments losses the most. However, combining all the management practices is the most successful approach to reducing watershed losses. With regard to policy and decision-making, it is recommended that data policies be updated to improve curation and access among relevant agencies to ensure that data is accessible for informing water resources management decisions.

2.4.1.4 Simiyu watershed

Location:



Simiyu River catchment Drains its water into the Lake Victoria

Total Area ~10,659 km^2

The River Simiyu is ephemeral and contains water during and immediately after a storm event only

The water towers of the Simiyu are from the Serengeti National Park (SNP) and the Maswa Game Reserve - famous touristic attractions in the world

Problem statement: The main concerns for the Simiyu watershed is the increased human activities that have led to major land use changes resulting in high amounts of sediment and nutrient losses into water bodies. In addition, climate change has led to reduced agricultural productivity with respect to both crop yields and livestock production. Another major issue is limited data to help determine and understand the impacts of these land use changes and climate change on the hydrology of the watershed.

Study objectives: The objectives of this study were to analyze current and future projected climate data to identify trends that have significant impacts on water resources and agricultural production, quantify the land use changes, and then use the SWAT model to assess the impacts of land use and land cover changes on water budget components and sediments of the Simiyu Watershed.

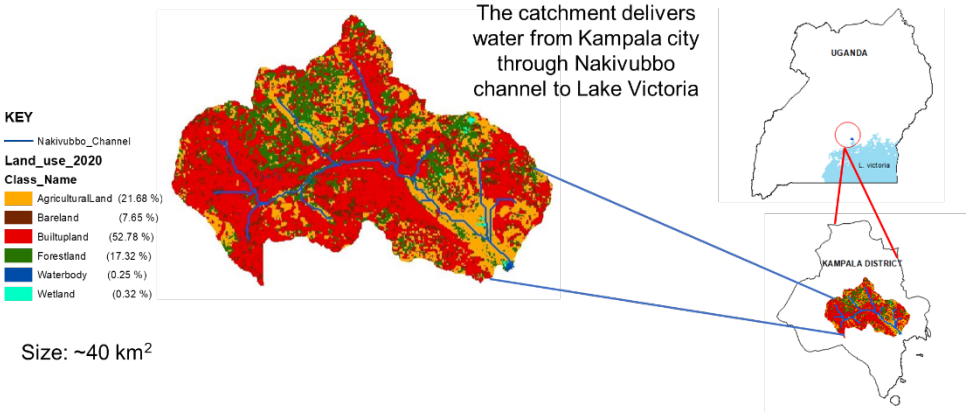
Validation of model outputs: Overall model outputs were within 13% of measured flow and within 22% of measured sediment and nutrients, which are within acceptable modeling performance criteria.

Scenarios & implications for policy & decision-making: The main scenarios in the Simiyu watershed involved quantifying the impacts of land use and climate change on water resources. The main land use changes are increase in urban and cultivated areas. Analysis of precipitation data indicated that currently, precipitation has increased by 62% compared to the historical baseline period while future projections indicated an increasing trend of more than 100%. Although temperature seemed to be increasing, trends were insignificant.

Modeling results indicated that overland flow and total water yield will increase rapidly in all the climate scenarios, which could lead to increased incidences of flooding in the basin. Results of impacts of land use changes indicated that sediments increased by more than 7%. The likelihood of increased sediments and nutrients will lead to poor water quality in the basin.

2.4.1.5 Murchison Bay watershed

Location:



Problem statement: The major concern for Murchison Bay watershed is human induced natural resources degradation and unregulated land use land cover changes over the last decade. Yet, the impacts of these changes on water resources are poorly understood.

Study objectives: The overall goal of this study was to assess the effects of land use land cover change on water quantity and quality. This was accomplished by assessing the spatial and temporal changes in land use and land cover in the watershed followed by the use of the validated SWAT model to predict the impacts of these changes on water resources.

Validation of model outputs: Slide Summary: Simulated stream flow outputs were within 3% of observed values, which is a satisfactory model performance. There were no measured surface runoff and sediment data with which to compare the model outputs. However, simulated surface runoff and sediment outputs were within the reported values.

Scenarios & implications for policy & decision-making: The main scenarios involved quantifying the impacts of land use changes from the past to present and to the projected future land use changes. Another scenario was to apply several management practices and

quantify their impact on water resources. The best management practices applied studied were vegetative filter strips, grassed waterways, and surface runoff detention ponds.

Overall, results indicated that stream flow, surface runoff, and some nutrients increased with current and projected changes in land use. The increased streamflow may explain the increasing incidences of flooding. Increasing population has been the leading driver of wetland loss and increased sediment yield over the years and the deteriorating water quality in the catchment. Results of the impacts of best management practices showed that vegetative filter strips at filter width of 2 m reduced sediment yield by 42% and 5 m by 70%. Retention ponds of 20 m^3 reduced surface run of by 60% in the catchment. However, the grassed waterways presented minimal impact. These interventions will lead to increased groundwater recharge, hence people in low areas will have to be resettled.

2.4.1.6 General conclusions

1) Generally, major challenges are associated with land use changes, climate change, and a growing population.
2) There is need for resilient and sustainable production systems for a growing population under a changing climate, while conserving the environment.
3) SWAT shows potential as a tool with which to quantify the impacts of land use and climate changes, and identify best management practice systems to mitigate against associated negative impacts.
4) A major observation is the issue of limited data. It is recommended that data policies be updated to improve curation and access among relevant agencies to ensure that data is accessible for informing water resources management decisions.

2.5 Useful Resources and Tools

- General Perspectives on Modeling and Modeling Applications Handouts
- LASER PULSE East Africa Water Security Quick Reference Guide

DISCUSSION QUESTIONS

1. What can be done to ensure data are available in ample quantities for use with modeling applications?
2. How many of you are familiar with use of model for work like this one? What specific topics would you be interested more about with respect to modeling?
3. What pollutants are causing the impairments/threats in your catchment? Where are the pollutants coming from?
4. What management/conservation practices are you familiar with?
    - Specifically – how is the riparian buffer defined for policy and decision-making in each country?
5. In general, have you noticed incidences of drought and flooding within your catchment? What have been/are the negative impacts of drought and flooding within your catchment?
    - From your observations, have you noticed a trend in the number of incidences related to drought and flooding within your catchment from the past to present? In general, would you say they remain same, decreasing, or increasing? What do you think would be possible solutions and why?

3 MODULE II: RESEARCH/RESULTS TRANSLATION

This Module aims at bridging the gap between knowledge generation (through research and modeling) and practice (implementation). It covers possible ways of packaging and disseminating the knowledge considering stakeholder preferences and capacity (including technological compatibilities).

3.1 Raw and Processed Data & Results

Data and results can be packaged in three different formats based on anticipated users and uses:

1. Processed data and results should be packaged to provide actionable information and enable their use by water quality managers and other water professionals in water resources decision-making and management. This can be done by packaging data for easy download and interoperability with different applications (e.g., as csv or txt files); providing online visualizations of detailed results using graphs, charts, or maps; and, providing downloadable pdf and printed versions of the visualizations to account for different levels of technology.
2. Snapshot visualizations of aggregated results in a variety of forms—including graphs, charts, maps, and color bars—with accompanying text narratives. These can be presented online as web-based visualizations with explanatory text and downloadable pdfs, and in print as easy-distribution pamphlets or factsheets. This format is targeted at the individual, including youth, and contains information on how to access the products in the other two formats depending on interest and need.
3. Raw data (where possible), processed data, and base model parameters should be packaged to enable their use in research. These data should also be packaged for easy download and interoperability with different models and tools (e.g., as *.csv, *.txt). The datasets are targeted at personnel in higher education and/or research institutions and consultants for use in conducting water resources research.

3.2 Research Results, Translation Products & Dissemination

In addition to raw and processed data, the research/modeling process generates various products including default model parameter sets and reports, among others. These products should be packaged into targeted translation knowledge products for different stakeholders. The knowledge products could include: 1) briefing documents; 2) press releases; 3) videos; 4) others.

3.2.1 Briefing documents

These include policy briefs, research briefs, evidence briefs, technical briefs, and white papers, among others. LASER PULSE identifies the following considerations for a brief.

- Map the policy environment to understand who will use your brief.
- Research key groups to understand what is most important to them and how to best influence them.
- Engage stakeholders early on to build confidence, trust, and ownership in your work.
- Tailor your brief's content, language, and framing toward a specific audience.

- Target the right people at the right time with the right message through the right channel.
- Consider a variety of complementary dissemination activities.

Additional guidance on the preparation and utilization of briefs, as well as templates, can be found here.[14]

DISCUSSION QUESTIONS

1. Which products are most produced through research and modeling?
2. What do you see as strengths and barriers in utilizing research and modeling products?
3. In which forms could the products be packaged and disseminated to enhance effectiveness?
4. What other products/types of products would be helpful in your work? In which other products would you be interested?

3.2.2 Press releases

A press release is an official statement delivered to the media to briefly communicate something significant and specific, e.g., an event, report, etc. The intention is to notify the media in the hope that it will trigger a news item about the topic. A press release should have a "catchy' heading, and the first paragraph should have information on the "who," "what," "why," and "where." When preparing a press release, keep your target audience in mind and send it to a journalist who has shown interest in the topic of the release.

3.2.3 Videos

The human brain remembers visual content a lot more than written content. An average person retains about 10% of the message when they read it and 95% when they watch it. (https://sheffieldav.com/production/5-reasons-we-love-video-marketing-and-you-should-too)

Make the knowledge products available in multiple formats to account for differences in stakeholder preferences and capacity (including technological compatibilities). The formats include electronic and print; text, maps, graphs, charts, color bars; downloadable data; etc. Publicize the products widely through socio-professional media such as LinkedIn, and through other media for example in newsletters, and personal and project websites.

3.3 Key Considerations for Success

Integrate translation in the research process instead of as a final phase: Instead of a two-phase process in which research findings are translated into practical applications after the research has been concluded, research translation is most effective if it is an integrated component of the entire research cycle. From the very beginning of the process, researchers (scientists) aiming to find solutions to a development challenge should collaborate with practitioners working to solve it, ensuring that the solutions are custom-generated, and easily adapted and applied by the practitioners.

Identify and involve key stakeholders early in the research process: Involving key stakeholders at critical -if not all – moments in the research process builds stakeholders' awareness about (and input into) the translated products, enhances stakeholder ownership of the process, and increases the likelihood of the stakeholders adopting and applying the

[14] https://laserpulse.org/wp-content/uploads/2022/01/How-to-Plan-for-and-Utilize-a-Brief.pdf

products. Stakeholder mapping, analysis, and engagement planning should be an integral part of the research process.

Custom-make the knowledge products: The content and language of the translation knowledge products should depend on the stakeholder's needs and be as context specific as possible. While not all members of your audience can relate well to scientific information, they most likely will like a good story about how research can solve their everyday problems. Instead of describing your research process, focus on why the problem needs solving (how it affects the audience), what solutions your research offers, and what it would take to implement the solutions.

3.4 Useful Resources and Tools

- Research/Results Translation Handout
- Embedded Research Translation Overview: https://laserpulse.org/wp-content/uploads/2021/06/Embedded_Research_Translation_Overview.pdf
- Effective Storytelling in Research Translation: https://laserpulse.org/wp-content/uploads/2021/10/Effective-Storytelling-in-Research-Translation-Summary.pdf
- Embedded Research Translation Stakeholder Analysis
- https://laserpulse.org/wp-content/uploads/2021/10/ERT_Stakeholder_Analysis_2020.pdf
- How to Plan for and Utilize a Brief: https://laserpulse.org/wp-content/uploads/2022/01/How-to-Plan-for-and-Utilize-a-Brief.pdf

4 MODULE III: DATA POLICY

This Module explains the important link between policy and data. It also addresses potential ways to improve documentation that will help increase the availability of data in the future.

4.1 Interdependence Between Data and Policy

It is important to acknowledge that data has value. It is a tool for research, and that research has the power to help decision-makers determine how to effectively distribute funding and what programs and concepts are worthy of their attention. If available, water and climate data can play a pivotal role in important projects like flood risk assessment and early warning systems, planning hydropower infrastructure, or understanding the best way to protect water resources. When data of future interest is not collected or when data is collected but remains inaccessible, this can be considered as a loss of potential. It follows then that funding towards climate and water data programs is a wise investment in informing decisions for success.

4.2 Crucial Elements for Increasing Access to Climate and Water Data

The use of comprehensive and direct language in policies and documentation indicating how data will be collected, stored, and made available to the public creates an excellent foundation upon which effective data infrastructure can be arranged. Based on a survey of existing documentation from various countries within and beyond the East African region, the presence of a formal commitment to making data available to the public was strongly correlated with data accessibility. Some additional key elements included clear definitions of the party responsible for collecting and disseminating a data type, the destination database where these records would be accumulated, and the format in which data would be stored (e.g. variables, units, file type).

4.3 Key Considerations for Success

Although no individual element would be expected to carry a national climate and water data program, there is evidence that thoroughness of documentation on these subjects is more likely to culminate in a functional, accessible portal for data access.

4.4 Useful Resources and Tools

- Data Policy Handout
- Comparative Evaluation of Water Resource Data Policy Inventories Towards the Improvement of East African Climate and Water Data Infrastructure: https://link.springer.com/article/10.1007/s11269-022-03231-z

PART B: FACILITATORS' GUIDE

5 FACILITATORS' GUIDE

5.1 Introduction

The training approach includes introductory PowerPoint presentations; open discussions and break-out sessions as needed for Trainees to share their experiences; on on-the-fly question and answer sessions to gauge Trainee learning and perceptions; and, where possible, a field visit to expose the Trainees to the on-the-ground application of the training. Each Module should end with a rapid evaluation—preferably using audience engagement apps such as Poll Everywhere or manual rapid response systems such as clickers—to evaluate learning, and/or obtain participant perspectives and suggestions for future engagement.

5.2 Workshop Personnel and Roles

Workshop Organizer(s): Coordinate workshop program and content development, register and consent participants, handle workshop and site logistics, facilitate hybrid participation and overall participant integration, assign workshop personnel roles, oversee overall workshop delivery.

Facilitator(s): Coordinate the delivery of specific modules including loading presentations, introducing speakers, time keeping, Question & Answer (Q&A) session, discussions, and rapid evaluation. One or two facilitators could be engaged in any one module depending on audience size and nature of workshop activities. If two are needed, the facilitators will decide on specific roles for each person and communicate these to the workshop organizers.

Notetaker(s): Keep a record of workshop proceedings either through hand-written or typed notes, or audio and video recordings. Generally, both formats are encouraged with a preference for audio and video recordings if only one format is feasible. Notetakers should also capture any comments/questions provided via online chat, if the workshop is offered online or in hybrid mode, and collect any written input provided by in-person participants.

Presenter(s): Develop and deliver presentation, engage audience in discussion related to the presentations, provide responses to questions from the audience, provide a copy of the presentation to module facilitator.

Coordinator(s): In the event that there are multiple presentations in a given module, workshop organizers will designate one of the presenters to coordinate the presentations—including content and delivery—to provide continuity and avoid duplication of content.

Note: workshop personnel may serve in multiple roles except that facilitators in any one module should not serve as notetakers for that particular module.

5.3 General Tips

Obtain signed consent forms and photo releases prior to starting the workshop. Ideally, these should be obtained as part of participant registration and can also be obtained at the time for the workshop for those not pre-registered. (*Workshop Organizer(s)*)

Online or Hybrid modes: Ask online participants to mute their microphones and stay on mute unless speaking to the larger group. Ask online participants to raise their virtual hand if they wish to speak. Assign one person to monitor online participation. This could be the same person throughout the workshop or one person per module. (*Workshop Organizer(s)*)

General tips for power point presentations (*Presenters*)

- Avoid wordy slides. The slide is as a reminder to you on what to say, not for your audience to read. Put short statements as reminders to yourself about what to say and in what order. Include illustrations, quotes, tables, and similar.
- Avoid font types and colors that are difficult to read. Check the presentation from where the participants will be seated and see if the slides are legible.
- Importantly, the number of slides should depend on the time available/allocated for your presentation. In general, plan for 1-1.5 minutes per slide. For interactive presentations, you will need an average of 3 minutes per slide, thus, do not prepare more than 10 slides for a 30-minute presentation.

5.4 Module I

- Decide upfront if you are okay with participants asking questions on–the-fly or you would prefer that participants hold their questions to the end of the presentation(s). For lengthy presentations, the presenter(s) could choose to pause briefly at intervals to allow participants to ask questions. (*Facilitator(s) in consultation with Presenter(s)*)
- Decide upfront if you will introduce all presenters at the beginning of the module or at each presentation. For longer and/or more complex presentations, introduce all speakers upfront. Obtain brief bios of the presenters beforehand. (*Facilitator(s)*)
- Start with general perspectives on modeling, framed considering regional contexts and needs. (*1 Presenter*)
- Provide examples of modeling applications within the region, starting with an overview of goals and methodologies used. Next, address watershed specific challenges including an overview of the problem addressed, goals, model calibration and validation, scenario evaluations, and a summary of key findings. Finally, tie things together by returning to and framing the findings in the broader context. (*1 Primary Presenter/Coordinator; other Presenters based on watersheds represented*)
- Provide information on tools and resources available to participants. (*1 Presenter*)
- Facilitate a discussion session on key issues related to the module. (*1-2 Facilitators, 1-2 Notetakers; use breakout sessions/rooms if necessary*). For hybrid sessions, online participants could form a separate breakout group, in which case, assign one of the online participants to take notes of the discussion. Encourage online participants to use the chat function to provide their inputs or questions. (*Facilitator(s)*)

- Provide a summary of key items coming out of discussions and any post-workshop action/activities to be undertaken. (*Facilitator(s), Notetaker(s)*)
- Conduct rapid evaluation. (*Facilitator(s)*)

5.5 Module II

- What you need for the session: presentation materials, discussion points (questions in manual provide a starting point), guides for group work. (*Facilitator(s), Presenter*)
- Check the participants' knowledge and adjust the length and speed of the module. Your audience may only need a refresher if they are already familiar with the topic. Ask the following questions at the start of the session: What does research translation mean? Why is research translation important? (*Facilitator(s)*)
- Engage the participants: break the presentation every few minutes to get participants' feedback. The feedback may be in form of questions, additional information or comments. When participants ask challenging questions, do not feel pressured to answer all by yourself; remember, your participants are experts, ask them to answer some of the questions. (*Facilitator(s), Notetakers*)
- Conduct rapid evaluation. (*Facilitator(s)*)

5.6 Module III

- What you need for the session: presentation materials, discussion points, ground rules and guide for group work. (*Facilitator(s), Presenter*)
- Check the participants' knowledge and adjust the length and speed of the module. Your audience may only need a refresher if they are already familiar with the topic. Ask the following questions at the start of the session: Why are data policies important? What data policies impact you in practice? (*Facilitator(s)*)
- Engage the participants: break the presentation every few minutes to get participants' feedback. The feedback may be in the form of questions, additional information, or comments. When participants ask challenging questions, do not feel pressured to answer all by yourself; remember, your participants are experts, ask them to answer some of the questions. (*Facilitator(s), Notetakers*)
- Provide information on tools and resources available to participants. (*Facilitator(s)*)
- Conduct rapid evaluation. (*Facilitator(s)*)

PART C: ANNEXES

6 ANNEXES

The pages that follow contain:

- Handouts of the PowerPoint presentations used in this training workshop. The presentations are also available online (see below).
- An Exercise Workbook comprising exercise worksheets for each of the modules.

Handouts

- Module I: Modeling
- Module II: Research Results Translation
- Module III: Data Policy

Workshop Presentation Links

- Module I: General Perspectives on Modeling
- Module I: Modeling Applications
- Module II: Research Results Translation
- Module III: Data Policy

Workbook with Worksheets

- Workbook with Worksheets

Consent and Photo Release Forms

- Consent and Photo Release Forms

MODULE I

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General Perspectives on Modeling

Focus on Data

LASER PULSE East Africa Water Security Workshop

September 5, 2022

Margaret W. Gitau

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Objectives

- Describe rationale and potential applications for modeling
- Explore challenges surrounding data needs for modeling and their resolution
- Explain additional issues that may be encountered in applications

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Why are we modeling?

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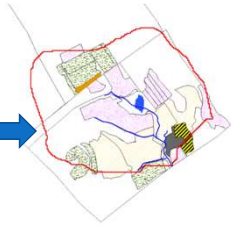
Models and Modeling



A representation of something, e.g. a watershed system

Use existing concepts, equations, and numbers to describe past, present, and/or anticipated future states

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How much of the contaminant will arrive at the stream and in what form?

Are there specific areas that we need to be concerned about

- Understand underlying processes and patterns
- Conduct assessments
- Make predictions/What-if-scenarios
- Decision-support
- Design solutions

Keep cattle away from the streams

What happens if we convert this pasture to an urban area?

If change is inevitable:
Measures to reduce runoff volumes and peak runoff rates, erosion
Measures to address source factors
Etc.

Photo credits: SFWMD, EPA

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What exactly are we modeling?

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Land Use Changes

Source of photos: 2009 SFWMD Photointerpretation Key ©WREE/2022

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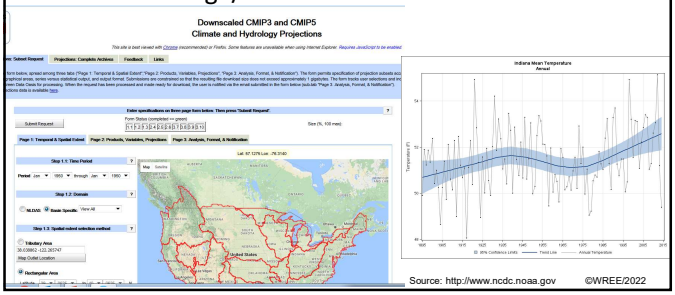
Climate Change/Interactions



Source: http://www.ncdc.noaa.gov ©WREE/2022

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Management Practice Effects

Photo Credits: USDA-NRCS ©WREE/2022

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To be able to do this we need…

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Importance of data in modeling

- Data
  - Basis for all modeling calculations and analyses
  - Factual information including raw measurements, processed or aggregated information, statistics, etc.
  - Provide the foundation for decision-making and management
- Available, Accessible, Good Quality Data
  - Improves objectivity of resulting information
  - Critical for making good decisions

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Model Inputs

- Baseline data
  - Land use, climate, soils, topography, watershed boundaries, hydrography, discharge stations
- Other inputs
  - Management operations
  - Crop parameters
  - Soils details
  - Reservoirs
  - Etc.
- In-stream data
  - Streamflow
  - Sediment
  - Nutrients, pesticides, etc.

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What if you don't have the data or have limited data?

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Data Categories

- Secondary
  - Data already published in any form
  - Not necessarily collected by the researcher(s)
  - Less costly, requires less resources
  - Maybe deemed less reliable*
  - *Scientific procedures exist by which these data can be handled reliably.*

Table 1. Saturated hydraulic con

USDA Soil Class	Texture	Rawls et al. (1982)* Porosity ($m^3 m^{-3}$)	Rawls et al. (1982)* K_s ($mm\ h^{-1}$)	Clapp & Hornberger (1978)† Porosity ($m^3 m^{-3}$)	Clapp & Hornberger (1978)† K_s ($mm\ h^{-1}$)
Sand		0.44	210.0	0.40	296.6
Fine Sand					
Loamy Sand		0.44	61.1	0.44	145.8
Loamy Fine Sand					
Sandy Loam		0.45	25.9	0.44	44.1

Source: Rawls et al., 1989

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Management Data

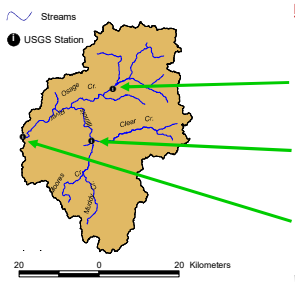
Table 1. Planting, harvesting, and grazing dates used in the model, based on Hively (2004) and Dewing (2005).[a]

Land Use	Year	Plant/Begin Growing Season	First Harvest	Second Harvest	Third Harvest	Grazing
Alfalfa	1	1 May		15 July	25 Aug.	
	2+	1 May	1 June	15 July	25 Aug.	
Corn	All	15 May	1 Oct.			
Grass	1	10 May		1 July	15 Aug.	
	2+	10 May	20 May	1 July	15 Aug.	
Grass (with grazing)	1	10 May		1 July	15 Aug.	
	2+	10 May	20 May			Graze 1 June, 15 June, 15 July, 15 Aug.
Pastures	All	1 May				Cows assumed to be uniformly spread over pasture areas
Pastures (intensive grazing)	All	1 May				Graze 10 and 25 May, 10 June, 1 and 25 July, 25 Aug., 25 Sept.

[a] Plow date = 1 May. Cows are moved from pasture after 1 day and return to the same area after 14 to 30 days. Cows reduce biomass by 50% when grazing. Manure not spread on pastures when cows are grazing.

Source: Gitau et al., 2008

Regionalization of SWAT Model Parameters



Monthly Nash-Sutcliffe Coefficients

Gage	Calib.	Global	Regr.
Elm Spr.	0.90	0.81	0.75
	0.77	0.66	0.79
Savoy	0.64	0.69	0.38
	0.64	0.61	0.55
Siloam Spr.	0.78	0.61	0.52
	0.77	0.49	0.69

WY 98-00; WY 00-04 (Gitau and Chaubey, 2010)

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Other ways of looking at model performance

Component	Simulated Value	Watershed Wide* and Published Estimates	Source
Sediment (tonnes/ha/yr)			
Cropland	19.20	20-25	Lamont (2003), Pers. Comm.
Pasture	1.66	1.73 and <2.50	CCE** (1987) Lamont (2003). Pers. Comm.
Forest	0.83	0.99	CCE (1987)
Dissolved P – Phosphorus (kg/ha/yr)			
Hay/Pasture	0.18 / 0.31	0.08 - 2.00	Osei *et al.* (2003)
Watershed	0.16	0.14	Scott *et al.* (1998)
Total P – Phosphorus (kg/ha/yr)			
Hay / Pasture	2.09 / 1.24	0.4 - 6.96	Osei *et al.* (2003)

Source: Gitau et al., 2006

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Weather/Climate Generators and Future Time Series Projections

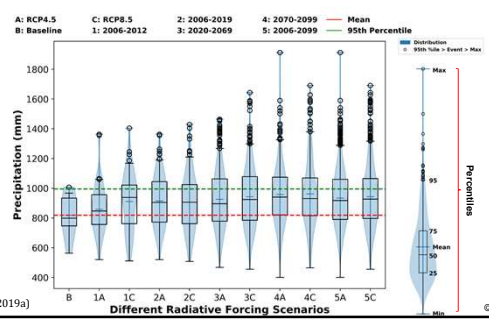
Keep in mind…

Weather Generator Effectiveness in Simulating Essential Characteristics of Weather/Climate

Characteristics	Obs†	CLIGEN	LARS-WG
Max Precipitation, mm	111.8	147.0	111.5
Max Temperature, °C	41.1	45.4	38.8
Min Temperature, °C	25.6	31.9	25.6
% days with Min Temp ≤ 0.5 °C‡	34.8	34.8	36.2
Wet Sequences Count	18.0	24.0	24.0
Dry Sequence Count	213.0	279.0	223.0
% days with Max Temp > 35 °C*	0.4	8.7	0.2
% days with Mean Temp <10 °C*	47.3	47.1	47.6

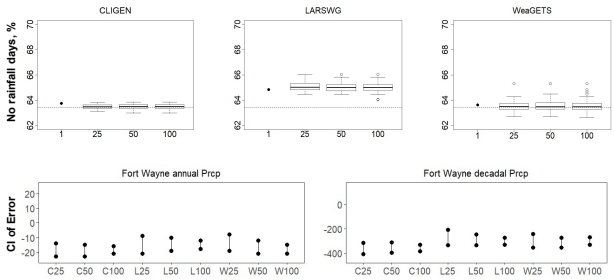
Mehan et al. (2017)

Precipitation Projections



Mehan et al. (2019a)

How many realizations (simulation runs) do we need to capture the observed value?



Guo et al. (2017)

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Additional Issues

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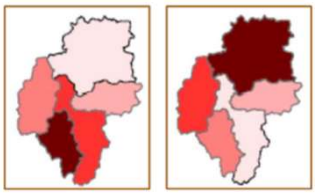
The problem of model divergence

Performance (especially statistics) obtained from calibration and validation are drastically different

Values of R^2 and NSE also differ by a large margin (give different diagnosis)



*Example representation

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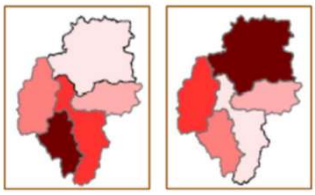
The problem of equifinality

Different parameter sets can give the same performance

Which set is representative of particular watershed responses?



*Example representation

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Getting around data limitations

- Know your data
- Be aware of strengths and limitations of your datasets
- Know your watershed
- Identify important parameters
- Use multiple methods of evaluating performance
  - Document carefully

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Documentation and Reporting

- Reproducibility of modeling results
- Include complete details of modeling effort
- Include table of default and calibrated parameter values (including acceptable ranges is good too)
- Include complete details on model performance (calibration, validation, diagnosis-with supporting info)
- Transition toward open information, open data:
  - Sharing data files, model code, supplemental materials
  - Major concern is source crediting.

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Next Up….

Modeling Applications (Results from Watershed Modeling)

Primary Presenters/Coordinators:

Dr. Daniel Moriasi, USDA-ARS/Dr. Nicholas Kiggundu, Makerere University

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Watershed model applications

Workshop 05/09/2022

D. Moriasi, N. Kiggundu, V. Garibay, S. Munishi, M. Gitau, B. Mati

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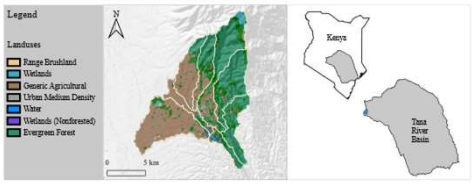
3- Watersheds: Sasumua - Kenya



Size: ~136km^2

Watershed is located within the Tana River Basin

Aqueduct connects Chania River to Sasumua River 5km upstream of dam, and water is diverted from Kiburu River to reservoir

Primary landcover transitions from agriculture to forest as elevation increases

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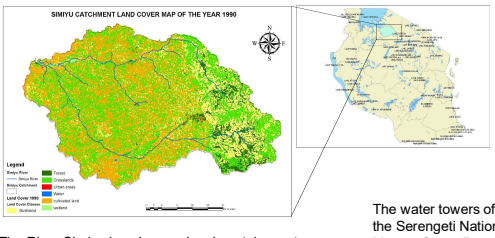
3- Watersheds: Simiyu - Tanzania



Simiyu River catchment Drains its water into the Lake Victoria

Total Area ~10,659 km^2

The River Simiyu is ephemeral and contains water during and immediately after a storm event only

The water towers of the Simiyu are from the Serengeti National Park (SNP) and the Maswa Game Reserve - famous touristic attractions in the world

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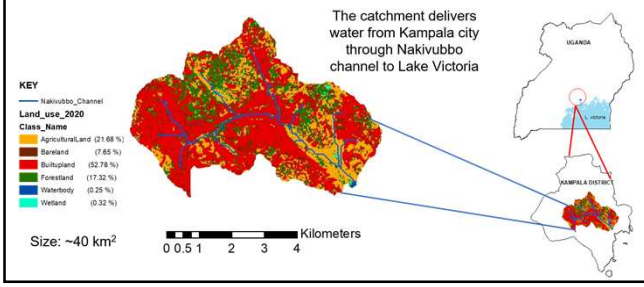
3- Watersheds: Murchison Bay - Uganda



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Modeling Approach

- Model
- Build the model: proper study site representation
- Model parameter adjustments – model outputs vs. measurements
  - Compare with available measurements and published literature
- Define and perform modeling scenarios

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Sasumua: Problem Statement

- Upstream catchment where agricultural activities have encroached on natural catchment for the dam
- Land fragmentation with intensive agriculture and use of inputs likely to pollute water resources
- Urban centres which have sprang up after the Sasumua dam was built. These are rapidly growing with threat of pollution of water resources
- Water abstraction for Nairobi city amid shortages for rural people (mostly shortage of irrigation water)
- Climate change threats and their impact on water resources not adequately quantified.

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Sasumua: Problem Statement

- Sasumua is an upstream watershed and provides a substantial amount of fresh water to Nairobi. Keeping water quality high is important to downstream interests.
- Agricultural land is slowly beginning to encroach on forested areas of the watershed.
- There is little information on what impacts the changing climate will have on Sasumua Watershed.

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Sasumua: Case Study Objectives

Overall Objective: Demonstrate data use for data-driven decision-making with respect to water resources management

Specific Objectives

1. Develop a SWAT + model for the Sasumua River Watershed.
2. Predict the effects of implementing a variety of management practices on sediment and nutrient losses.
3. Form an impression of how projected changes in climate will affect the watershed.

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Sasumua: Validation of model outputs

	ET	Surface Runoff	Sediment
Target	75%	14%	< 10 tons/ha
Calibration	43%	15%	0.04 tons/ha
Validation	37%	20%	0.07 tons/ha

- Archer, D. (1996) Suspended sediment yields in the Nairobi area of Kenya and environmental controls. In *Erosion and sediment yield: global and regional perspectives. Proceedings of the Exeter Symposium, July 1996*, Eds. Walling, D.E. & Webb, B.W. Vol. 236, 37–48.
- Hunink, J. E., & Droogers, P. (2011). Physiographical baseline survey for the Upper Tana catchment: erosion and sediment yield assessment. Future Water Report, 112, 31. https://futurewater.nl/wp-content/uploads/2013/01/2011_TanaSed_FW-1121.pdf Accessed 7 Jan 2022.
- Mwangi et al.(2015) in *Journal of Soil and Water Conservation*, *70*(2):75–90. https://doi.org/10.2489/jswc.70.2.75

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Sasumua: Scenario Descriptions

Two scenario types were considered in the Sasumua case study:

- Effects of Conservation Measures (6 Scenarios)
- Effects of Future Climate (4 Scenarios)

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Sasumua: Management Scenario Descriptions

Management Scenario	Modifications
Baseline	Cross slope tillage implemented on agricultural land.
1 Riparian Buffers	Indiscriminate buffer of rangeland around the stream network.
2 Filter Strips	Field Border filter strips.
3 Terracing	Contoured terraces on 3-8% slopes with sod outlets implemented on agricultural land.
4 Field Diversions	Field diversion terraces at 40 m intervals on 3-8% slopes implemented on agricultural land.
5 Agricultural Water Harvesting Ponds	Addition of ponds on farms for irrigation modelled as equivalent subbasin pond.
6 Combined Application	Modifications for Scenarios 1, 2, 3, and 5 together.

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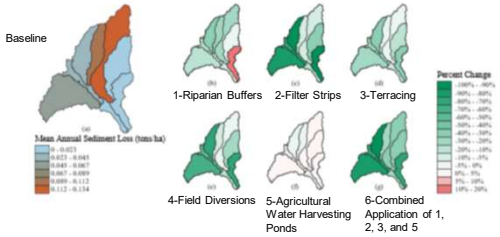
Sasumua: Management scenario implications for policy and decision-making



12

The combined management scenario 6 produced the most substantial results; scenario 2 was the most effective among single measures.

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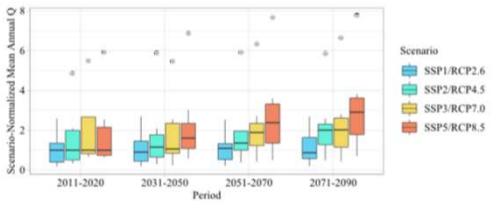
Sasumua: Climate scenario implications for policy and decision-making



3 of 4 climate scenarios showed a flow increase of 2+ times the modern period.

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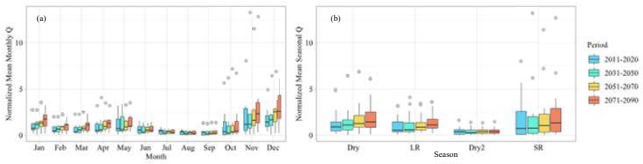
Sasumua: Climate scenario implications for policy and decision-making

- Monthly and Seasonal Flows for "Middle-of-the-Road" Scenario



Flow increases for first dry and short rains season are projected (Nov/Dec/Jan) in response to more short rains precipitation.

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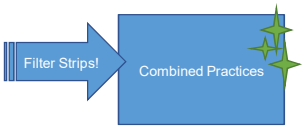
Sasumua: Findings

Flows for three of four future scenarios are in excess of double the 2011-2020 values.



The management practice scenario which was most successful at reducing basin losses was that which combined several practices together.

The single measure which resulted in the greatest positive impact when modelled was filter strips, suggesting the implementation of this practice at minimum.

Data policies must be updated to improve curation and access among relevant agencies to ensure that data is accessible for informing water resources management decisions.

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Simiyu: Problem Statement

- Increased in Anthropogenic activities that have resulted in extensive Land Use changes
- The Simiyu river is reported to yield high amount of sediments, nitrogen and phosphorus draining into the Lake Victoria (Machiwa, 2003; Mwanuzi, 2006 Kimwaga et al., 2011)
- High rainfall fluctuations between seasons and from one year to the other, affecting the communities around the wetlands whose socio-economic activities are heavily dependent on the rainfall resulting in a reduction of agricultural and livestock production.
- Insufficient Data on the impacts of land uses and climate on the catchment hydrology
- Poor understanding of the Impacts of land uses and Climate changes of the catchment hydrology

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Simiyu: Study Objectives

- The Specific Goals:
  1. Analysis of the climate data from 1980 to 2019 and to the projected scenario 2030 - 2060 to identify periods of heavy rainfall, extended dry periods and trends in climate data
  2. Quantifying the Land Use Changes and Climate Changes in the Simiyu Catchment from 1970 to 2019
  3. Hydrological Modeling Using SWAT model to assess the Impacts of Land Use and Land Cover Changes on water budget components and sediments of the Simiyu Catchment

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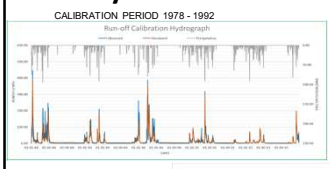
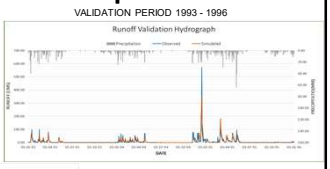
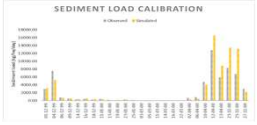
Simiyu: Validation of model outputs

CALIBRATION PERIOD 1978 - 1992



VALIDATION PERIOD 1993 - 1996





Slide Summary: 5% and 13% overall error for flow during calibration and validation periods, 22.1% overall error for sediments and nutrients

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Simiyu: Scenario Descriptions

- Impacts of Land Use changes on the Catchment Water Balance
- Impacts of Climate Changes on the catchments Water Balance

Source: https://www.facebook.com/CloudsFmRadio/photos/

Slide Summary: improper expansion of cultivated land in areas around Simiyu catchment. Recent studies have projected occurrence of flooding incidents in the catchment

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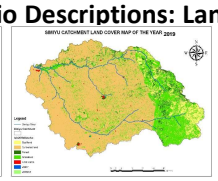
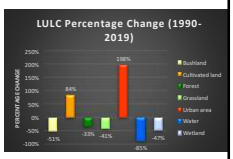
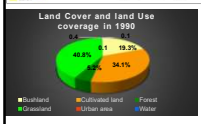
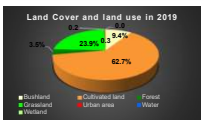
Simiyu Scenario Descriptions: Land Use Changes









Slide Summary: Urban areas are increasing rapidly followed by the increase cultivated land in Simiyu catchment

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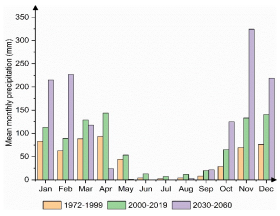
Simiyu Scenario Descriptions: Precipitation Changes



- Historical Dataset
- RCP 6.0

Slide Summary: precipitation in the current period increased by 62% as compared to the historical baseline period. In the future period, precipitation show an increasing trend of more than 100%. Temperature is increasing with non-significant trend

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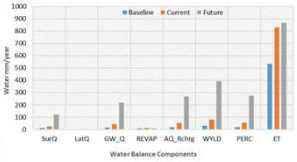
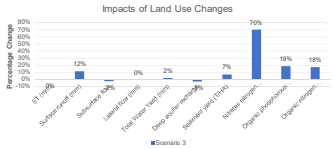
Simiyu: Model outputs of scenarios and implications

Scenario Description	
Scenario 1	Average annual change in water balance parameters with the change in climate from 1972/1988 - 2000/2019
Scenario 3	Projected average annual change in water balance parameter with the changing in climate condition from 1972/1988-2030-2060
Scenario 2	Average annual change in water balance parameters with the change in Land cover and land use in Simiyu watershed from 1990 to 2019





Slide Summary: Overland flow are increasing rapidly in all the climate scenarios averagely above 12 % Sediments is increasing by more tha 7% in land use change scenario

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Findings

- Projected climate show increase in surface run-off and the total Water yield in the catchment show possibility of flooding in the basin
- Rapid increase in Nutrient in the basin which indicates the increase of human and pollution activities in the catchment threating the integrity of the water quality

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Murchison Bay: Problem Statement

- The Murchison bay catchment has undergone several Human induced natural resources degradation and unregulated land use land cover changes (LULCC) over the last decade (Anaba et al, 2017).
- The current and future impacts of such changes on water quality and quantities are poorly understood and have not been predicted.
- Hence a study of the impacts of LULCC on catchment hydrology for better water resource management in the catchment.

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Murchison Bay: Study Objectives

Overall Objective: To assess the effects of Land use Land cover change on water quantity and quality in the Murchison Bay catchment of Uganda.

Specific Objectives

1. To assess the spatial and temporal nature of Land use Land cover changes in the Murchison Bay catchment in Uganda,
2. To calibrate and validate a SWAT model for the simulation of discharge and sediment yield for the Murchison Bay catchment,
3. To predict the future impacts of Land use land cover changes on water quantity and quality in the catchment.

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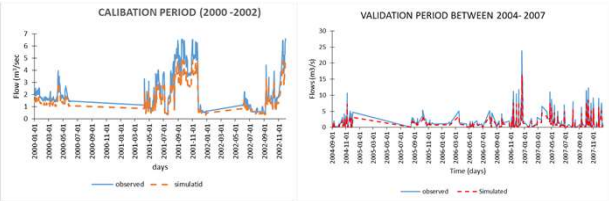
Murchison Bay: Calibration &Validation of model outputs



Slide Summary: Model over estimated flow during calibration but predicted perfectly during validation

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Murchison Bay validation out puts

Model Prediction Performance was considered satisfactory

Stage Model	Evaluated statistics			
Performance indices	R2	NSE	RSR	PBIAS
Calibration (2000-2002)	0.74	0.72	0.43	-0.05
Validation (2004-2007)	0.68	0.75	0.55	2.35

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Murchison Bay: Validation of model outputs

Stage	ET (%)	Surface Runoff(%)	Sediment (ton/ha)
Target	80	30	< 7
Calibration	45	18	0.17
Validation	38	24	0.23

Slide Summary: the flow was overestimated during calibration

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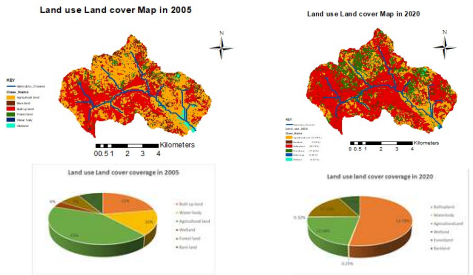
Murchison Bay: Scenario Descriptions Land use change between 2005 to 2020



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Murchison Bay: Model outputs of scenarios and implications for policy and decision-making

Component	Budget	Watershed		
		Scenario1 (mm) Baseline (2000)	Scenario 2 (mm) Predicted output2030	Scenario 3 Predicted output2040
Water quantity	ET (mm)	581	588	589
	Surface runoff (mm)	269	298	310
	Subsurface flow (baseflow) (mm)	725	716	706
	Soil moisture (mm)	20	19	19
	Stream flow(mm)	993	1015	1015
	Discharge (mm/day)	736	1024	1023
	Deep aquifer recharge	38	37	36
Water quality	Soil erosion			
	Sediment yield(T/ha)	13	12	12
	Total nitrogen (Kg/ha)	150	164	171
	Nitrates nitrogen (leaching) (Kg/ha)	69	62	62
	Total phosphorus(Kg/ha)	26	29	31
	Total soluble phosphorus(Kg/ha)	0	0	0
	Organic phosphorous(Kg/ha)	2	2	1
	Organic nitrogen(Kg/ha)	16	12	11

Slide Summary: SWAT Outputs Between the year 2000 to 2020, 2030, 2040

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Murchison Bay: Scenario Descriptions, Best management Practices(BMPs)

Management scenario	Response
1. Vegetation Filter strips(VFS)	Both Back Yard and compound strips instead of paved surfaces, but also garden borders
2. Grassed waterways	These were applied at the mean width (GWATW) 1 m, 2 m, 5 m at shorter length ranging between 0.5 km to 1 km, since Murchison bay is in the city
3. Surface runoff detention Ponds	At the backyard of every infrastructure and along highways (1 m width, 2 m , 5 m and 10 m)

GMW2

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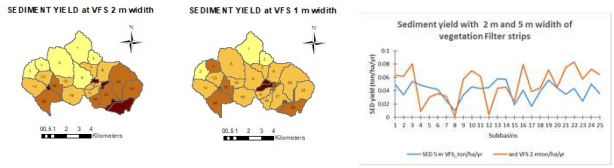
Murchison Bay: Model outputs of scenarios and implications for policy and decision-making



Slide Summary: the Vegetation filter strip at 2 m reduces sediment yield by 21 %

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Tying Things Together

- Over the last 20 year the Murchison Bay has undergone several land use land cover changes with built up land increasing at faster rate of 0.7%.
- This explains why the Stream flow is increasing and floods as indicated by scenario results.
- The increasing population in the catchment is the leading driver of wetland loss and increased sediment yield over the years and the deteriorating water quality in the catchment.

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Best Management Practices Recommended

1. Planting of vegetation filter strips at filter width of 2 m reduced sediment yield by 42% and 5 m by 70% in all subbasins.
2. The retention ponds of 20 m^3 reduced surface run of by 60% in the catchment. However, the grassed waterways presented minimal impact.
3. The interventions are leading to increased groundwater recharge, hence people in low areas will have to be resettled.

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Tying Things Together

Therefore, sustainable environmental management measures are suggested:

i. Sensitizing the masses on proper waste management,
ii. Improved drainage structures with grass strips,
iii. Demarcation of buffer zones and enforcement against encroachment at least 30 m from the riverbanks and 300 m form the lake,
iv. Rainwater harvesting promotional campaigns to control excess roof and ground surface runoff water.

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Discussion Questions

1. What can be done to ensure data are available in ample quantities for use with modeling applications?
2. How many of are familiar with use of model for work like this one? What specific topics would you be interested more about with respect to modeling?
3. What management practices are you familiar with?
   - Specifically – how is the riparian buffer defined for policy and decision-making in each country?

MODULE II

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Module Two
Research/Results Translation

Workshop 05/09/2022

V. Kongo, B. Mati, J.W. Kisekka

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In this presentation …

- Overview
- Data and results
- Knowledge products
- Considerations for success
- Moving forward

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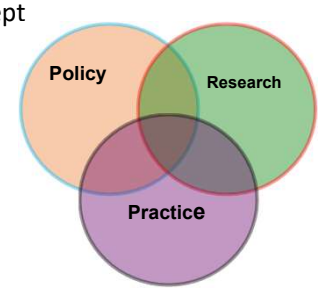
The Triple Helix Concept



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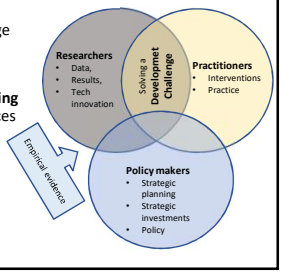
Overview: Moving from Research to Practice

- Module Aim: **bridging the gap** between knowledge generation and practice
- Covers: possible ways of **packaging & disseminating** the knowledge considering stakeholder preferences and capacity



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Data & results are the starting point …

- Processed data and results
  - packaged data for easy download and interoperability with different applications (e.g., csv, txt files)
  - providing visualizations of detailed results (graphs, charts, maps) – > online and printed
  - Targeting water quality managers and other water professionals
- Raw data, processed data, and base model parameters
  - packaged for easy download and interoperability (e.g., as *.csv, *.txt)
  - targeting personnel in higher education and/or research institutions and consultants
- CONSIDER DATA SHARING PERMISSIONS

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Example …

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Which (other) outputs are most produced through (your) research and modelling?

LASER PULSE EA WS Project will generate:
- Default model parameter sets,
- Reports,
- Quick reference guide

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Transform data & results into SH targeted knowledge products, e.g.

1. Briefing documents
   - policy briefs, research briefs, evidence briefs, technical briefs, white papers, brochures, etc.

   Important
   - **who** will use your brief
   - what is **most important to them** and how to best influence them
   - **engage early** on to build confidence, trust, and ownership
   - **Tailormade** content, language, and framing
   - Target the **right people** at the right **time** with the right **message** through the right **channel**
   - Consider a variety of **complementary dissemination** activities

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Example …

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Transform data & results into SH targeted knowledge products, e.g.

2. Press releases
   - **official statement** delivered to the **media** to **briefly communicate** something significant and specific

   Important
   - "catchy' **heading,**
   - **first paragraph** should have information on the "**who,**" "**what,**" "**why**," and "**where**
   - **Facts and figures (+ source),** but preference differs among SH
   - **A photo** that 'communicates'
   - keep your **target audience in mind** and send to an '**interested' journalist**

COMMUNICATIONS EXPERTISE NEEDED

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Transform data & results into SH targeted knowledge products, e.g.

3. Videos
   - Retention of visual content vs written content.
   - An average person retains about 10% of the message when they read it and 95% when they watch it.

Example

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Transform data & results into SH targeted knowledge products, e.g.

What other (types of) knowledge products would be helpful in your work?

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Important considerations for success

What would enhance success of research translation?

- Translation should be **part of the process**, rather than a final step
- Identify and **involve key stakeholders early** in the research process
- **Custom-make** the knowledge products

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Moving forward …

What do you see as strengths and barriers in utilizing research and modelling products?

What would you want to know more about?

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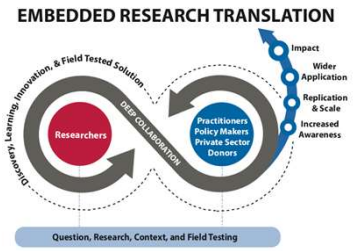
LASER PULSE ERT model



MODULE III

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Improving Data Policy:

Crucial Elements for Increasing Access to Climate and Water Data

LASER PULSE East Africa Water Security Workshop

September 5, 2022

V.M. Garibay, M. Gitau, J. Kisekka

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Primary Objective

Identify impediments to data-driven decision making for water resources decision making and management

- What policy elements are not resulting in open data dissemination?
- What do countries with reputations for open data do differently?
- Which aspects of data policy are the most important to the development of open data infrastructure?

Approach: Mine existing and past documents related to water resources management and analyze data obtained.

Published Paper:
Garibay, V.M., Gitau, M.W., Kongo, V., Moriasi, D. (2022) Comparative Evaluation of Water Resource Data Policy Inventories Towards the Improvement of East African Climate and Water Data Infrastructure. *Water Resource Management.* *https://doi.org/10.1007/s11269-022-03231- z*

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Procedure Overview

Locate Documents & Determine Scope

- Legislation, Official Websites, and Officially Sourced Documents
- 3 Primary Countries + 3 East African Countries + 4 Additional Countries

Develop and Conduct Survey

- Common elements were identified.
- Question-based survey with binary (Y/N) response options.

Analyze Results

- Comparison of elements present for functioning versus non-functioning databases/data streams.
- Representation Metric calculated for simplified comparisons by region, country, and data type.

3

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Survey Organization

Themes

- Meteorology
- Water Quantity
- Water Quality

Elements

- Format
- Instrumentation
- Digitization
- Destination
- Service Provision
- Responsibility
- Chain of Command
- Functionality
- Accessibility

4

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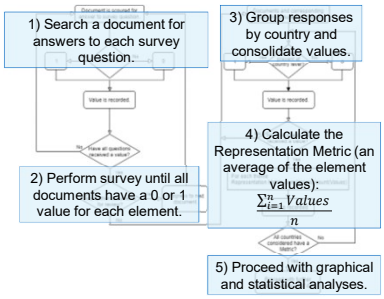

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Example Document Survey Questions: Data Curation

Category: Data Curation

Element: Destination | Digitization | Service Provision | Functionality | Accessibility

Question

Accessibility

"Does data access require approval?"

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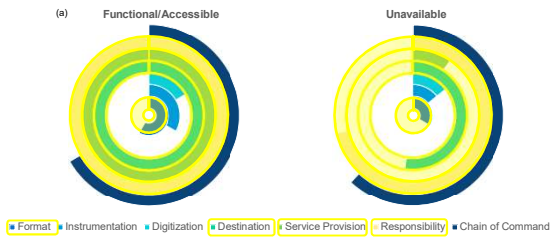

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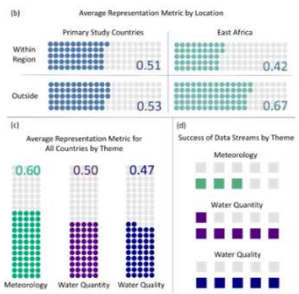

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Summary and Recommendations

The presence of more elements is correlated with data stream success.

Processes surrounding water quantity and quality data are not as well documented.

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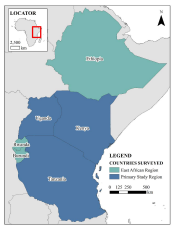
Summary and Recommendations



avg (Burundi, Canada, Ethiopia, Germany, Rwanda, South Africa, United States) ≈ avg (Kenya, Tanzania, Uganda)

avg (Kenya, Tanzania, Uganda) > avg (Burundi, Ethiopia, Rwanda)

avg (Kenya, Tanzania, Uganda) < avg (Canada, Germany, South Africa, United States)

10

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Summary and Recommendations

Build on the elements Format, Destination, Responsibility, and Service Provision.

- Define variables to be collected.
- Standardize units.
- Define a database or repository for consolidating data.
- Improve inter-database accessibility.
- Clarify which agencies are charged with collecting specific data types and the procedure for assimilating data from external collection efforts
- Formally commit to making water data freely accessible for the greater good

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Discussion

- What is your impression of data policies that you use in practice?
- Do you wish there was more or less structure in the way data is collected and/or managed?

EXERCISE WORKBOOK WITH WORKSHEETS

EXERCISES MODULE I: MODELING

This module focuses on the science and application of hydrological modeling.

Instructions: Take some time to ponder the questions (1-5) that follow and provide your responses in the spaces provided. You may consider the questions at a national, regional, or catchment level as appropriate.

1. What can be done to ensure data are available in ample quantities for use with modeling applications?

2. Have you worked with/are you familiar with the use of complex physically-based models in decision-making?

What specific topics would you be interested more about with respect to modeling?

3. What pollutants are causing the impairments/threats in your catchment? Where are the pollutants coming from?

4. List management practices with which you are familiar

How is the riparian buffer defined for policy and decision-making in each country?

5. In general, have you noticed incidences of drought and flooding within your catchment? Elaborate.

What have been/are the negative impacts of drought and flooding within your catchment?

From your observations, have you noticed a trend in the number of incidences related to drought and flooding within your catchment from the past to present? Explain your response.

In general, would you say they remain same, decreasing, or increasing?

What do you think would be possible solutions and why?

Any other comments

EXERCISES MODULE II: RESEARCH/RESULTS TRANSLATION

This module aims at bridging the gap between knowledge generation (through research and modeling) and practice.

Instructions: Take some time to ponder the questions (1-5) that follow and provide your responses in the spaces provided. You may consider the questions at a national, regional, or catchment level as appropriate.

1. Which products are most produced through research and modeling?

2. What do you see as strengths and barriers in utilizing research and modeling products?

Strengths:

Barriers:

3. In which forms could the products be packaged and disseminated to enhance effectiveness?

4 What other products/types of products would be helpful in your work?

In which other products would you be interested?

5 Additional Comments

EXERCISES MODULE III: DATA POLICY

This module is focused on the important link between policy and data and addresses potential ways to improve documentation to help increase data availability.

Instructions: Take some time to ponder the questions (1-2) that follow and provide your responses in the spaces provided.

1. What is your impression of data policies that you use in practice?

2. Do you wish there was more or less structure in the way data is collected and/or managed? Explain

3. Additional Comments

GENERAL COMMENTS

Instructions: Please provide any additional comments you might have on the three modules covered, questions posed, or related content.

CONSENT AND PHOTO RELEASE FORMS

Consent Information

The Laser Pulse East Africa Project on Water Security aims to provide water information, data access, and decision support to improve water resources (quantity, quality) management and, ultimately, water security in East Africa. As part of this effort, we will actively recruit and engage participants in stakeholder meetings and a training workshop with a target representation of 50-50% men and women and at least 25% young adults (both female and male). We will use your inputs to inform the project so as to better tailor our outputs to stakeholder needs and determine future project needs.

During the meetings, we will keep track of inputs (including but not limited to: advice, opinions, comments, suggestions) coming from men separately from that coming from women using paper, video, audio, and/or any other electronic recordings. We will use sex and age disaggregated information to evaluate whether we are meeting our targets for engagement and, if not, what interventions might be needed. Audio and/or video recordings will be used to verify and improve recordings made on paper and ensure inputs are attributed correctly. All video and audio recordings, and any identifying information will be destroyed once the information has been transcribed. Your input will not be associated with your name, likeness, image, and/or voice in the transcript that is developed. Transcribed information will be maintained in secure storage and may be re-used in the future. The information will be compiled by sex and age and may be used in reports, presentations, publications, and any other materials we develop through this project. We do not anticipate any risks from participating in this meeting. Outputs from the project will benefit the East African society as a whole, and ensure long-term sustainability with respect to water security in the region. Please let Dr. Victoria Garibay (vgaribay@purdue.edu) or Dr. Margaret Gitau (mgitau@purdue.edu) know if you have questions.

What you agree to:

· You grant LASER PULSE East Africa Water Security project personnel (We/we/us/our) the right to record free of charge your inputs on paper, video, audio, and/or any other electronic recordings, and to use your inputs in any media (whether already known, or developed in the future) throughout the world without any payments.
· We may edit or translate your inputs, and you agree not to exercise any rights you may have with respect to use of your inputs against us and our partners.
· You may not inspect or approve finished products or any materials that use your inputs.
· We may use your de-identified inputs again at any point in the future.
· You understand that we may choose not to use your inputs.

Consent

By participating in the meeting: I affirm that I have read the above information and have received answers to any questions I asked; I agree to participate in the meeting and provide my inputs; and, I confirm that I am 18 years of age or older.

Signature _____ Age: ☐ 18-34 ☐ 35+ ☐ Do not wish to provide

Participant Name _____ Sex: ☐ F ☐ M ☐ Do not wish to provide

Photo Release

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RELEASE AGREEMENT

I, the undersigned, grant permission to the Laser Pulse East Africa Project on Water Security to photograph and/or video record my image and/or voice. Permission is granted for the Laser Pulse East Africa Project on Water Security to release, publish, broadcast or quote this material in public information programs and activities. Content procured may be included in future speeches, on the Internet, through multiple broadcast channels and print media. The content (image, audio or ideas) will not be used for commercial purposes.

Name: _____

Organization: _____

Telephone: _____

E-mail: _____

Date: _____