USDA Forest Service Technical Assistance Africa Program: Project Summary

Nyungwe National Park, Rwanda
The Ruaha River Landscape, Tanzania
Luangwa Valley, Zambia

In Support to the Wildlife Conservation Society in Assessing the Hydrologic Systems Present and Effects of Land use Practice on those Hydrologic Systems

January - September, 2011

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Introduction

The US Department of Agriculture (USDA) Forest Service International Programs (USFS IP) office has a charge of, promoting sustainable forest management and biodiversity conservation internationally. They meet this charge by partnering with other government agencies like the United States Agency for International Development (USAID) and non government agencies like the Wildlife Conservation Society (WCS) to fund projects and provide technical expertise from Forest Service specialist to address environmental issues faced by developing countries.

WCS works throughout Eastern and Southern Africa where water is an important resource for humans and wildlife. The quantity and quality of water in these areas are stressed due to a variety of reasons including land management practices and climate change. In order to protect this resource while contributing economically to the livelihoods of the people in this area, WCS is interested in developing payment for watershed services (PWS) schemes. In developing a PWS scheme WCS needed more information on the links between land uses in a watershed and the services that those watersheds provide, and partnered with the USFS-IP for technical assistance in modeling hydrological systems, and quantifying interactions among the land surface, land-use management and water quality/quantity. WCS focused on three sites for this assessment, the Nyungwe National Park in Rwanda, the Ruaha River Landscape in Tanzania, and the Luangwa Valley in Zambia. The USFS team that provided the technical assistance consisted of Matthew Edwardsen (Africa Program Coordinator, USFS-IP), Erika Cohen (Project Manager/GIS Specialist, Eastern Forest Environmental Threats Assessment Center(EFETAC)), Steve McNulty (Research Ecologist, EFETAC), Ge Sun (Research Hydrologist, EFETAC), and Matthew Wingard (GIS Specialist, Daniel Boone National Forest).

Objectives

The objectives of this study were to provide WCS Rwanda, Tanzania, and Zambia with tools that could assess the interactions between land management and water quantity and quality; to parameterize and run those tools for the sites of interest using local scale datasets; to address specific research questions defined by the WCS offices; to provide each site with the tools, databases to run the tools, and results from the tool runs; and to provide quantitative information for the land conservation agency to make sound decisions. The USFS was tasked with beginning and completing the project within FY 2011. To accomplish these objectives the USFS team structured the project into three phases; scoping mission, assessment, results and recommendations.

Project Phases

Phase I: Scoping Mission

The scoping mission was conducted from January to March 2011. During this phase the research questions were defined, the models were identified for use in the project, and three members of the USFS team visited each site location (See Appendix A for site visit itinerary). At each location the

USFS team introduced the WCS teams to the models that would be used in the project: the Water Supply Stress Index-Carbon and Biodiversity (WaSSI-CB) model and the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) model. They assessed the availability of data to run the models, and when possible, acquired data for the model. They met with local stakeholders to learn more about the environmental issues at each location, and they went on field tours to see examples of the current land use practices within each study area to determine possible economic incentives for watershed services.

Research Questions

1. What are the watershed boundaries within the Nyungwe National Park, Rwanda; the Ruaha River Landscape, Tanzania; and the Luangwa Valley, Zambia?

2. What are the hydrological responses resulting from different land use practices on total streamflows, either within a specific sub-catchment, or accumulated downstream from the headwaters to the exit of the entire catchment?

3. What effect do different land use practices have on sediment yield, (i.e. eroded soil reaching the stream and being transported downstream) and do the effects vary between the wet season and dry season?

4. What are the likely impacts of climate change on the Nyungwe hydrology?

5. Are there certain areas within Nyungwe where the impacts would be more severe due to physiographic characteristics (e.g. slope/ and or soil properties)?

6. How do the watersheds within the Luangwa Valley, Zambia rank in terms of land degradation?

7. What watersheds remain the most critical to sustaining year-round water flow in the Luangwa Valley?

Environmental Issues

Rwanda is a densely populated country with greater than 350 people per square kilometer. Deforestation, soil erosion, sedimentation, and wetland loss are some environmental issues within the country. The major land use throughout the country is agriculture and that is driving the increased deforestation. Water is used for domestic uses, power generation, and irrigation as tea and rice plantations are abundant throughout the country. Nyungwe National Park is a part of the Albertine Rift region of Africa and covers an area of approximately 1000 square kilometers. It has a large diversity of plants and animals. The park receives between 1800-2500 mm of rainfall per year and it straddles the largest basins within Africa: the Nile and Congo Basins. This park is an important source for watershed services.


Pictured above are examples of deforestation and rice farming in Rwanda.

The Great Ruaha River is located in south-central Tanzania and at 475 km long is the largest river within the Rufiji Basin. The river is an important resource within Tanzania as its water is used for domestic water use, irrigation for agriculture, fishing, livestock, and hydropower. The power generated by this river serves over 70% of the country. The river also runs through the largest national park in Tanzania, the Ruaha National Park, which is home to a diversity of plants and animals include elephants, giraffes, and crocodiles. Some environmental issues facing this river are no flow during the dry season and erosion.


Pictured above is the completely dry Ruaha River inside the Ruaha National Park in March 2011, and an example of sheet erosion on severely eroded land adjunct to the national park.

The Luangwa River Valley straddles the Eastern and Northern Province of Zambia and covers an area of approximately 24,000 square miles. The valley contains four national parks and is home to a diverse population of wildlife including hippos, giraffes, and crocodiles. The water from the river is used for domestic water use and transportation. Several environmental issues in the valley are excessive clear cutting of forest to produce charcoal and to grow crops, and over farming of the land. The over farming is stripping the soil of all nutrients such that nothing will grow on the land thus leaving the land barren. The barren land is a source for erosion and increased sedimentation within the river.

Pictured above is eroded land within a Luangwa Valley village and charcoal that is produced from deforestation.

Phase II: Assessment

The assessment was conducted from April to August. 2011. During this phase data was acquired, data was processed, and WaSSI-CB and InVEST were run. The Water Supply Stress Index-Carbon and Biodiversity (WaSSI-CB) model was developed and validated by the USDA Forest Service for assessing impacts of land management and climate change on water availability and ecosystem productivity at the continental scale (Sun et al., 2008; Sun et al., 2010). Climate, land use change, and human population predictions are integrated into WaSSI-CB to examine multiple stresses on water stress. WaSSI-CB was used to address the water quantity questions of this project. The Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) model was developed by the Natural Capital Project and is a suite of models that assess biodiversity, carbon sequestration, crop pollination, managed timber production, water purification for nutrients, reservoir hydropower production, and reservoir sedimentation (Tallis et al., 2010). InVEST is unique in that it models natural processes and some of the economics associated with those processes to give a complete picture of management options. InVEST version 2.0 was used for this project; specifically the sediment retention model to address the sedimentation and water quality questions of this project. Both models are portable, can be run at a variety of scales, and require a minimal amount of input data.

Figure 1. Modeling frame work of WaSSI-C

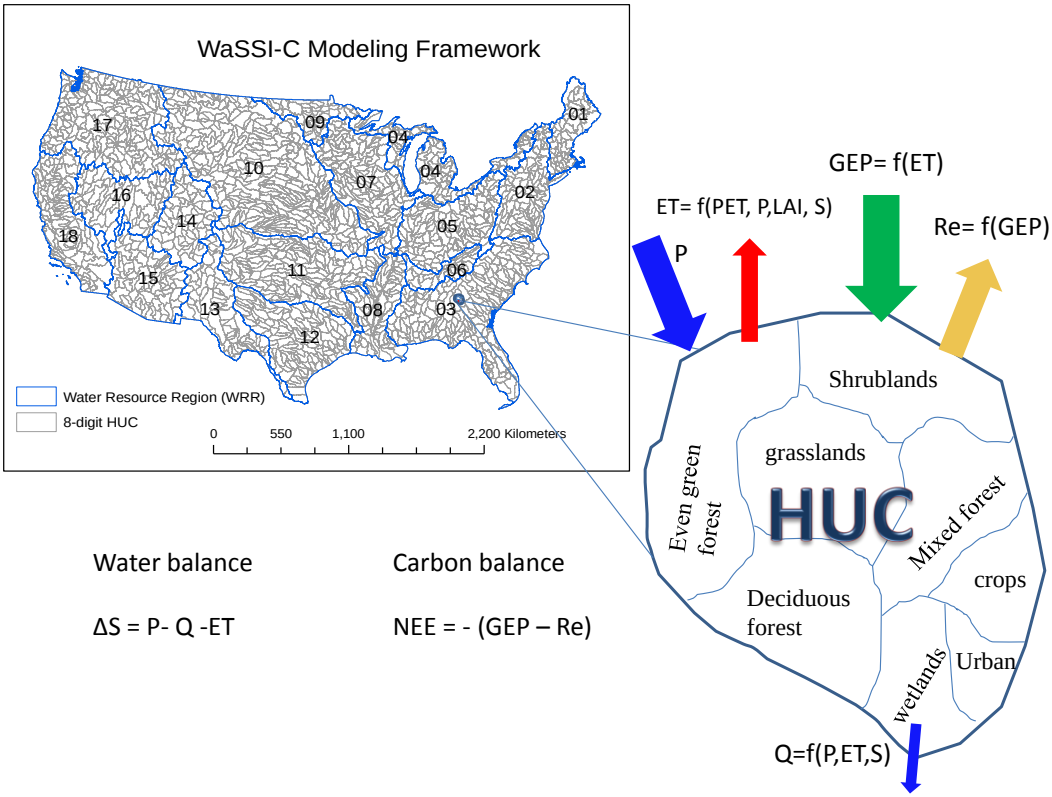
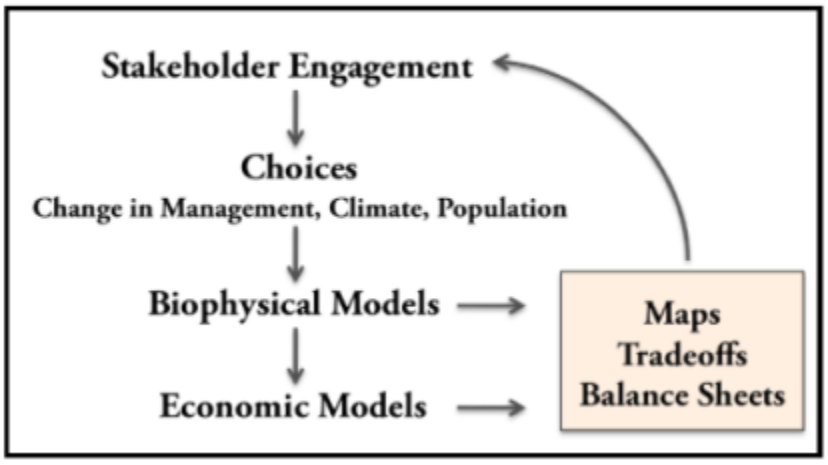


Figure 2. Model framework of InVEST



The USFS team worked with WCS teams at each location to acquire local data for the model runs. The data needed for the models included monthly precipitation, monthly average temperature, monthly leaf area index, land use, digital elevation model, soils characteristic information, watershed boundaries, stream flow for validation, and base layer data (e.g. administrative boundaries, city/town/market location, streams, and roads). Each location provided a varying amount of data to the GIS analyst within the USFS team. Upon receipt the GIS analyst assessed the completeness of the dataset both temporally and spatially, the resolution of the data, presence or absence of supplemental information included with

the data, and general quality of the data to determine if it could be used in the project. If the local dataset could not be used then that parameter was filled with data from a global dataset. See Appendix B for data provided by each location and for global dataset used in model runs.

All data processing was conducted by the USFS GIS analyst. The models were run at a watershed scale, and watersheds were delineated for each study site from 30 meter x 30 meter ASTER digital elevation model. All other input datasets were rescaled to the watershed and input for model runs. Four scenarios were developed to assess the possible implications of land use practices and future climate change on water. Those scenarios were baseline, deforestation, climate change one degree Celsius temperature increase, and climate change one degree Celsius temperature increase and ten percent reduction in precipitation. The baseline scenario represented current conditions of each watershed and used historic land use (year 2009) and climate data (years1960 to 2009). The deforestation scenario converted twenty percent of forested land in each watershed to cropland. Each land use and climate change scenario was compared to the baseline scenario to quantify the possible impacts of that change on water and sediment.

Phase III: Results and Recommendations

This phase of the project had two purposes: first to provide a hands-on technical training on using WaSSI-CB and InVEST, and second to present the results and implications of the assessment to key stakeholders from Rwanda, Tanzania, Zambia, and transboundary watershed management authorities across Africa. See APPENDIX D and E for workshop agendas and participant statistics. Two hands-on technical training sessions were conducted, the first one was held August 22-25, 2011 in Raleigh, North Carolina at the USFS office. Four people attended the training, representing WCS New York, Rwanda, Zambia, and Tanzania. The participants learned the theory behind WaSSI-CB and InVEST sediment retention, ran WaSSI-CB, visited several field sites and learned about best management practices (BMP) in place on those sites. BMP's are management techniques used to protect water quality and promote soil conservation with the United States. The participants went home with a copy of the WaSSI-CB Rwanda model and numerous brochures, books, and manuals on BMPs.

Pictured above are the participants and instructors of the August technical training session, and a questions and answer session of the training.


Pictured above are participants of the August technical training visiting a field site and learning about best management practices used on the site.

The second hands-on technical training was held September 15-16, 2011 in Kigali, Rwanda. Forty one people attended the training representing fifteen countries: Angola, Botswana, Burundi, Burkina Faso, Cameroon, Democratic Republic of Congo, France, Gabon, Kenya, Namibia, Rwanda, Tanzania, Uganda, USA, and Zambia. September 15 was devoted to WaSSI-CB. The participants spent the morning learning about the algorithms that drive WaSSI-CB, the required data and data format for input, GIS techniques for converting input data into the input format, the outputs from the model and ways to present those outputs. The afternoon was spent running the model. WaSSI-CB Rwanda, Tanzania, or Zambia and their databases were loaded on each attendee's computer. Each attendee was given a manual to go with the model. The attendees were broken into groups and each group was given three exercises to complete. These exercises were designed to allow users to manipulate input parameters for the WaSSI-CB model, and each group ran the model on their watershed of interest. Three groups presented their model run results and interpretations in short presentations. September 16th was devoted to learning about two additional ecosystems models. The morning session focused on the InVEST sediment retention model and the afternoon session focused on the Artificial Intelligence for Ecosystem Services (ARIES).Attendees were given a demonstration of both models and the ARIES demonstration presented draft results from a case study at the Great Ruaha River Basin, Tanzania.

Pictured above are the participants and instructors for the September technical training, and a question and answer session of the training.



Pictured above is a group presenting the results from their WaSSI-CB exercise and Jon Erikson presenting the results from ARIES on the Ruaha River Landscape.

The results and implications were presented to key stakeholders at the Modeling and Managing Watersheds Workshop in Kigali, Rwanda. This two day workshop had a policy focus and was held September 13-14, 2011. Sixty-six people attended the workshop representing fifteen countries: Angola, Botswana, Burundi, Burkina Faso, Cameroon, Democratic Republic of Congo, France, Gabon, Kenya, Namibia, Rwanda, Tanzania, Uganda, USA, and Zambia.

This workshop was structured to highlight watershed management activities and challenges within a regional and local context. The regional context was addressed by the Nile River Initiative. This group works with nine countries in Africa to manage watershed resources. The local context focused on the sites addressed by this project: Nyungwe National Park, Great Ruaha River Landscape, and the Luangwa Valley. Over the two day period the USFS team gave presentations on modeling 101, WaSSI-CB, InVEST sediment retention, and finally the results from the case studies. The results suggested the following at all three sites: due to global climate warming, specifically increases in temperature and reductions in precipitation would cause decreases in stream flow; conversion of forest to cropland would have minimal impact on stream flows; and deforestation would greatly increase erosion and sedimentation. The model suggested that Nyungwe has relatively high water yield, 30% -40% of its annual precipitation, and due to steep slopes and high rainfall, deforestation within Nyungwe would cause serious sedimentation problems. The team recommended that increased stream flow and sediment monitoring was needed at each study location, because the monitoring was essential to validating WaSSI-CB and InVEST sediment retention estimates of water and sediment yield. In lieu of validation the estimates from those models were useful to identify priority sites within the larger watershed for further studies. See Appendix C for the baseline runoff, runoff percent difference, and potential soil loss results maps. The percent difference maps compare the land use and climate change scenarios to the baseline scenario.

The team was able to answer most of the research questions defined at the beginning of the study. They delineated watersheds for all three sites. The deforestation scenario simulated a conversion from forest to cropland and addressed the questions on flow and sedimentation responses to land use practices. The hypothetical increase in temperature and combination increase in temperature and decrease in precipitation addressed the climate change impacts question. The team was able to rank the Luangwa Valley watersheds based on highest potential for soil erosion and most sediment export. The team was unable to address the question on which watersheds were most critical to supporting year round flow in

Luangwa Valley as this version of the WaSSI-CB does not include a routing function. The model assumed that all water was generated within the watershed boundary.

Deliverables

The deliverables from the project included the summary report, the WaSSI-CB model, the InVEST sediment retention model, local datasets, global datasets, all output data and results, and all pictures taken during the course of the project. Each WCS office (Rwanda, Tanzania, and Zambia) were given an external hard drive that contained all deliverables.

Proposed Next Steps

1) Validation of the Water Supply Stress Index Carbon and Biodiversity Model within the Nyungwe National Park.
    a. This step builds confidence that WaSSI-CB is a useful tool and validates the WaSSI-CB estimates are reasonable such that management plans can be designed and implemented by policy makers. This step would involve:
        i. Comparing the modeled runoff estimates and modeled sediment export estimates to measured stream flow and sediment.
        ii. Comparing WaSSI-CB modeled evapotranspiration and gross primary productivity to MODIS derived evapotranspiration and gross primary productivity.
        iii. Comparing global climate data with climate data measured at selected weather stations.
        iv. Rerunning WaSSI-CB with flow routing on the entire park including the portion that is in Burundi.
        v. Rerun both models using the local soils dataset.
2) Run the Water Supply Stress Index Carbon and Biodiversity Model for another transboundary ecosystem within the Eastern African community using global data. A multi-country location.
    a. This step demonstrates the scalability of the tool. That it can be used for regional assessments when local data is unavailable for a regional assessment.
3) Run proposed management plans from the East African community in WaSSI-CB
    a. This step demonstrates how managers would use the tool to make decisions. By running different management scenarios managers can evaluate the tradeoffs of implementing one proposed scenario over another. This allows managers to make a more informed decision when pushing forward with a management plan.
4) Encourage East African Community to develop a proposal that address how they would incorporate WaSSI into their monitoring network to solve questions related to ecosystem services (water and tourism)
    a. This step builds momentum for increasing the monitoring infrastructure and improving the quality of information coming out of that infrastructure within these East African countries. It also ensures that WaSSI-CB is added to the East African Community toolbox, and is used for many more years. The East African Community may be more likely to invest in a tool that is going to be used for more than one year.

References

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APPENDIX A: SCOPING MISSION ITINEREY

Travel General Overview

Tuesday, Feb.22: Depart USA	Friday, Mar. 4: Rwanda
Wednesday, Feb. 23: Arrive Zambia	Saturday, Mar. 5 Travel to Tanzania (Steve and Erika) Ge goes back to the US
Thursday, Feb. 24: Zambia	Sunday, Mar. 6: Tanzania
Friday, Feb. 25: Zambia	Monday, Mar. 7: Tanzania
Saturday, Feb. 26: Zambia	Tuesday, Mar. 8: Tanzania
Sunday, Feb. 27: Travel to Rwanda Erika, Ge, and Steve	Wednesday, Mar. 9: Tanzania
Monday, Feb. 28: Rwanda	Thursday, Mar. 10: Tanzania
Tuesday, Mar. 1: Rwanda	Friday, Mar. 11: Travel to USA
Wednesday, Mar. 2 Rwanda	
Thursday, Mar. 3: Rwanda	

Zambia Detailed Agenda

Zambia Detailed Agenda **Travel itinerary Zambia**	
Days	**Activities**
Wednesday, Feb. 23: Arrive Zambia	Arrive Zambia
Thursday, Feb. 24	Meetings in Lusaka with USAID, representatives at Norwegian Embassy, government officials from Luangwa Valley Initiative, and representatives from Forestry Department of Ministry
Friday, Feb. 25	Field Visit; Luangwa Valley
Saturday, Feb. 26	
Sunday, Feb. 27	Travel to Rwanda

Rwanda Detailed Agenda

Travel itinerary Rwanda	
Days	**Activities**
Sunday, Feb. 27	Arrive Rwanda
Monday, Feb. 28	Meetings in Kigali with key stakeholders including USAID: Presentation of the project objectives and expected outcomes
Tuesday, Mar. 1	Travel to Nyungwe with a stop at the GIS Center/National University of Rwanda to look at the existing GIS data on Rwanda
Wednesday and Thursday Mar. 2 – Mar. 3	Field visits (Nyungwe forest, tea estates and rice farmers downstream of Nyungwe)
Friday, Mar. 4	Travel back to Kigali
Saturday, Mar. 5	Travel to Tanzania

Tanzania Detailed Agenda

Travel itinerary Tanzania	
Days	**Activities**
Saturday Mar. 5	Arrive in Dar es Salaam: To be picked from airport and taken to the booked hotel by WCS. Review finalized program for their stay in Tanzania in particular the courtesy call on USAID Tanzania. WCS to book hotel and inform Steve and Matt accordingly.
Sunday, Mar. 6	Travel from Dar es Salaam to Iringa Iringa: Arrive Iringa evening. Night in Iringa WCS to book accommodation.
Monday, Mar. 7	Morning: Program and initial meeting with WCS personnel in WCS Offices, Iringa (Meeting to include Bakari Mbano, David Mutekanga, Ally Mbugi, Rogasian Mtana, Guy Picton, Machaku Geni and Clara Mjinja) Courtesy call on Local Government officials in Iringa District including the Ruvuma Water Program officers. Afternoon: Travel to field to visit project area (To be accompanied by at least 3 WCS officers). Booked to stay in field based hotel.
Tuesday, Mar. 8	Meet and visit field area and local village leaders etc.
Wednesday, Mar 9	Morning: Early morning depart for Iringa. Debriefing meeting in WCS offices in Iringa Afternoon: Rest in Iringa
Thursday, Mar. 10	Early Morning Travel from Iringa to Dar es Salaam. Meet with the USAID Natural Resources Technical Coordinator morning hours: Once this is confirmed we shall go ahead to make & confirm the relevant appointments.
Friday, Mar. 11	Depart Dar es Salaam for the US

APPENDIX B: DATABASE SUMMARY

Global Data

1) Climate
    a. Climate Research Unit (CRU) Time-Series (TS) dataset 3.1
    b. Monthly precipitation and temperature
    c. 1960-2009
2) Digital elevation model
3) Landcover
    a. Globcover dataset
    b. 2009
4) Leaf Area Index
    a. Zhao et al.,2005; Numerical Terradynamic Simulation Group (NTSG) at the University of Montana Missoula
    b. MODIS Imagery, MOD15(FPAR/LAI)
    c. Monthly
    d. 2000-2006
5) Soil
    a. Harmonized World Soil Database version 1.1

Rwanda Data

1) Base Layer
    a. Administrative boundaries
        i. Districts, national parks, provinces, and sectors
    b. Forestry boundaries
    c. Hydrologic data
        i. Island, Kivu Lake, lakes, and rivers
    d. Roads
    e. Market and towns
    f. Watershed boundary
        i. Congo basin and subcatchments
2) Digital Elevation Model
3) Climate
   These data represent a variety of sites and a variety of years
    a. Daily and monthly rainfall
    b. Daily and monthly temperature
4) Landuse
5) Orthophotos
6) Population
7) Soils
    a. Types and desciptions
8) Stream flow
   These data were measured at a variety of sites and a variety of years

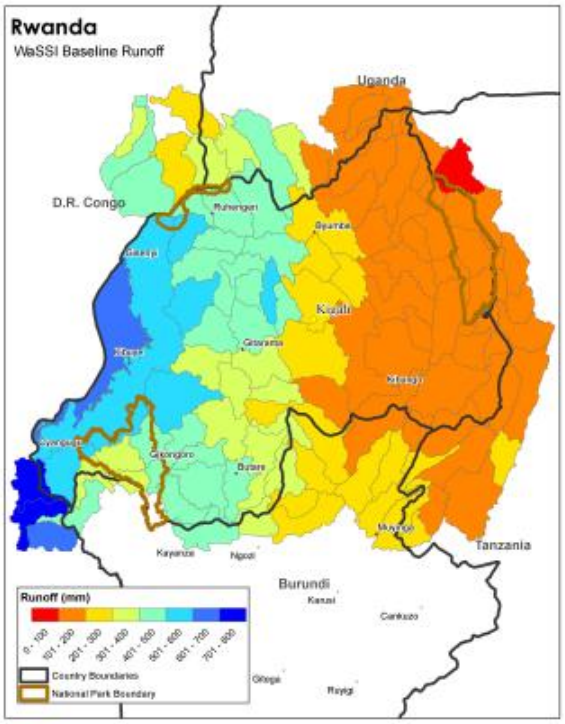
Tanzania Data

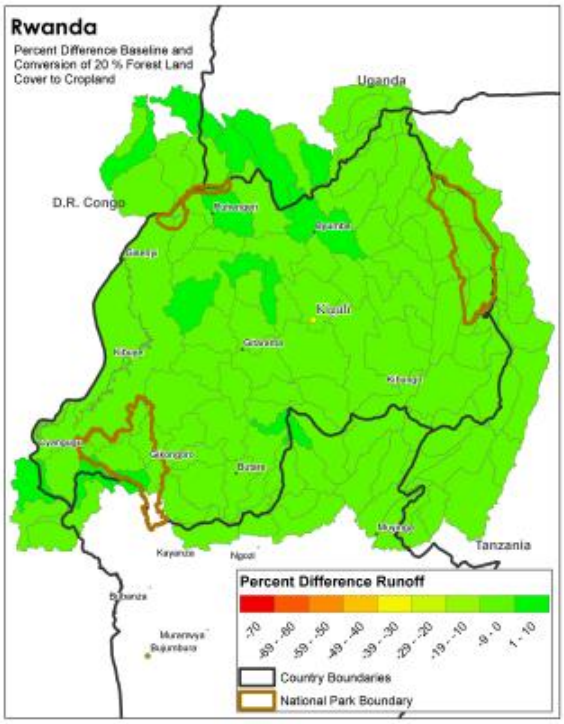
1) Base Layer
    a. Administrative boundaries
        i. Districts, national park, regions
    b. Hydrologic data
        i. Inland water and rivers
    c. Roads
    d. Towns and wards
    e. Watershed boundary
        i. Rufiji basin
2) Climate
   These data represent a variety of sites and a variety of years
    a. Monthly rainfall
    b. Monthly radiation
    c. Monthly temperature
3) Steam Flow
   These data were measured at a variety of sites and a variety of years

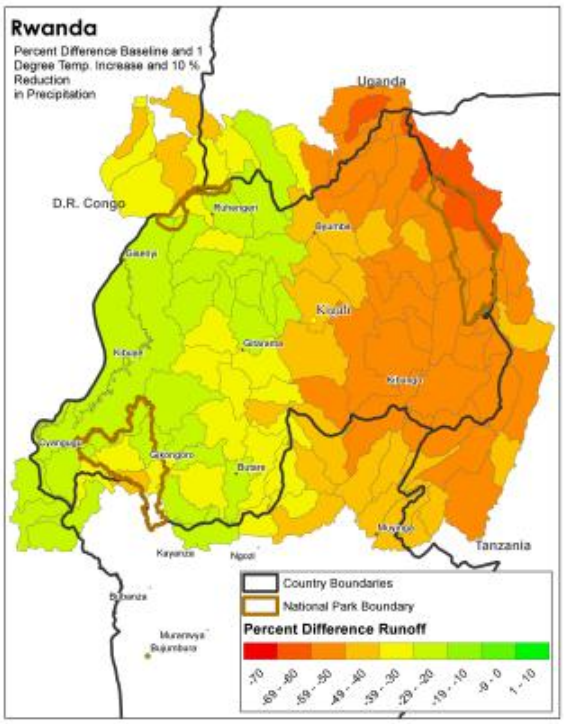
Zambia Data

9) Base Layer
    a. Administrative boundaries
        i. Districts, game management areas, national parks, provinces
    b. Forestry boundaries
    c. Hydrologic data
        i. Inland water, floodplains, lakes, river, and wetlands
    d. Roads
    e. Towns and wards
    f. Watershed boundary
        i. Luangwa and Chembeshi
10) Climate
   These data represent a variety of sites and a variety of years
    a. Monthly humidity
    b. Monthly rainfall
    c. Monthly temperature
11) Population
12) Soils
    a. Zones and types
13) Water Level and Steam Flow
   These data were measured at a variety of sites and a variety of years
    a. Chambeshi and Luangwa watersheds

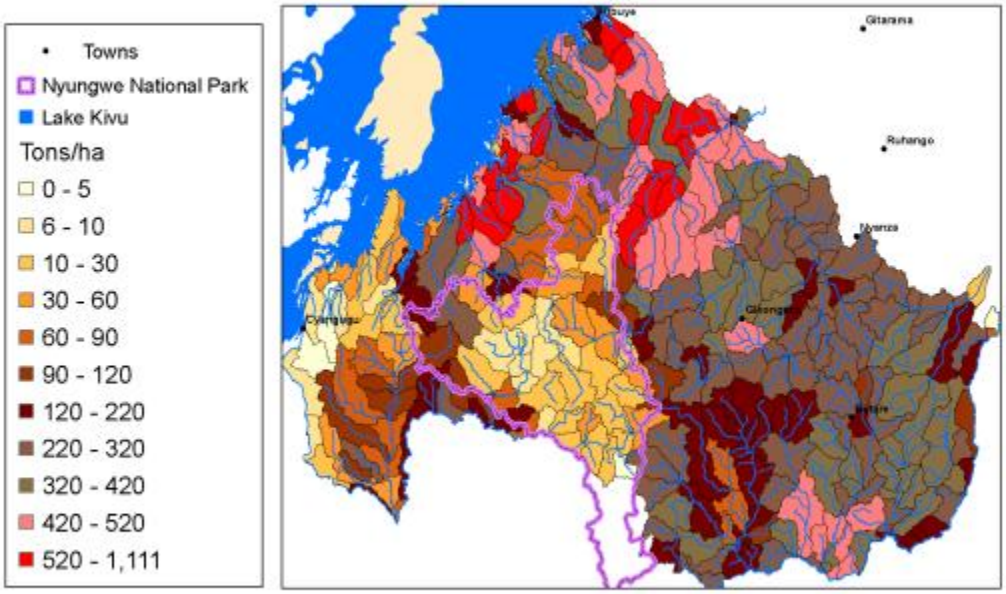
APPENDIX C: RESULTS MAPS



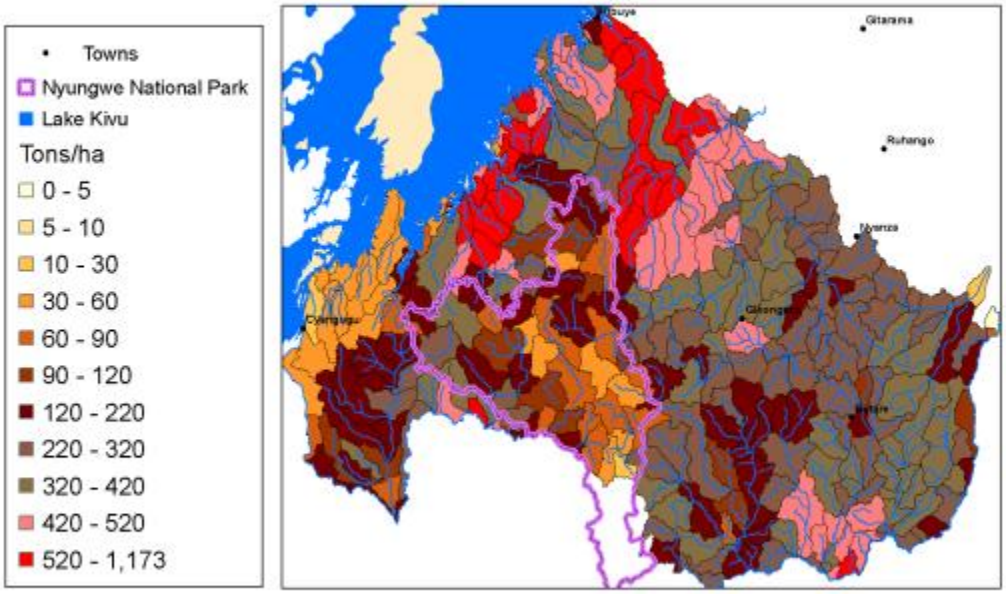


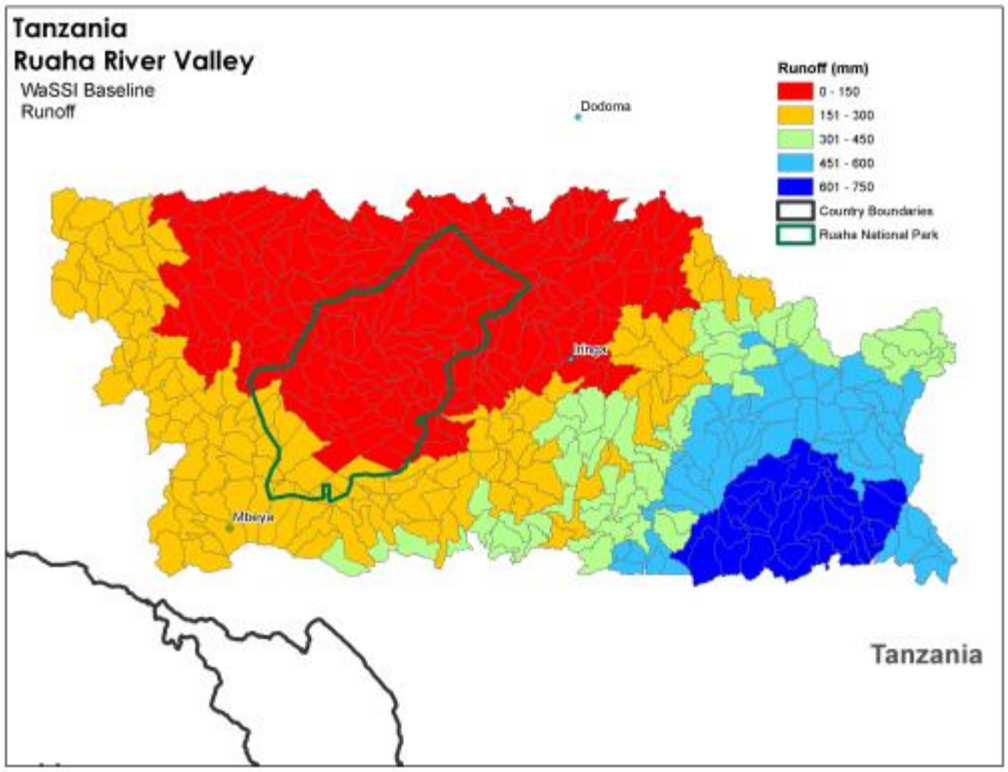


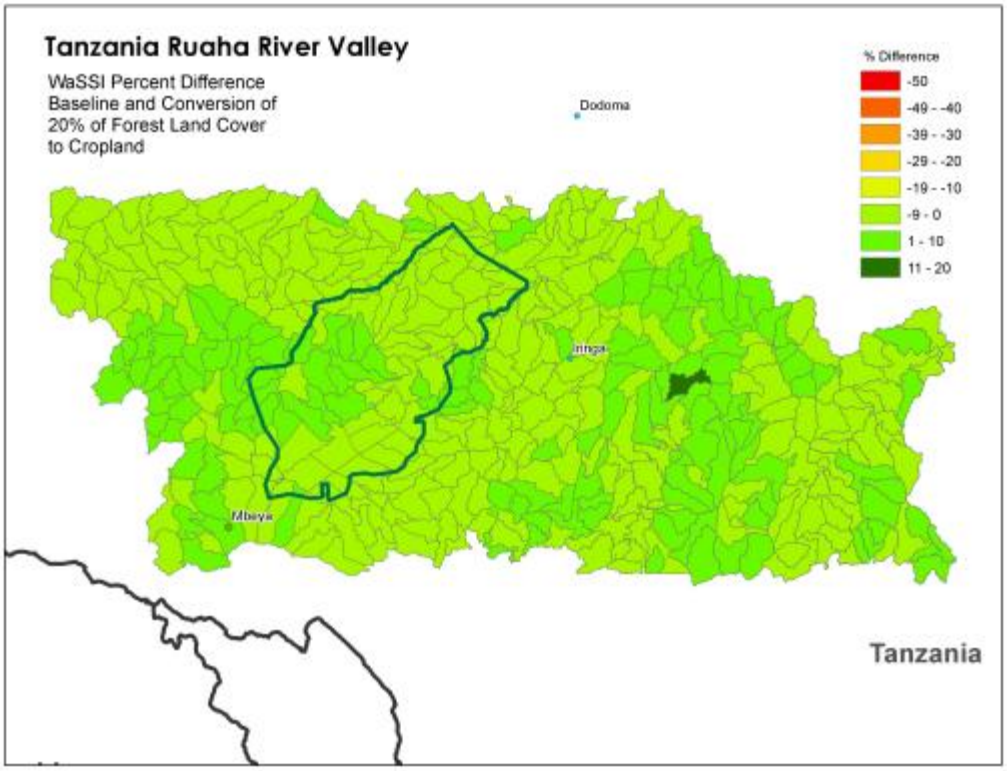
Universal Soil Loss Equation Mean
Potential Soil Loss by Watershed: Baseline

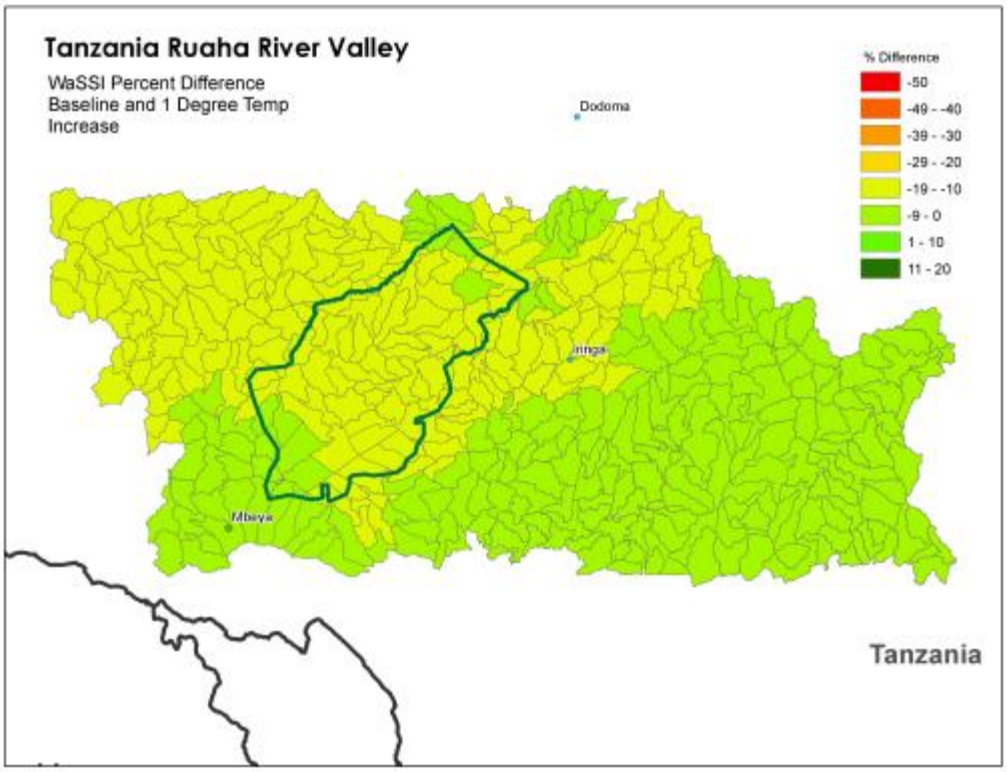


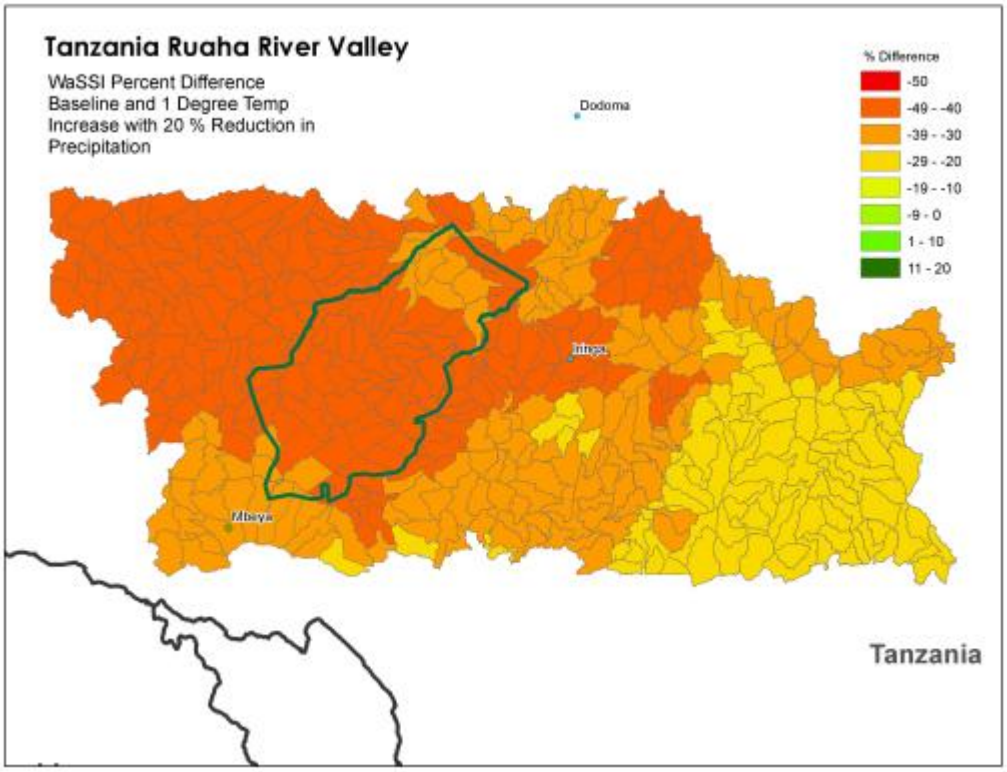
Universal Soil Loss Equation Mean
Potential Soil Loss by Watershed: Deforestation

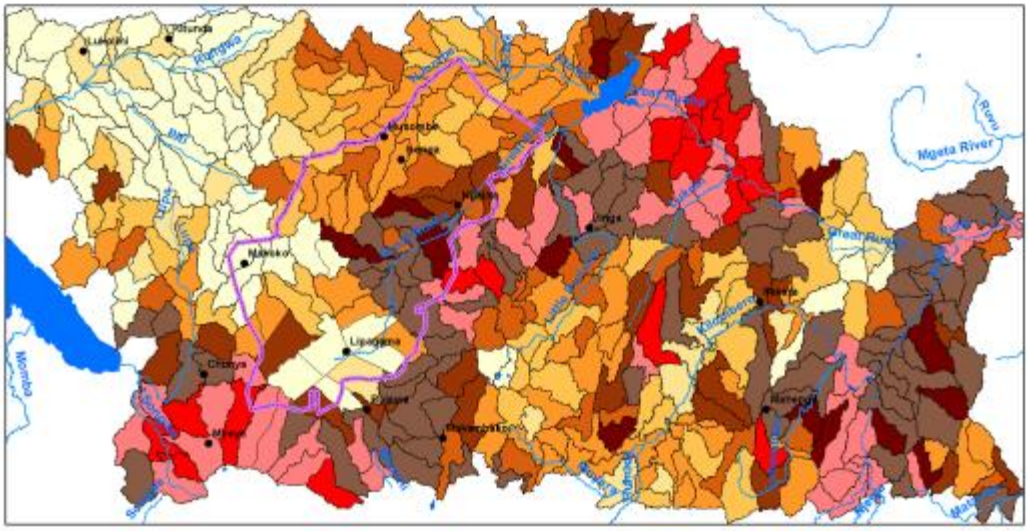



Tanzania
Ruaha River Valley
WaSSI Baseline
Runoff
Dodoma
Runoff (mm)
0 - 150
151 - 300
301 - 450
451 - 600
601 - 750
Country Boundaries
Ruaha National Park
Iringa
Mbeya
Tanzania


Tanzania Ruaha River Valley
WaSSI Percent Difference
Baseline and Conversion of
20% of Forest Land Cover
to Cropland
Dodoma
% Difference
-50
-49 - -40
-39 - -30
-29 - -20
-19 - -10
-9 - 0
1 - 10
11 - 20
Iringa
Mbeya
Tanzania

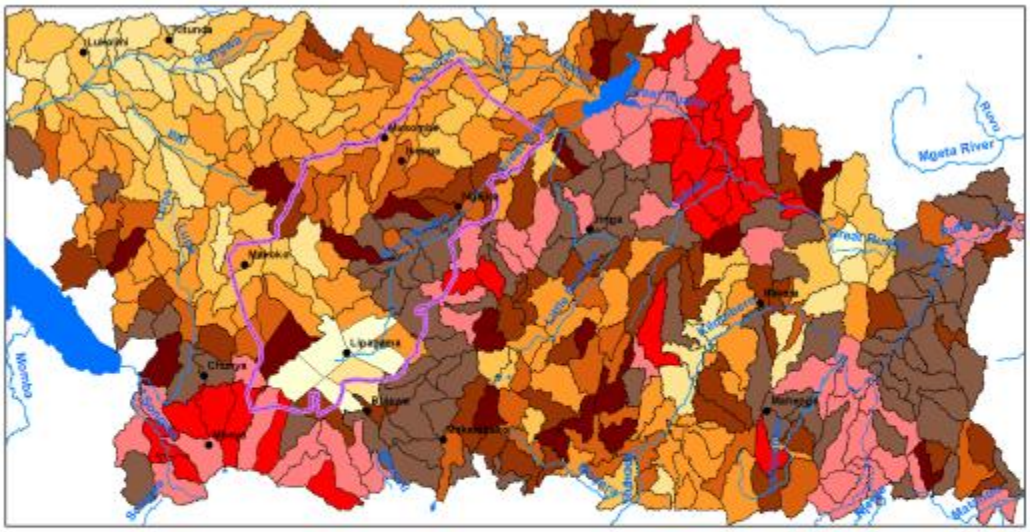

Tanzania Ruaha River Valley
WaSSI Percent Difference
Baseline and 1 Degree Temp
Increase
Dodoma
Iringa
Mbeya
% Difference
-50
-49 - -40
-39 - -30
-29 - -20
-19 - -10
-9 - 0
1 - 10
11 - 20
Tanzania


Tanzania Ruaha River Valley
WaSSI Percent Difference
Baseline and 1 Degree Temp
Increase with 20 % Reduction in
Precipitation
Dodoma
Iringa
Mbeya
% Difference
-50
-49 - -40
-39 - -30
-29 - -20
-19 - -10
-9 - 0
1 - 10
11 - 20
Tanzania



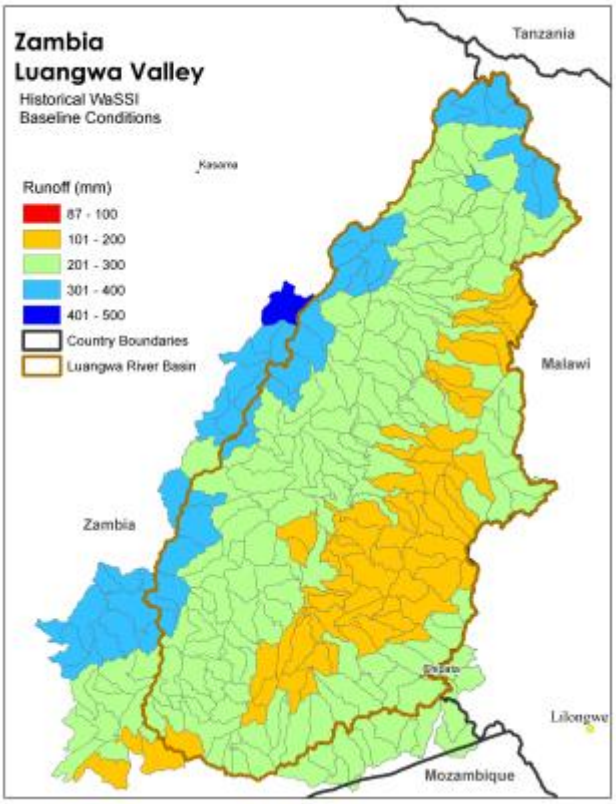
Universal Soil Loss Equation
Mean Potential Soil Loss
by
Watershed: Baseline

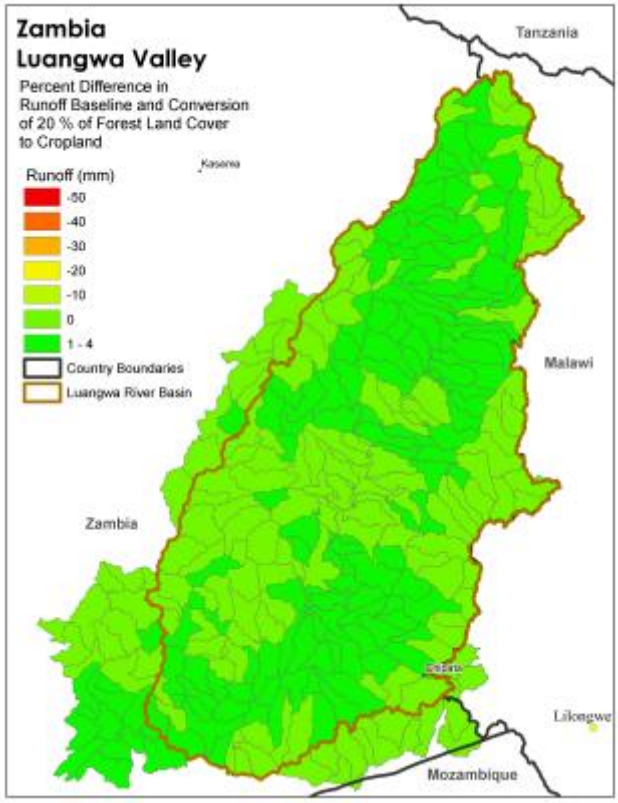
• Towns	10 - 20	100 - 200
Ruaha National Park	20 - 40	200 - 400
Tons/ha	40 - 60	400 - 1,014
0.2 - 5	60 - 80	
5 - 10	80 - 100	

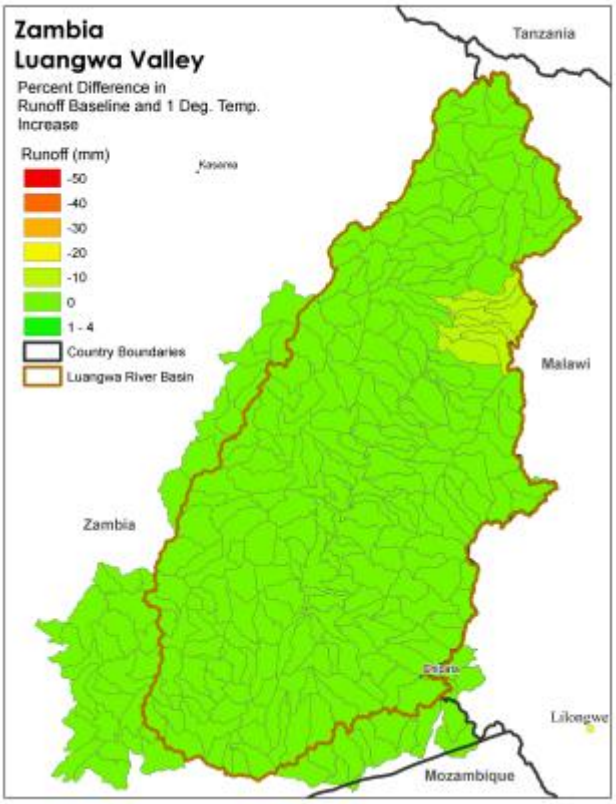


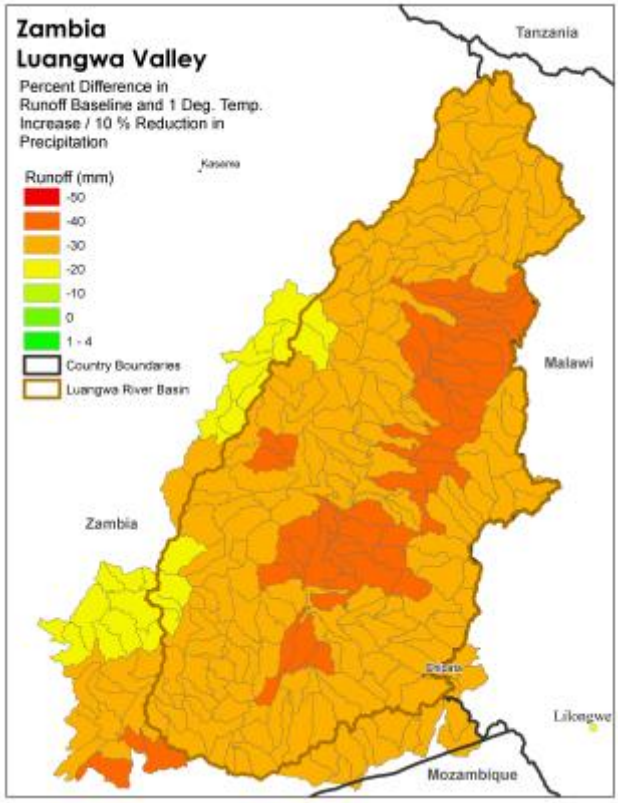
Universal Soil Loss Equation
Mean Potential Soil Loss
by
Watershed: Deforestation

• Towns	10 - 20	100 - 200
Ruaha National Park	20 - 40	200 - 400
Tons/ha	40 - 60	400 - 1,126
0.2 - 5	60 - 80	
5 - 10	80 - 100	

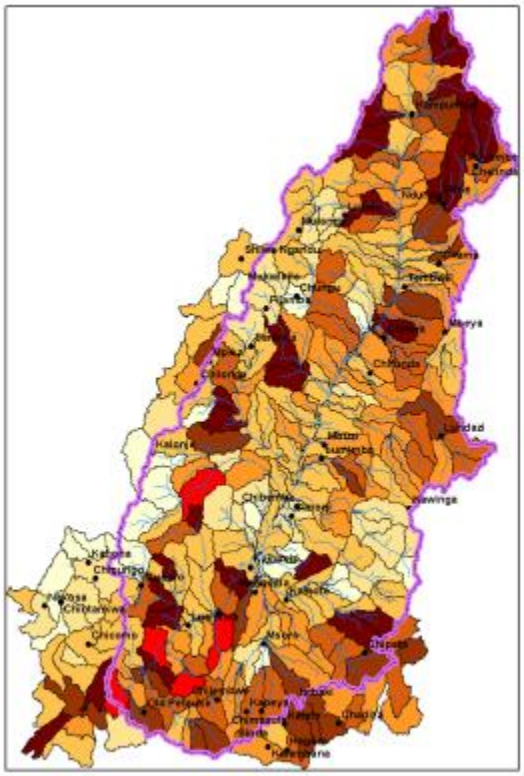

Zambia
Luangwa Valley
Historical WaSSI
Baseline Conditions
Runoff (mm)
87 - 100
101 - 200
201 - 300
301 - 400
401 - 500
Country Boundaries
Luangwa River Basin
Tanzania
Malawi
Zambia
Mozambique
Lilongwe


Zambia
Luangwa Valley
Percent Difference in
Runoff Baseline and Conversion
of 20 % of Forest Land Cover
to Cropland
Runoff (mm)
-50
-40
-30
-20
-10
0
1 - 4
Country Boundaries
Luangwa River Basin
Tanzania
Malawi
Zambia
Mozambique
Lilongwe

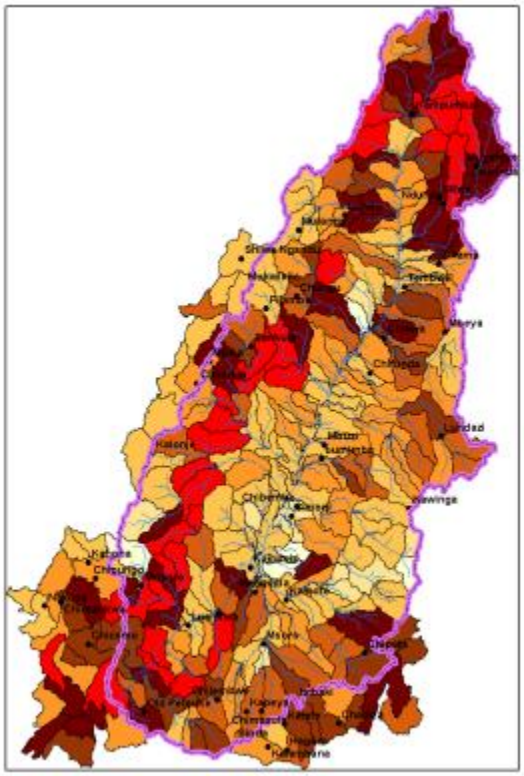

Zambia
Luangwa Valley
Percent Difference in
Runoff Baseline and 1 Deg. Temp.
Increase
Runoff (mm)
-50
-40
-30
-20
-10
0
1 - 4
Country Boundaries
Luangwa River Basin
Tanzania
Malawi
Zambia
Mozambique
Lilongwe


Zambia
Luangwa Valley
Percent Difference in
Runoff Baseline and 1 Deg. Temp.
Increase / 10 % Reduction in
Precipitation
Runoff (mm)
-50
-40
-30
-20
-10
0
1 - 4
Country Boundaries
Luangwa River Basin
Tanzania
Malawi
Zambia
Mozambique
Lilongwe

Universal Soil Loss Equation
Mean Potential Soil Loss
by
Watershed: Baseline



Universal Soil Loss Equation
Mean Potential Soil Loss
by
Watershed: Deforestation



APPENDIX D: KIGALI WORKSHOP STATISTICS

	Attendance Counts	
	Policy	Technical Training
Female	13	8
Male	53	33
Country	15	15

		Attendance	
	Organization Name	**Policy**	**Technical Training**
1	ARCOS	X	X
2	Conservation International	X	X
3	Deputy Director General for Water Resources/Rwanda	X	
4	DG INECN/Burundi	X	
5	Directeur de l'Energie de l'EGL/Burundi	X	
6	DSFAC/GIRE	X	X
7	EAC	X	X
8	ERR Consulting	X	
9	Geological Survey Botswana	X	X
10	GLOWS-RIWSP	X	
11	Gund Institute for Ecological Economics, UVM	X	
12	IGCP	X	
13	MINIRENA NBI/Rwanda	X	
14	MINIRENA/Rwanda	X	X
15	Ministry of Agriculture, Water and Forestry, Namibia	X	X
16	Ministry of Environment/Gabon	X	X
17	Nile Basin Initiative Kagera River Basin Project	X	
18	Nile Basin Initiative SAP	X	
19	NUR CGIS	X	X
20	OKACOM/Angola	X	X
21	OSFAC	X	X
22	RDB/Nyungwe National Park	X	X
23	RDB-TXC	X	
24	REMA	X	X
25	REMA Protected Areas Biodiversity Project (PAB)	X	
26	RNRA	X	
27	Rufiji Basin Water Office/Tanzania	X	
28	Rwanda Agriculture Board (RAB)	X	X
29	SIDA	X	
30	Sofreco	X	
31	South Dakota State University/DRC	X	X
32	Southern Africa Regional Environmental Program (SAREP)	X	X
33	Tanzania National Parks	X	X
34	The New Times	X	
35	University of Vermont		X
36	USAID	X	
37	USFS	X	X
38	WCS/Cameroon	X	X

39	WCS/DRC	X	X
40	WCS/Gabon	X	X
41	WCS/NY	X	X
42	WCS/Rwanda	X	X
43	WCS/Tanzania	X	X
44	WCS/Uganda	X	X
45	WCS/Zambia	X	X
46	WWF/Kenya	X	X
	Total	**45**	**28**

APPENDIX E: WORKSHOP AND TECHINICAL TRAINING AGENDAS

Ecosystems Services Modeling Meeting
August 22-25, 2011
Raleigh, North Carolina

August 22, 2011

Time	Item	Presenter
09:00 – 09:15	Welcome Attendee Introduction Safety Moment and Logistics	Steve McNulty All Erika Cohen
09:15 – 10:30	What is the Water Supply Stress Index Carbon Biodiversity (WaSSI-CB) ○ Tool Overview ○ Science/Theory	Ge Sun
10:30 – 11:00	Morning Break	All
11:00 – 12:00	What is WaSSI-CB continued? ○ Data requirement	 Erika Cohen
12:00 – 13:00	Lunch: Café Carolina and Bakery	All
13:00 – 14:00	What is WaSSI-CB continued? ○ Data preparation	 Matt Wingard
14:00 – 16:30	Case Study Rwanda: Water Treatment Plant Applications of WaSSI in Rwanda, Tanzania, and Zambia	Rafel Chudy Ge Sun
16:30 – 17:00	WaSSI Installation on computers Exercise Introduction	Erika Cohen/Matt Wingard Ge Sun
17:00	Wrap-Up/ Conclusion	All
18:00	Depart Hotel Dinner: Fujisan Japanese Steakhouse	All

August 23, 2011

Time	Item	Presenter
08:30 – 10:30	Hands on WaSSI Exercise	All

10:30 – 11:00	Morning Break	All
11:00 – 12:00	WaSSI Exercise Presentations	All
12:00 – 13:00	Lunch: Farmers Market Restaurant	All
13:00 – 13:30	WaSSI Exercise Presentations Continued	All
13:30 – 14:30	What is the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) o Tool Overview o Sediment Retention Model a. Universal Soil Loss Equation	Erika Cohen
14:30 – 16:30	What is InVEST continued? o Data Requirements o Data Preparation	 Erika Cohen Matt Wingard
16:30	Wrap-Up/ Conclusion	All
17:00	Dinner: The Pit Authentic Barbecue	All
19:00	Optional Concert	

August 24, 2011

Time	**Item**	**Presenter**
08:30 – 09:30	Applications of InVEST in Rwanda, Tanzania, and Zambia	Erika Cohen
09:30 – 10:00	Software installation and exercise intro	Erika Cohen
10:00 – 10:30	Moring Break	All
10:30 – 12:00	InVEST Hands on Exercise	All
12:00 – 13:00	Lunch: Baja Burrito	All
13:00 – 14:00	InVEST Hands on Exercise continued	All
14:00 – 16:30	InVEST Exercise Presentations	All

16:30	Wrap-Up/ Conclusion	All
18:00	Depart Hotel Dinner: Pizza ala Steve	All

August 25, 2011

Time	**Item**	**Presenter**
08:30 – 09:15	History and Background on BMPs in the Southeastern United States	David Jones
09:15 – 10:00	BMP Effectiveness Study Overview	Johnny Boggs
10:00 – 10:45	BMP Implementation Survey	David Jones
10:45 – 11:45	Travel to BMP Site	All
11:45 – 12:45	Lunch near weir	All
12:45 – 14:15	Tour	All
14:15 – 15:30	Travel back to office	All
16:00	Transport to hotel	All
17:30	Depart Hotel; Dinner: Tobacco Warehouse District; Durham, NC	
19:00	Optional Minor League Baseball Game: Durham Bulls	

Modeling and Managing Watersheds Workshop Agenda
September 13-14, 2011
Umubano Hotel, Boulevard de l'umuganda
Kigali, Rwanda

September 13, 2011

08:00 Registration

09:00 Welcome and Introductions, *Michel Masozera/Wildlife Conservation Society*

09:30 Keynote address by the Hon. Minister of Natural Resources, Rwanda

09:45 Introduction to the United States Forest Service (USFS) and the Wildlife Conservation Society (WCS) Collaborative Project on Watershed Modeling and Management in Rwanda, Zambia and Tanzania, *Matthew Edwardsen, United States Forest Service*

10:15 Watershed Management and Development in the Nile Equatorial Lakes Region: Perspectives and Challenges, *Mrs. Francoise Kayigamba, Nile Basin Initiative*

10:45 Coffee Break

11:15 Understanding the Use of Water Resources in the Narango Catchment, Antoine Niragire, Nile Basin Initiative

11:45 Watershed Management Challenges in Rwanda, *Leon Nabahungu, Senior Scientist, Rwanda Agricultural Board*

12:30 Lunch

14:00 Watershed Management Issues at Project Site in Zambia, *WCS/Zambia*

14:30 Watershed Management Issues at Project Site in Tanzania, *WCS/Tanzania*

15:00 How Project Models Have Been Applied to Address Watershed Management Challenges Around the World and Within Each Case Study Site, *Steve McNulty, USFS*

16:00 Coffee Break

16:30 Model Overview, *Ge Sun, USFS*

17:00 Adjourn

September 14, 2011

09:00 Welcome and Introduction to the Day

09:15 Kivu and Ruzizi River Basin Authority: A new initiative for integrated water resources management at a regional scale, *Ir Kayitenkore Claude, Directeur de l'Energie de l'EGL*

9:45 Results and Recommendations Rwanda Project, *USFS and WCS*

10:45 Morning Break

11:00 Results and Recommendations, Tanzania Project, *USFS and WCS*

11:45 Results and Recommendation, Zambia Project, *USFS and WCS*

12:30 Lunch

13:30 General Discussion on Project Results and Introduction to Working Groups, *USFS and WCS*

14:00 Break into Working Groups on Using Model Results to Address Watershed Management Challenges in the Region

15:00 Reports from Working Groups

15:30 Afternoon Break

16:00 Conclusions: Synthesis of the Meeting and Next Steps, *Michel Masozera/WCS*

17:30 Adjourn

Modeling and Managing Watersheds Workshop Agenda
September 15-16, 2011
Umubano Hotel, Boulevard de l'umuganda
Kigali, Rwanda

September 15, 2011

09:00 Welcome and Introduction, *Michel Masozera/WCS*

09:30 What is the Water Supply Stress Index-Carbon and Biodiversity (Wassi-CB) model?, *Ge Sun, USFS*
- Objective
- Algorithms/Theory

10:15 Morning Break

10:45 What is Wassi-CB, Continued?, *Ge Sun and Matthew Wingard, USFS*
- Databases
- Model Application

12:00 Lunch

13:30 What is Artificial Intelligence for Ecosystem Services (ARIES)?, *Jon Erikson, University of Vermont*

14:30 Assessing Soil Erosion with the Universal Soil Loss Equation and the use of the Integrated Valuation of Ecosystem Services and Tradeoffs (InVest) Model, *Steve McNulty, and Erika Cohen, USFS*

15:30 Afternoon Break

16:00 Install Wassi on Computers and Walk through WaSSI model on computers *Ge Sun, Erika Cohen, and Matthew Wingard, USFS*

17:30 Wrap-Up and Adjourn for Day

September 16, 2011

09:00 Review of Wednesday, *Steve McNulty, Ge Sun and Erika Cohen, USFS*

09:15 Introduce Wassi Exercise and Break Into Groups, *Steve McNulty, Ge Sun and Erika Cohen, USFS*

09:30 Wassi Exercise and Break Into Working Groups, *Steve McNulty, Ge Sun and Erika Cohen, USFS*

10:30 Morning Break

11:00 Wassi Exercises/Group Work, continued

12:00 Lunch

13:00 Finish Wassi Exercises/ Start Group Presentations

15:00 Afternoon Coffee

15:30 Finish Group Presentations and Discussion

16:00 Synthesis Session On Using Models For Watershed Conservation Management and Next Steps

17:00 Adjourn