Teaching Watershed Stewardship By Using a Topographical Model of Island of Guam - A Community Education Program About Protecting the Coral Reef From Upland Sedimentation Caused By Human Activities

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Introduction

Guam depends largely on the tourism industry to support its economy. In doing so the island caters to tourists seeking warm sandy beaches with beautiful, healthy coral reefs. One major concern to the health and preservation of this system, and thus a risk to the island economy, is inland sedimentation from the island's watersheds, which are often worsened by human activity.

Left: The Guam Watershed Model illustrating the sediment trapping capability of vetiver grass on the Western shore with clear water deposited in contrast with bare soil on the Eastern shore with murky water.

Top: Example of a Healthy Coral Reef System (Photo by D. Minton, NPS)
Bottom: Example of a Coral Reef System Degraded by Sedimentation (Photo by D. Minton, NPS)

What is a Watershed?

"A watershed is the area of land that contributes runoff to a lake, river, stream, wetland, estuary, or bay (EPA, 2008)." The word watershed is often associated with the words "drainage basin or catchment (USGS, 2013)." Proper watershed management requires active participation from stakeholders, the analysis and quantification of the causes and sources of the different water quality problems such as sedimentation and erosion, the identification of measurable water quality goals, and the implementation of actions needed to solve those problems (EPA, 2008).

Left: Example of revegetation efforts with Vetiver grass on teh Talakhaya Watershed in Rota
Right: Dr. Golabi showing the effectiveness of Vetiver technology in trapping sediment to middle school students using the Guam Model

Sedimentation

The movement of sediment in a watershed is an important, natural process in the development and maintenance of coastal habitats, including wetlands, lagoons, estuaries, sea-grass beds, coral reefs, mangroves, dunes and sand barriers (UNEP, 2006). However, human activities (i.e. off-roading) can change the natural processes of erosion and sedimentation including altering the flow of rivers and the amount of sediments carried downstream.

Left: Off-road vehicle activities contribute to erosion in watersheds that can harm downstream reefs through increased sedimentation (Photo by D. Minton, NPS) Right: A recently burned grassland area on Guam.

Agriculture, forestry, urban development, and other human activities all have some impact on the sedimentation process. Another significant cause of changes in sedimentation and erosion patterns is through hydrological modifications from the construction of reservoirs, dams and causeways, dredging of water bodies and the development of large-scale irrigation (UNEP, 2006).

The Guam Topographical Model

A view of sediment deposited in the moat "ocean" produced by upland unvegetated, bare areas.

In order to educate the public about the causes and effects of sedimentation, a Guam Watershed model project was developed. The watershed model of Guam is meant to be representative of the topography of Guam. The project included the construction of the watershed model and testing of the impacts on the watershed through the use of rainfall simulators. The watershed model was designed to be used for demonstration for classroom and public education. The dissemination of information will be made along with the model demonstrations in order to increase public awareness of watershed sedimentation issues and their impacts on coral reefs (Golabi and Biggs, 2010).

What can we learn from the Guam Model?

Dr. Golabi explaining sedimentation using the Guam Watershed Model to group of middle school students.

Increased sedimentation can affect reef systems by smothering the fragile marine life and potentially suffocating the coral, mangrove stands or seagrass beds. Sedimentation may also decrease the amount of available sunlight, which may reduce growth of natural vegetation. The impact of sediment may not only degrade fish habitats, but they may also harm local fish by irritating or scouring their gills. The various toxic chemicals and nutrients which are physically and/or chemically adsorbed by soil and are carried by sediments can also lead to increased levels of toxic substances in our bays and ocean (UNEP, 2006). The watershed model was designed to educate the public about the issues regarding the health of the coral reef and marine environment, most especially fire and off-roading activities and their impacts.

A typical southern Guam Watershed with both developed and undeveloped areas.

School activities will also be encouraged to promote watershed management and coastal protection Educational workshops and demonstrations were designed for school children, educators and government officials and agencies in order to demonstrate the effect of different preservation techniques for possible implementation. We believe this demonstration project will be effective in educating the public, most especially younger generations whom have a major impact on watershed management and protection. The implementation of land and watershed stewardship will lead to improved water quality of streams and rivers and cleaner shoreline and hence healthy marine environment and is expected to improve the current conditions of corals and protect and preserve the reefs (Golabi and Biggs, 2010).

Watershed Sedimentation Projects

Erosion control methods are also being implemented on Guam and the neighboring Commonwealth of the Northern Marianas Islands (CNMI) by various local and federal government agencies. The primary erosion control method illustrated by the Guam Model is the use of *Chrysopogon zizanioides*, commonly know as vetiver grass.

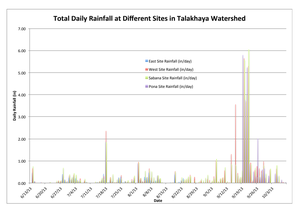
Vetiver grass growing within the Guam Watershed Model.

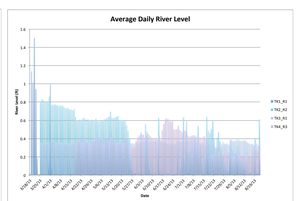
Case Example: Talakhaya Watershed Soil Loss Assessment Project

The Talakhaya Watershed on the neighboring island of Rota, CNMI is one area in which techniques, such as the use of vetiver grass to cover bare and eroding areas, is being used to control erosion and sediementation. The Talakhaya Watershed is an area containing very steep slopes and experiences grass fires, which occur frequently during the dry season. Local and federal environmental agencies are currently involved in attempts to reduce the amount of sedimentation carried from this watershed into the nearby bays. The watershed is comprised of federal lands on the Sabana (the highest peak on Rota), local government land, and privately owned property, which is largely used for farmland and grazing activities. In addition to revegetation efforts, local residents have been hired as a part of the project for grassfire monitoring during the dry season.

Left: Talakhaya Watershed in Rota non-vegetated project control site.
Right: Talakhaya Watershed revegetated badland area planted with *Chrysopogon zizanioides*.

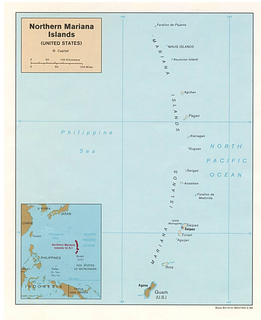
The Talakhaya Watershed Revegetation Project that is being undertaken by the various local agencies however did not include any form of monitoring of the sedimentation in the watershed. This highly valuable gauge into the effectiveness of the project was thereby sought by representatives from the National Oceanic and Atmospheric Administration (NOAA), which was actively involved in and a funding source for the project. The University of Guam (UOG) was brought onto the project to assist in monitoring the effectiveness of the Revegetation through the Talakhaya Watershed Soil Loss Assessment Project.



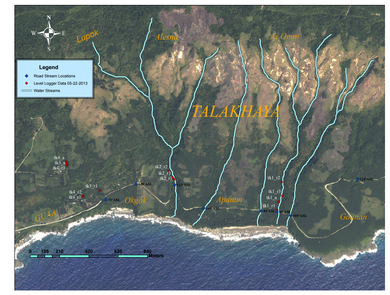


Left: Talakhaya Watershed Daily Rainfall Data (in/day)
Right: Talakhaya Average Daily River Level (ft)

This project is conducting monitoring of the Talakhaya Watershed through measurement of stream hydrologic factors in four of the rivers flowing through the watershed system. The monitoring of soil loss from the Talakhaya Watershed is currently being conducted through the measurement of stream factors including: turbidity, total dissolved solids (TDS), pH, dissolved oxygen (DO) electrical conductivity, water level, and discharge (flow). In addition, several rain gauges have been installed throughout the watershed to monitor the total rainfall and the distribution of rainfall to the area. The graphs above depict the daily rainfall measured (in) and the stream level (ft) that have been measured thus far.



Political Map of the Northern Marianas Islands (nationmaster.com)



Map of the Talakhaya Watershed in Rota with current stream data collection sites (Map Courtesy of: Bill Pendergrass, CRM).

Conclusions

Protection of the watershed and preservation of other natural resources (i.e. coral reefs) will benefit the island through enhancing the natural beauty of the island. This in turn may lead to increased tourism industry and improved economical sustainability for local people in Guam and the other islands of Micronesia (Golabi and Biggs, 2010). The Guam watershed model is therefore not only a means to educate the public and especially the youth about the necessity of preserving and improving the conditions of our watershed, but also to improve the environment for the benefits of a sustainable tourism market hence local economy.

View of the Talakhaya Watershed coastline from the Sabana, Rota.

The Talakhaya Watershed Soil Loss Assessment Project is an example of the implementation of watershed management practices in a real-world environment. The revegetation efforts are also attempting to reduce the amount of sediment carried out of the watershed system through methods also demonstrated in the Guam Watershed Model.

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Acknowledgements

UOG Soil Lab

The Guam Watershed Model was made possible by University of Guam Sea Grant Education and Extension Program Grant #: NA09OAR4170197

The Talakhaya Watershed Soil Loss Assessment was made possible by the National Oceanic and Atmospheric Administration (NOAA) and the National Fish and Wildlife Foundation and NFWF Project #: 0301.12.034503/34503