

Utilizing Scientific Programming  
and Improving Sediment  
Retention in Puerto Rico

**Utilizing Scientific Programming and Improving Sediment Retention in Puerto Rico**

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### **Abstract**

This research project investigates the impact of sediment retention on ecosystem services and land development in Puerto Rico, an island increasingly affected by climate change, particularly through heightened rainfall and hurricanes. These environmental changes lead to soil erosion and sediment loss, threatening agricultural practices, notably coffee cultivation, and degrading nearby coral reefs. Using a dataset encompassing over 40 watersheds, the study analyzes various sediment parameters, including total solids, dissolved solids, and suspended solids, employing advanced data processing techniques in R Studio and Python. The research aims to evaluate how sediment retention can enhance ecosystem services such as agricultural irrigation and flood control while informing policy-making frameworks. By visualizing data through graphs and other tools, this study seeks to provide actionable insights for sustainable land management in Puerto Rico, ultimately contributing to improved resilience against environmental challenges.

## **Utilizing Scientific Programming and Improving Sediment Retention in Puerto Rico**

### **Background**

Over the years, the effects of climate change have caused land changes on the island of Puerto Rico. The increase in rainfalls and hurricanes affects water quality and disrupts the growth of crops such as coffee, which is the primary agricultural crop (Yuan et al., 2015). Hurricanes and other disasters can also peak streamflow with different physiography and climate characteristics (Murphy, 2012). These issues also cause sediment loss and soil erosion, which causes the island to discuss better land use planning to create more resilience to this major environmental issue. Furthermore, land cover, soil, and slope also play a key role in sediment transport and how the amount of sediment loads that are distributed in different watersheds (Gellis, 2013).

In Puerto Rico, the upstream sediment causes detrimental issues that threatens the island. For example, soil erosion causes land loss, which is caused by rainfall, stormwater runoff, and land use practice (Larsen & Webb, 2009)". To contribute to improved understanding of this problem, the potential relation between river sediment and nutrient discharges and degradation of coral reefs surrounding Puerto Rico will be studied using water-quality data. However, sediment retention is a key component in land development and ecosystem services that improve water quality and erosion control. By using computer programming software such as InVest Workbench, R Studio, and Python, we can evaluate data by coding and using other visualization tools to display to stakeholders and create better land use practices to maintain sediment and find different stream buffers. Analyzing parameters such as erosivity, suspended sediment, and settleable sediments gives credible information about the transport and variables that causes land use change in Puerto Rico.

### **Methods**

In this research project, I will be evaluating different factors of sediment retention and loads by drainage areas. First, with the help of Mariam Valladares-Castellanos, Doctoral of Environmental Science student at Louisiana State University, I will be provided with a dataset that will be coded from R Studio to Python after running certain parameters and evaluates the multiple factors of the sediment: total solids, dissolved solids, suspended solids, total suspended solids, and settleable solids of over 40 watersheds on the island of Puerto Rico from 1977-2000 (De Jesus Crespo et al., 2023). We will also be using ArcGIS Pro and InVest Workbench as a tool for sediment retention and ArcGIS to incorporate mapping of the watersheds. According to Yuan, it states “runoff generated from storm events of high intensity or long duration transports large quantities of suspended sediment (SS); annual SS in some PR watersheds can be as high as  $130t\ ha^{-1}year^{-1}$ ” (Yuan et al., 2015). From this research project we need to figure out how these parameters of sediment retention improve ecosystem service and land development of Puerto Rico over time. This can lead the stream bank erosion and can damage the agricultural activities that provide revenue for Puerto Rico. Furthermore, we will add various packages to exclude bad data to ensure accurate data. After conducting the research and using the code, we will examine the data to figure out different land use practices to improve Puerto Rico’s historic landscape. We will analyze the concentrations of the parameters and compare the data and factors based on the watershed. Lastly, we will observe specific data to display for our charts, graphs, and other visualization tools to explain the problems, solutions, and importance of my research questions for my final presentation and report. From collecting data, implementing new technology, and understanding the purpose of these parameters, we need to find ways to provide these aspects to develop a new framework for policy making to incorporate ecosystem services that provide benefits such as agricultural irrigation and flood control in Puerto Rico. In conclusion, our parameters of the sediment retention will affect and impact certain watersheds across Puerto Rico based on topography and ecosystem services due to the byproducts of climate change.

# **Figures**

During my project, I will use different figures to display visual data by practicing the skills I learned throughout the Scientific Programming Class. In Figure 1, this is an example of the data set being organized in Python and showing the number of watersheds in Puerto Rico that we will be evaluating. Since we will utilize data from the Water Quality Portal and United States Geological Survey (USGS), I plan to create tables, graphs on Python through Matplotlib, and creating a gif file if possible. I will also be

	Dan_DrainageWatershed	Number of Microcatchments	AreaSqKM	\
0	Vivi	20	16.79	
1	Adjuntas total	100	53.98	
2	AdjuntasCorte	61	38.12	
3	Caonillas	209	125.15	
4	Carite	24	21.47	
5	Cerrillos	79	45.09	
6	Cidra	83	21.04	
7	Coamo	205	169.67	
8	Daguey	3	2.92	
9	Garzas	39	15.86	
10	Guajataca	35	60.46	
11	Guayabal total	117	112.03	
12	GuayabalCorte	62	54.54	
13	Guayo	35	25.00	
14	Guineo	14	4.24	
15	Icacos	9	7.39	
16	LaPlata total	858	467.45	
17	LaPlataCorte	834	445.98	
18	LasCurias	12	6.17	
19	Loco	26	21.84	
20	Loiza total	1081	537.91	
21	LoizaCorte	995	497.87	
22	Luchetti	84	45.06	
23	Matrullas	15	11.57	
24	Patillas	90	66.65	
25	Pellejas	30	22.03	
26	Portuguez	38	27.10	
27	Prieto	22	24.60	
28	RetencionAcueductoNorte	23	25.93	
29	Rio Fajardo	35	27.37	
30	ToaVaca	55	57.49	
31	Valenciano	86	40.04	
32	DosBocas total	683	436.03	
33	DosBocasCorte	324	218.09	
34	Rio Blanco total	36	29.12	
35	RioBlancoCorte	27	21.73	

Figure 1: Organized Dataset of Number of Watersheds in Puerto Rico in Python

utilizing ArcGIS Pro to show the different locations of the watersheds to compare the data and evaluate the possible factors (see Figure 2). I also plan to use Pandas and NumPy to display the sediment.

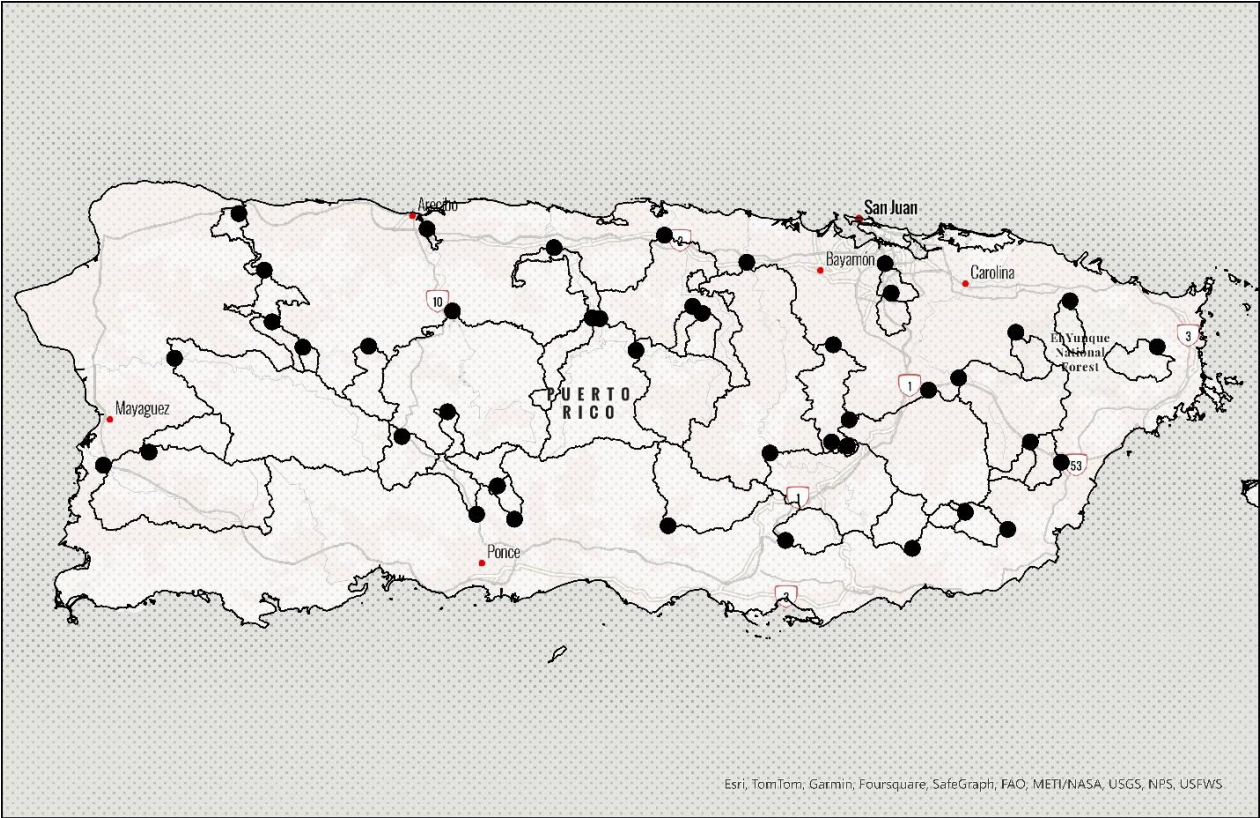


Figure 2: Different locations of the watersheds researched in Puerto Rico

Timeline

In Table 1, it shows the expected timeline of the project. The final report and presentation will be completed in early December before finals week.

November 3rd- November 9th, 2024	Running R Studio Code into Python
November 10th- November 16th, 2024	Conducting Methodss, Organizing Data, and Creating Graphs Through Matplotlib
November 17th- November 23rd, 2024	Analyzing Data to Start Report and Presentation
November 24th-November 30th, 2024	Working on Report and Presentation
December 1st-December 7th, 2024	Turn in Final Report and Presentation

Table 1: Weekly Timeline of Project

### References

- De Jesus Crespo, R., Valladares-Castellanos, M., Mihunov, V. V., & Douthat, T. H. (2023). Going with the flow: The supply and demand of sediment retention ecosystem services for the reservoirs in Puerto Rico. *Frontiers in Environmental Science*, 11.  
<https://doi.org/10.3389/fenvs.2023.1214037>
- Gellis, A. C. (2013). Factors influencing storm-generated suspended-sediment concentrations and loads in four basins of contrasting land use, humid-tropical Puerto Rico. *CATENA*, 104, 39–57.  
<https://doi.org/10.1016/j.catena.2012.10.018>
- Larsen, M. C., & Webb, R. M. T. (2009). Potential Effects of Runoff, Fluvial Sediment, and Nutrient Discharges on the Coral Reefs of Puerto Rico. *Journal of Coastal Research*, 25(1 (251)), 189–208.  
<https://doi.org/10.2112/07-0920.1>
- Murphy, Sheila F., and Robert F. Stallard. "Hydrology and climate of four watersheds in eastern Puerto Rico." *US Geological Survey, Professional Paper* (1789).
- Yuan, Y., Jiang, Y., Taguas, E. V., Mbonimpa, E. G., & Hu, W. (2015). Sediment loss and its cause in Puerto Rico watersheds. *SOIL*, 1(2), 595–602. <https://doi.org/10.5194/soil-1-595-2015>

