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.

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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(Scientific Investigations Report, 2022). 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 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^-1year^-1"(Yuan et al., 2015). 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. In conclusion, our parameters of the sediment retention will become be impacted due to the byproducts of climate change.

Research Questions

1. **From this research project, how can these parameters of sediment retention improve ecosystem service and land development of Puerto Rico over time?**
2. **What does collecting data, implementing new technology, and understanding the purpose of these parameters provide 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?

Figures

During my project, I will use different figures to display visual data by practicing the skills I learned throughout the Scientific Programming Class. 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 also plan to use Pandas and NumPy to display the sediment parameters.

	Dam_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	21.84	
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: Number of Watersheds in Puerto Rico

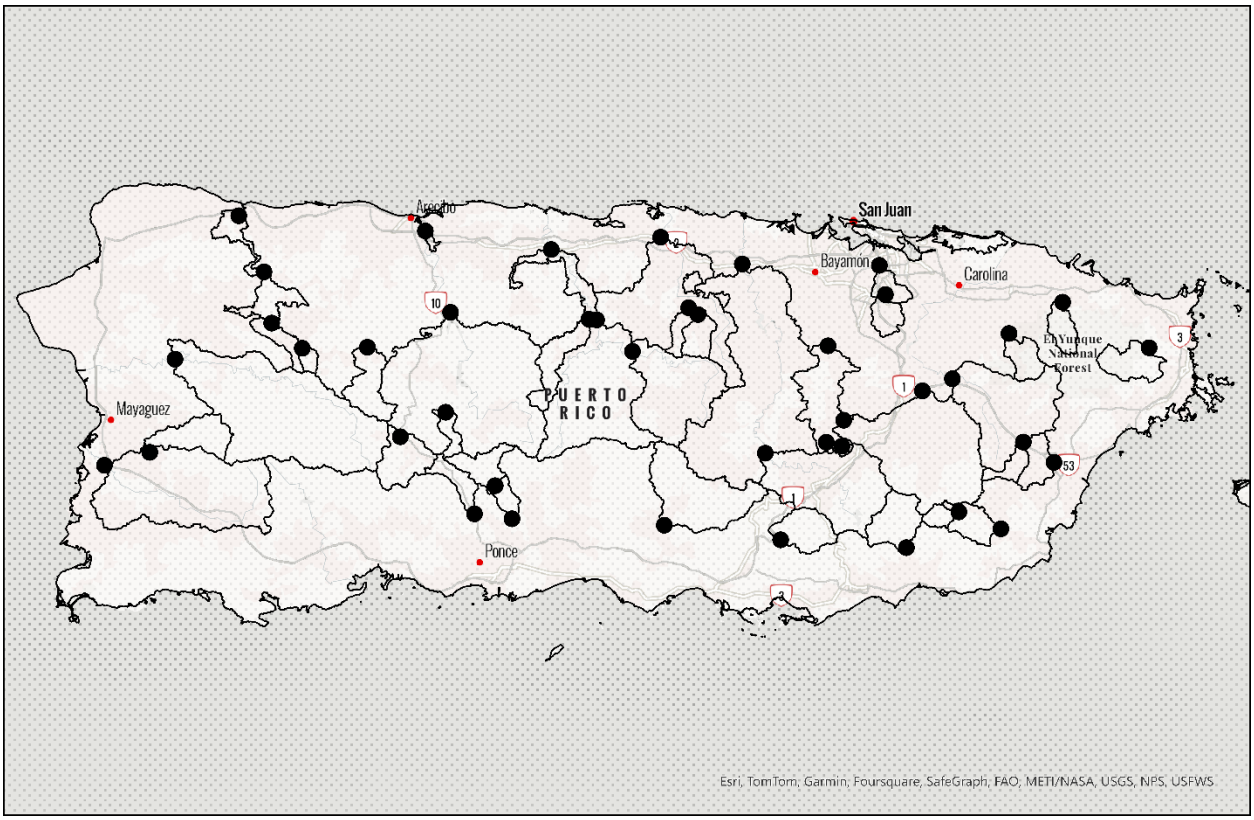

Figure 2: Map of Puerto Rico Watersheds(De Jesus Crespo et al., 2023)

Timeline

The final report and presentation will be completed in early December before finals week.

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

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