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Riparian Plants and Their Hypothetical Impacts on the Restoration and Rehabilitation of the Pasig River: A Thematic Study

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Abstract: *Riparian plants have an important role in the restoration of river ecosystems that have been ruined by human activity and pollution - like the Pasig River. There are many ways to analyze whether enough research has gone into riparian agriculture and the many ways in which they can help riparian environments, but one of the best ways is through bibliometric research. This study utilizes bibliometric analysis - specifically the analysis of five bibliometric maps, namely, an Overlay Visualization Map, a Network Visualization Map, a Density Visualization Map, a Thematic Map, and Thematic Evolution Map. These were used to primarily identify the key themes, temporal trends, and main contributors to researches that surround river ecosystems, their restoration and rehabilitation, and whether the effects of riparian plants on these ecosystems have been acceptably developed. The results of the findings were that while riparian vegetation is, indeed, a peripheral topic often studied in tandem with river restoration and ecosystems, they are underdeveloped - especially when it comes to studies that are geographically-specific to the Philippines. In that regard, it was found that riparian plants in the river restoration of Philippine rivers like the Pasig River is a research gap - thus one that provides an ostentatious opportunity for innovation and development.*

Keywords: Pasig river, Riparian plants, and River ecosystems

1. INTRODUCTION

Our environment is the fruit from which our entire society feeds on. If this fruit is left to rot, our society would be the next to follow in its footsteps. Unfortunately, human civilizations have been particularly creative with their ways of degrading the environment upon which we rely on. Especially, in a digital age where it is hard to miss what used to be and what could still be, when we have all sorts of apps and gadgets to simply show us. However, when one decides to step away from their screens, they will find that reality paints quite a different view, which is that Mother Nature is suffering - you can see it in the way buildings overrun forests, the way animals fester out into extinction, and, of course, in the way that rivers, once the source of life for ancient civilizations, are getting killed by the poison of pollution.

Many rivers around the world have been declared biologically dead due to the amount of pollution that has accumulated over the years and the fact that their maintenance levels are quite low. Of course, many people and even government entities around the world do what they can to ensure that these rivers are taken care of, but they sometimes do not lead to better circumstances for the bodies of water. For example, in countries like New Zealand, India, and Bangladesh some bodies of water have been recognized as living entities/legal persons. However, rather than empowering these rivers and serving as their protection, they are still denied specific legal rights that they need to remain existent like the right to flow freely [1]. Some rivers *do* manage to get restored, like the Han River in South Korea or the Kallang River in Singapore, but others are not as lucky. An example of this being the Pasig River in the Philippines.



Fig. 1. The Han River in South Korea [2]



Fig. 2. The Kallang River in Singapore [3]

The Pasig River - long before becoming known as one of the Philippines' most polluted rivers - played a monumental role in Philippine history as a major trading route, an alternative form of transportation, or simply as a "source of life" [4]. However, a series of events eventually led to the river being declared "biologically dead" in 1990 by the Danish International Development Agency [5]. Since then, many restoration and

rehabilitation efforts have been in effect, but until now, the tarnished smell of the river can still be smelled floating in the winds of the capital city.



Fig. 3. The Pasig River in the Philippines [6]

Now, while it is important to note that clean-up drives and government policies on river maintenance can go a long way in creating the change necessary for the river to be restored to a state befitting current water quality standards, another way that has not been completely explored is with the use of sustainability-focused landscape architecture and structural engineering. The Philippines is in a geographical location that makes it susceptible to seismic, volcanic, and tectonic activity [7], but it is also a country that has numerous river ecosystems. Although engineering is quite often used in a more practical manner for the former problem, it is usually only brought up for the latter when the conversation revolves around making river banks more aesthetically pleasing. Instead of that, a possible solution that could be applied to the Pasig River is to create a natural greenspace surrounding the river that not only makes it more aesthetic, but also makes use of riparian plants that could “clean” its waters.



Fig. 4. Pasig River Esplanade [8]

However, in order to gauge how impactful riparian plants could be to a riparian environment that has already been considered “biologically dead”, we must first see how much riparian research has already developed in the field and build upon the foundations that have already been established. Given this, it is an absolute necessity to make use of a bibliometric analysis to evaluate scientific literature on riparian plants and their impacts on river ecosystems. Such as when conducting research for seismic activity and road infrastructure, it will not only improve comprehension of the current research landscapes but also serve as a guide for future

investigations and policy decisions. [9]. The objectives of this analysis are to identify key research themes, highlight influential researchers and collaborative networks, and uncover temporal trends in the field. Through this quantitative research method, a more in-depth understanding of riparian plants and their utmost importance to river ecosystems can be reached. A data-driven approach could also lead to a better-made hypothetical greenspace model for the Pasig River itself, and even further allow us to find the specific species needed to be planted to ensure that they will be able to filter pollutants in the water.

2. METHODOLOGY

The primary methodology of this study is a bibliometric analysis, and Figure 1 - as seen below - shows a flowchart of the specific methodologies used to accomplish this analysis. It starts with the acquisition of data, and then processing data to find which ones are mainly relevant to the topic and which ones can be taken away. Upon accomplishing this step, we then move to the creation of the maps, which are the key points of the research to be analyzed. After making use of apps and websites appropriate for the accomplishment of the previous step, the analysis of the maps begins.

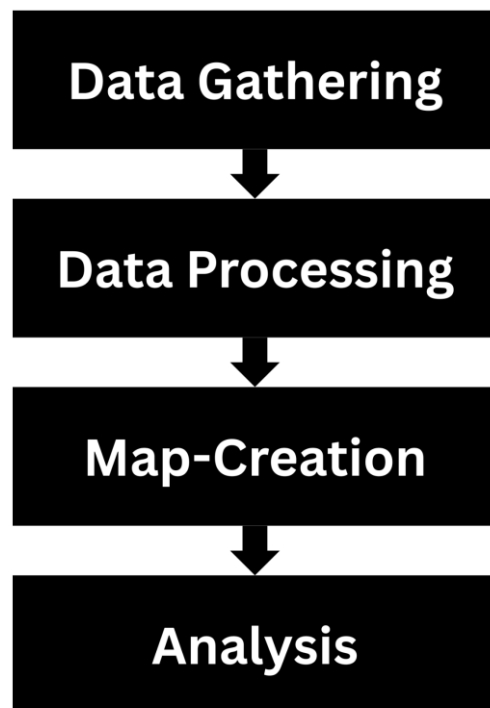


Fig. 5. Methodology of the Study

2.1 Data Gathering

The first step to create the database needed to be turned into bibliometric maps is the collection of related literature from reputable sources. This paper made use of Scopus to get the necessary information, and encompassed all studies related to riparian plants, river restoration, and the Pasig River.

2.2 Data Processing

After acquiring the necessary information for the

research, it was then double-checked to ensure that all papers were relevant and that none were repeated. Subsequently, the bibliometric data was organized in a manner that was appropriate for the analysis to make it easier to extract and then turn into maps.

2.3 Creation of Maps

Using VOSViewer and Bibliometrix, the data was then turned into the following maps for analysis:

- Network Visualization (Authors' Correlation)
- Overlay Visualization (Keywords Correlation)
- Density Visualization (Keywords)
- Thematic Map
- Thematic Evolution Map

2.4 Map Analysis

From there, we noted down important trends, correlations, and discoveries that were made using the visualizations provided.

3. RESULTS AND DISCUSSIONS

3.1 Overlay Visualization Analysis

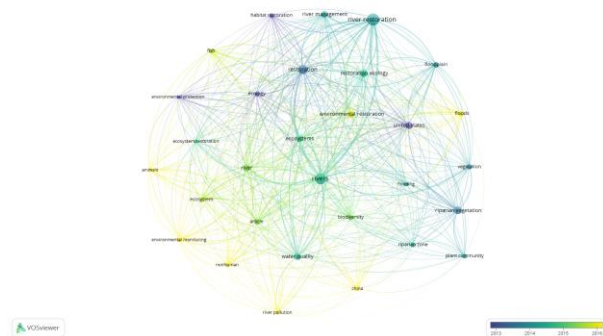


Fig. 6. Overlay Visualization Map

At first glance, the density of the network of topics clearly indicates the interdisciplinary nature of research specifically regarding river restoration.

At the center of the network are the central topics or the core research themes, which are focused on keywords like “rivers”, “river restoration”, “restoration”, and “water quality”. They are highly interconnected with keywords such as “ecosystem”, “water quality”, and “environmental restoration”. This shows us that in terms of river restoration and rehabilitation, this topic has already been highly saturated with all sorts of research, likely focusing on methods to rehabilitate river ecosystems or better their water quality for the good of the environment.

In terms of temporal trends, the blue nodes which have keywords such as “restoration”, “river restoration”, and “riparian vegetation” have had longer research history, prominent in around 2013-2014. The yellow-green nodes with keywords such as “environmental monitoring”, “animals”, and “floods”, on the other hand, are emerging topics that have gained attention in more recent years circa 2015-2016. Other peripheral topics show that their research is either more specialized (e.g., “plant community”) or geographically-specific (e.g., “china” and “united states”).

Overall, from this overlay visualization map, we can

parse many things. The first of which is that research on river restoration is vast, wide and has a long research history, however, they lack specialization in the Philippines, specifically, and they also lack focus on riparian vegetation. As can be seen from the map, “riparian vegetation” and “riparian zone” are at the periphery, meaning they are not quite the focus of most studies. Apart from that, they are also colored in shades of blue, indicating that they were more prominent back in the years of around 2013-2014.

3.2 Density Visualization Analysis

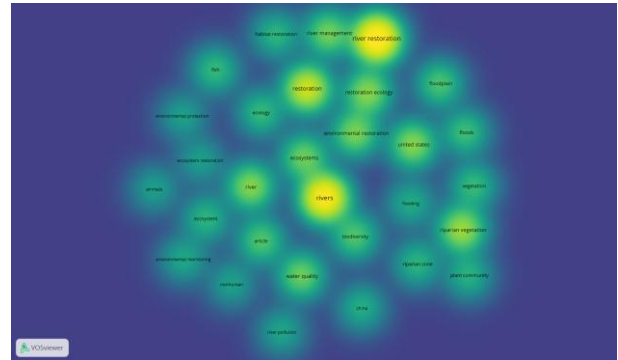


Fig. 7. Density Visualization Map

From the map, again, we can see that the literature is highly multidisciplinary with many topics saturated into the total main research of “river restoration”. Again the keywords that are central to these studies are “rivers”, “river restoration”, “restoration”, “water quality”, “biodiversity”, and “ecosystem”. The topics at the periphery include “floods”, “riparian vegetation”, and “habitat restoration”, but are still interconnected to the central themes.

From the colors, we can tell once more that research regarding river restoration is highly interconnected with many different topics. The brighter yellow words like “river restoration” have a more frequent co-occurrence and are more relevant in the data set.

Here we can see that “riparian vegetation” is colored slightly yellow, so while in the periphery, it has a relatively high frequency within the dataset. This indicates that there are a number of papers on riparian plants and their general interconnection to river restoration. Once again, geographically-speaking, there are not keywords that feature the Pasig River or the Philippines, but the fact that riparian vegetation has a prominent research history shows its importance in the study of the restoration and rehabilitation of rivers.

3.3 Network Visualization Analysis

Among thousands of authors, the parameters used to determine the data appearing on this map, using VOSViewer, are the top twenty authors who have had at least two papers published relevant to the research field. From there, only nine researchers have remained - separated clusters with only a thin line connecting them.

The first group - the red cluster - includes authors such as Kathrin Januschke, Jochem Kail, Daniel Hering, Peter Haase, and Armin W. Lorenz. While the lines on the map indicate multiple links between members and show strong internal collaboration, they have only a very weak

connection to the green cluster, made up of Herve Piegay, G. Mathias Kondolf, Ellen Wohl, and Juergen Geist, who are also very strongly interconnected. The connection between the two groups is the thin line going from Kail Jochem and Herve Piegay.

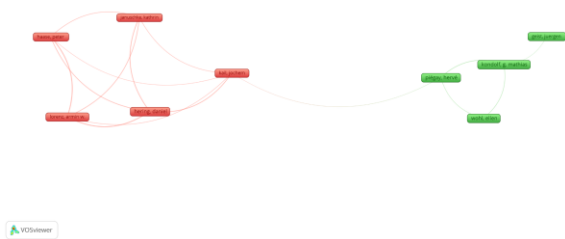


Fig. 8. Network Visualization Map

From this, we can determine that these two groups - based on the aforementioned parameters that were set - are the leading researchers in the field of river restoration. The strong interconnection between and among the two clusters suggests frequent co-authorship and that they may either share an institutional background or a regional one. Though only a weak intraconnection is shared, it still suggests opportunities for cross-group collaboration which could help develop the interdisciplinary nature of this field of study.

3.4 Thematic Analysis

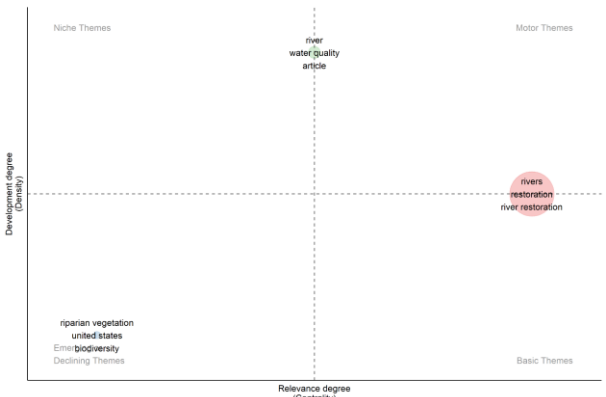


Fig. 9. Thematic Map

Here we have a thematic map where we're given four quadrants to analyze based on two dimensions: the development degree or the density, which indicates how much research has gone into the topic, and the relevance degree or the centrality, which indicates how important these topics are to the research area.

In the upper right corner, we have Motor Themes, with keywords like “rivers”, “restoration”, and “river restoration”. Again, these are the most important and most well-established themes in the research area. The fact that they are in this quadrant indicate that they have had much research developed over the years, that they have become the primary topics being given focus to, and that they are quite important to the field.

In the upper left corner, we have Niche Themes, with keywords that include “water quality”. The topics that are a part of this quadrant are well-developed internally, and from this we can assume that a lot of research has gone into making it a multi-disciplinary study. However, in the

wider scope of things, these are essentially specialized themes, and they are not central to the area of study. This indicates that when it comes to research papers that are primarily focused on topics like water-quality, they can give us insight into many ways in which river restoration can be achieved or enlighten us on things we may be doing incorrectly.

On the lower right corner, we have the Basic Themes, where fundamental but underdeveloped topics can appear, but given that no keywords were present for this quadrant, we shall be moving onto the lower left corner, where we have Emerging or Declining Themes. These are the themes that have either just popped up in the field or have died out, and they include keywords such as “riparian vegetation”, “united states”, and “biodiversity”. These are underdeveloped areas that have not been given primary focus to, but with more collaborative research and perhaps more opportunities, there is a possibility for these topics to dominate the research field.

From this, there is one primary insight that we can attain, which is the fact that “riparian vegetation” is a part of the themes that are underdeveloped and inessential. While it may be unfortunate that this is a theme, so central to this paper, that could be on the declining side, the fact is that this presents a research gap and opportunity. There are not a lot of researches that focus on riparian plants, despite the fact that they have been proven helpful to river rehabilitation, so if this gap is addressed it could open the door to a new field of research dedicated to riparian ecosystems and how they help in restoring rivers.

3.5 Thematic Evolution Analysis

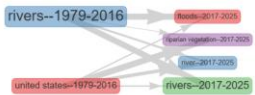


Fig. 10. Thematic Evolution Map

Here, we have a thematic evolution map that has shown us the progress of research in this field of study from 1979 to present-day. We can see that “rivers” is a persistent topic that is both foundational in past research and central in recent ones. The keyword “united states” is also a foundational topic presumably because of their country’s scientific research prowess. On the right side, we have the topics that are more concurrent in the modern period of 2017-2025, which include “floods”, “riparian vegetation”, and “rivers”.

These show indications that in recent years, the research field has been progressing more towards connecting rivers and their restoration to papers concentrated on riparian vegetation and flooding, indicating a growing field for these specialized topics. They paint a brighter picture for riparian plants and their usage in rehabilitation given the papers that have recently been focused on this

particular topic.

3.6 Applications

Now, all these analyses could have many different applications depending on the focal point that you are aiming for. In this case, since it is an evaluation of how much research has gone into riparian plants and their importance in river restoration - particularly, for the Pasig River - then, we'll be focusing on the results that we have garnered for that. Firstly, one thing is very clear about the research field, and that is the fact that it is very interdisciplinary. While the central topics are focused on the restoration and rehabilitation of rivers, they are connected to multiple different topics from flooding to biodiversity to water quality and more. One of these peripheral topics are riparian plants and vegetation. This segment of the research field is particularly underdeveloped, meaning that while there are papers that cover it, it is not a focal topic of interest. In the same vein, none of the maps showed the Philippines or the Pasig River itself as a geographically-specific research theme, meaning that it is *highly underdeveloped* to the point that papers mentioning these topics are not even shown on the maps. While this may be discouraging, it actually presents an opportunity for innovative development. River restoration is nothing new, and certainly, researches have before been focused on riparian plants and the Pasig River, but the maps paint a picture of their underdeveloped nature. This could allow future researchers to develop it and essentially make it integral to the multidisciplinary field. This analysis can be used to find out how to find a more unique edge to researching in a field highly saturated with such topics.

3.7 Comprehensive Narrative of Field Progress

Overall, the research field has been “booming” so to say since the mid-1970s. River restoration has been a popular topic to further delve into since so many of the rivers - and many other natural landscapes - have fallen prey to the whims of human development. That being said, studies on rivers and their restoration have been around for a long time and are the foundations upon which many niche topics have now popped up. Now, we have papers focusing on how rivers are connected to flooding and how that can be stopped. We also have river restoration and its connection to biodiversity within ecosystems. Our focus, of course, is on how river restoration can be connected to riparian plants and how that can impact rehabilitation efforts. While there is moderate development on this side of the field, it is still quite underdeveloped and considered a peripheral topic. Apart from that, research efforts of this kind of topic still do not prominently mention the Philippines even though its very own Pasig River is renowned for its pollution. That being said, this could provide a research opportunity for all those who intend to delve deeper into this field.

3.8 Future Research

For further research focusing on bibliometric analyses, it is suggested that the researchers take care during data acquisition and data processing. A majority of the maps shown here were quite frankly all focused on the “rivers” and “river restoration” parts. It is suggested to take out these keywords when doing the data gathering so as to

have a more diverse variety of keywords and so that your analysis will yield results closer to the ones desired at the start of the study. It is also suggested that during data processing, it is wiser to be strict with the papers to be included in the analysis. It might be 4000 research papers, but if every map will show you the same three keywords that are all relatively similar to one another, it means that something went unnoticed during the organization of the data.

4. CONCLUSIONS

To conclude, the research field for rivers and river ecosystems is saturated with many different studies and scientific literature dating back to the 1970s. Many of them are interconnected with different topics such as those focusing on water quality, riparian agriculture, flooding, and even newly emerging topics such as those focused on animals and nonhuman species. This indicates the interdisciplinary nature of the research field and how far and wide its reaches are in the scientific community. However, it is also clearly seen from the results that riparian agriculture, which is the main focus of this study, was consistently a *peripheral topic*. It was quite often connected with topics related to rivers and their restoration, but it is an underdeveloped topic of study, and it makes up a part of the side topics that can be considered either declining or having just emerged in prominence. Apart from this, only nine main authors for the research field, in general, met the parameters to be considered for this study - which is for them to have two papers on the subject. They are divided into two groups with a weak interconnection, indicating lack of collaboration. Furthermore, when it comes to geographically-specific research, in every single one of the maps, not once was the Philippines mentioned. It always showcased countries such as the USA or China, but Philippine-specific research, much less Pasig River-specific research, was not prominent enough to be seen on the maps. That being said, we can clearly see that the use of riparian plants for river restoration in the *Philippines* is a niche subject bordering on a research gap. However, this presents an opportunity for further development and innovation in the field. Riparian plants are important in river ecosystems - that much is clear, and the maps have shown that it is a subject that has already been broached. Nonetheless, it is important to delve deeper in this topic to analyze its potential and create a better greenspace model for the Pasig River, not only focusing on its aesthetics, but also making for a better and cleaner Pasig River.

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