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STORMWATER TO FOOD WATER: REUSING FLOOD AS IRRIGATION FOR URBAN AGRICULTURAL AREAS THROUGH REGENERATIVE LIVING LANDSCAPE

Charlamaine P. Morales[1*] and Angelo Paulo Mogul & Ruen Balmores[2]
[1]Sto. Nino Calumpit, Bulacan, Philippines
[2]Department of Landscape Architecture, College of Architecture and Fine Arts,
Bulacan State University, City of Malolos, Bulacan, Philippines

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ABSTRACT

The Philippines is ranked 3rd as the most disaster-prone country worldwide according to the World Risk Index 2016 considering multiple calamities such asflooding. Flood disasters are on the rise in the past years and even occurs becauseof monsoon rains, damaging crops, and infrastructure. At present, some urban areas experience floods and other environmental risks due to the growing population that leads to unsustainable demand. The study focuses on an urbanized municipality of Bulacan having a high rate of urban sprawl. The municipality experiences flooding events on a regular basis and the infrastructure for its protection has been lacking due to the funds needed for their development. The aim of the study is to create an example application of integrating regenerative development concepts to usually grey infrastructure solutions to flooding. The Regenerative Living Landscape, a term coined by Turenscape, is a strategy of converting an area into a living system that shall provide comprehensive ecosystem benefits including food production, flood regulation and water purification. The concept uses stormwater in developing agricultural growth and reduce flood events through harvesting and storing stormwater to use as agricultural irrigation. These additional concepts aid the creation of flood reduction infrastructure that will have additional uses like stormwater reduction, harvesting and reuse, constructed wetlands for flood risk reduction and river pollution alleviation, agricultural production areas and eco-commercial establishments for economic improvements, and open spaces for activities of potential new users. The study interviewed key personnel from the local government units and local agriculture department to determine the needs of the municipality and through baseline data of the general area, a specific sample site was selected. Best practices of integrating stormwater infrastructure with usable and productive landscape was gathered and assessed on their applicability on the study site. To determine the correct strategies to implement, a Design Strategy-Regenerative Living Landscape Correlation Matrix was created. This allowed the researchers to investigate which best practice strategies to integrate into the schematic landscape design of the area. This pilot study of the methodology of the application of Regenerative Living Landscape concepts on the local setting is recommended to be utilized for other location within the municipality for a system wide solution.

*Corresponding author: mainemorales04@gmail.com

1. INTRODUCTION

Flooding is one of the most widespread hydro-meteorological risks that cause huge annual losses in terms of damage and disruption to economic livelihoods, business, infrastructure, services, and public health (Few et al., 2004). Flood disasters are on the rise, and in the past decade, millions of people have been affected. The Philippines experiences unexpected heavy rainfall in mid- July which continues through the end of October. Floods are generally caused by unmanaged stormwater that overflows rivers over the carrying capacity within their banks and overpowers current drainage infrastructure of urban areas. This usually occurs during the long and short rains, and especially during spells of intense and heavy rainfall in the catchment of the rivers. Floods have become more serious and frequent, and the rivers have gradually lost their capacity to buffer environmental variability. Deforestation and degradation of natural areas by human development punctuated the severe worsening of these problems during the rainy seasons. Flooding is a rapidly growing public health problem in urban areas leading to an increased incidence of water-related-illnesses among humans and animals, constrained crops, and tree selection, made transportation more difficult, interrupted schooling, and destroyed property and infrastructure.

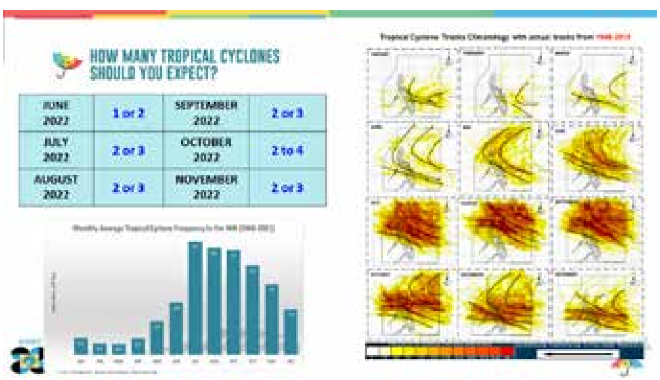

Figure 1: Tropical Cyclone information of the Philippines. Source: https://bagong.pagasa.dost.gov.ph/climate/tropical-cyclone-information

Urban sprawl worsens the flood problems in the Philippines because an estimated a total of 6% of the areas in urban places increased flooding cases in a 10-year period (Bragais, M., Johnson B., et al). The loss of vegetation areas resulting into poor food production areas and worse water recharge scarcity. Furthermore, the built-up environment causes increased chance for groundwater contamination because the natural filtration is by-passed by impervious surfaces such as asphalt, and concrete and modern drainage systems. The increasing demand and extraction of groundwater have led to the sinking of some urban areas. The stormwater runoff problems and impacts are most evident in areas where urbanization has occurred. Changes in land use have a major effect on both the quantity and quality of stormwater runoff and can dramatically alter the natural hydrology of an area. Increased impervious cover decreases the amount of rainwater that can naturally infiltrate into the soil and increases the volume and rate of stormwater runoff. These changes lead to more frequent and severe flooding and potential damage to public and private property (State of NSW and Office of Environment and Heritage 2017).

Figure 2: Floodwater has inundated an inner road in Marilao City, Bulacan, Philippines, July 23. Source: Gallardo, Troy

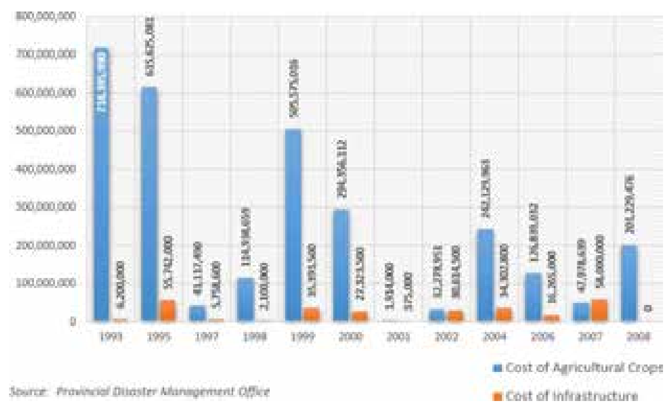

Figure 3: Cost of Damage of Flooding in Bulacan (1993-2008). Source: Provincial DisasterManagement Office

The province of Bulacan has been rapidly urbanizing shifting from its originally agricultural focus into the other industries and service provision. Cities in the province have continuously changed agricultural land-use into urban uses leading to reduction of permeable spaces, and food production potential. Being one of the most progressive provinces in the country, increased its industrial establishments and roads that have a wide network of national and provincial road connecting to Metro Manila. Due to this, flooding events rose because there are more impervious surfaces that allows infiltration that affects the quality and quantity of stormwater. Moreover, the reduction of green spaces within the city and the contribution of upstream communities and urban areas has led to the increase pollution and decline in water quality of the river system. This directly affects the surrounding urban areas because it overflows during heavy rains. Most of the areas in Bulacan are currently experienced flooding even from monsoon rains and according to PAGASA (Philippine Atmospheric, Geophysical and Astronomical Services Administration), the seasonal rainfall will increase by 4.2% in 2020 and large rainfall will increase by 12.8%. In 2020, a 1,174.7mm of projected seasonal rainfall in 2020 will increase by 2050 having 1,287.17mm. It shows that most of the urbanized areas Malolos City, Marilao, and City of Meycauayan of Bulacan that frequently experience flooding from 2012-2015 have an average of 2-5 feet depth of flood and have the highest precipitation of rainfall of 2402 mm annually. Continued urban developments in the province exacerbate flood risk and pollutants in the river. Therefore, stormwater infrastructures are implemented throughout the province. These consists of grey infrastructure such as Small Water Impounding Projects (SWIP), earth filled structure with a height of 5-15 meters constructed across narrow valleys or depression to create a reservoir that will harvest and store rainfall that have minimum coverage capacity of 15 hectares, and Small Farm Reservoir (SFR), a storage facility with concrete or plastic as lining and protection of embankment that have a minimum coverage area of 0.5 hectares. However. grey infrastructure is insufficient in answering growing issues of flooding.

The literature reviewed for the study mainly focuses on methods and strategies that will reduce the effects of stormwater runoff on the river system and reduction of pollutants present in them. The regenerative development paradigm introduces a new methodology of designing and developing spaces which allows designers to operationalize and apply complex and abstract ecological and sustainability concepts into scales that are more suitable to their applications. The collection of stormwater runoff for subsequent re-use for agricultural systems in an urban setting bears the characteristics of a regenerative design. The study by Gibbons, Cloutier, Coseo, and Barakat focuses on five steps to create a regenerative development:

1) Regenerative developments should manifest the potential of the area where it enhances the regenerative capacity in living systems that leads to higher levels of health and potential. It focuses on the positive outcomes for all involved in the systems such as the natural, economic, and social.

2) Developments should be able to shift worldviews by engaging stakeholders and inhabitants of an area to shift their worldview to a more ecological mindset. In the case of this study, stormwater runoff is perceived originally as a detriment and can be used as a resource.

3) They should be instrumental in creating mutually beneficial, co-evolving relationships through fostering mutual relationships between sociocultural and economic components of the system. Open spaces and productive landscapes can be integrated into the development of rainwater reuse infrastructure. This will create a holistic development that combines the functionality of rainwater harvesting and opportunities of improving the sociocultural usage of the area through the landscape.

4) There must be addition of value across scales by enhancing integral, life-conducive values of the system. They can affect smaller scale to larger scale systems. The improvements of the area can affect both the temporal and spatial scales of users and the environment. The improvement of everyday lives of people that interact and use the spaces, and long-term benefits because of the increased productivity and reduction of flooding occurrences of the area will be seen from integrating regenerative developments in the study.

5) There must be an impact in growing regenerative capacity in whole systems. The improvements should be with the whole living systems and not just isolated fragments. The creation of constructed wetland systems will improve the natural environment and its associated flora and fauna as well as the human component of the landscape.

According to Begum and Rasul, the use of stormwater can be used to increase water supply and reduce water pollution. Stormwater is becoming recognized as a valuable resource rather than as an inconvenience that needs to be disposed of as quickly as possible. Storage and recycling technologies have been developed to utilize it as an alternative water source for non-drinking uses. The use of stormwater harvesting systems are being employed to reduce the runoff that reaches the river and recycle the collected water for agricultural purposes that will be developed in the same site. Dordio, Palace Carvalho, and Pinto's study on wetlands as living filters state that natural wetlands have been utilized knowingly and unknowingly over the course of human history as filters to purify various waters that are polluted with a kind of pollutant. Wetlands filtrate pollutants from point source and non-point source pollutants. Natural wetlands are also known to reduce the impacts of rain on water body systems such as rivers because of the arrest of stormwater runoff and reduction of disposal speed towards water systems. Artificial wetlands function similarly as natural wetlands that are developed to have flood control capabilities, food production capacity, and water quality improvement potential. The primary limitations for the effectiveness of wetland systems are the requirement for a large land area, the need for a long period of time to filtrate water, and long-term maintenance. Even with the limitations of wetland systems, constructed wetland systems can be designed to have lower cost with lower maintenance requirements as compared to other filtration technologies. These systems can be designed as a free water surface or subsurface type wherein a combination of both can maximize the usage of the area, and with the development of larger parts of land to support constructed wetlands the area can have integrated uses such as usable open spaces and agricultural production facilities. Using constructed wetlands instead of traditional infrastructure and technology will help preserve the ecosystem through water treatment and reduction of disposed runoff towards the river system, and socioeconomic benefits of the water reuse for agricultural irrigation and opportunities for more social open spaces.

The design approach of Regenerative Living Landscapes converts the area into a living system that provides a comprehensive ecosystem benefit including food production, flood regulation, and water purification. Man-made wetland terraces were used as a water cleaning mechanism. Ecologically friendly riprap or loose stones replace the concrete flood controls of the site, to enable native species to grow. Constructed wetlands are used to filtrate pollutants in the water, improve biodiversity, sequester carbon, provide open space for residents of the city, and reduce the cost of water usage. An example of regenerative living landscape application is in Shanghai, China, wherein a brownfield area is developed with green technologies for flood control, water treatment, and a park. It is located at the Huangpu River with a lot area of 14 hectares. The Regenerative Living Landscape can be applied through the Sponge City technique which consists of four main principles (urban water resource management, sustainable water management, green infrastructure, permeable urban pavement). It increases the capability of absorbing, processing, allowing rainwater to be permeated and cleaned and releasing as stored water when necessary. Sponge cities are developed to have high-quality living environments and create a safe water circulation network with less expensive means. They treat rainwater as a resource to save enough space for water conservation in the urban development. It facilitates the reduction of flooding and improving the security of water resources while reduce surface runoff and decreases run-off possibility to control non-point source pollution.

2. METHODS/APPROACH

The primary data of the study consists of face-to-face interviews of the local government unit (LGU) of the area because they are the most knowledgeable of the issues of the vicinity and they can perceive the needs of their constituents, the students and residents who will enjoy the activities on-site, in the potential development. The LGU will be tasked as maintenance personnel of the public and production areas.. The activities that will be integrated into the site will be based on their opinions and insights for an inclusive approach in the landscape design. Site observations were also conducted in the area for the researchers to experience the site. This data will be used to determine the activities of the area and general park design inclusions. The local Department of Agriculture key person that was done face-to-face using a semi-structured interview that both had general queries on the background knowledge on the status of rain harvesting usage, status of agricultural farming in the municipality, and more specific topics such as the potential crops that can be used for the agricultural production of the development that will use the harvested rainwater.

Secondary data consists of flooding maps, levels plans, pollutants present in the water, the average precipitation of stormwater per year and, other scientific data about the Meycauayan City area. These will be used as design parameters in the schematic design of the sample area. Design strategies and implementation methods were also gathered as secondary data as a basis for the schematic landscape design that will be used to showcase the solutions of the study. The strategies will be derived mainly from the projects and best practices of Kongjian Yu who has been using the concept of regenerative landscapes in some of his flood related projects. Visual data and a sample design are effective methods in communicating the solution to local government and private entities, especially those who are not familiar with scientific concepts.

Gathered data from both primary and secondary data will be synthesized into a schematic design strategy. The validity and applicability of strategies will be cross referenced through the primary (site observations and needs analysis) and secondary (best practices and strategies from literature) data. The water quality and level of pollution in the river water for reuse is an important aspect of the viability and specification of planting materials and detailed engineering of the constructed wetlands. However, the study delimits that exact planting materials to bring certain levels of polluted water to an acceptable quality will not be part of its scope because the primary focus of this study is to show the viability and methodology of an originally minimally used land to become a usable and productive form of flood reduction infrastructure. Future studies can focus on the exact specifications of the hardscape and softscape engineering aspects of the landscape design to be constructed.

3. FINDINGS AND SOLUTION

The data gathered are presented into three tables where they are analyzed within the context of the needs of the study. The first table summarizes the results from the interview which can be grouped into three main concerns regarding projects that deal with open spaces and flood reduction infrastructure. These are the Environmental, Economic, and Social concerns. Environmental concerns deal with the effectiveness of the strategy to resolve the issues like flooding, river water reuse, and stormwater management. Economic concerns consider the sustainability of development and maintenance of the infrastructure. The Social concerns deal with the usability of the area that allows it to become more than just infrastructure for flood reduction.

Table 1: *Tabulation of Interview Results*

Question	Summarized Response	Implications on the Study
A) Local Department of Agriculture staff		
What is the current state of flood prevention infrastructure in the province?	Use of grey infrastructure to reduce the risk of flooding across the province but is still lacking across the scale of the province because of its high cost. Flood reduction infrastructure can be developed with multiple uses to make the investment more "worth-it".	Developed infrastructure can be integrated with income generating opportunities to offset the cost and sustain the development for the long term. Flooding occurrence also cause economic damage to affected areas by destroying property, public works, and agricultural production.
What is the current state of stormwater reuse for agriculture in the province?	Lack of stormwater reuse infrastructure for agricultural usage across the province	With the lack of flood reduction infrastructure, the province is yet to invest more on stormwater reuse infrastructure, the potential flood reduction development can integrate stormwater reuse function to maximize the usage-to-investment of the project.
B) LGU official		
How prominent is the selected study area to the daily life of the residents around it?	It is notable that residents just pass by the area without any though or notice. Meanwhile, there are some users like students that utilize the area for their school activities as this is one of the only accessible open spaces in its general vicinity.	Improvement of the amenities of the site will increase the usage of more types of users.
What environment would encourage people to visit an open area/ park?	Currently, the area is not shaded so users tend to go there at the early morning or the late afternoon. Better amenities and climatic comfort are the primary factors for improving open space/park usage.	The planting materials used across the site can be designed towards the reduction of heat and improve the comfort of the users.
How do people use the existing open area/ park?	There is a given emphasis on the usability of the area as an open space that can be used for various activities from personal exercise and training to school group works.	The enhancement of the existing uses of the park will encourage users to continuously visit the area and potentially attract other users to the area.
What are the challenges foreseen when maintaining the area after its potential development (landscaped areas, agricultural production, constructed wetlands)?	The wider developed area will be harder to maintain especially with additional planting materials. The LGU might have a challenge to maintain all the areas effectively because of their limited manpower.	The usage of low maintenance landscape plants can help in reducing the amount of work to be done by the maintenance personnel. The LGU can create activities that will foster and encourage community engagement.

Figure 4*: Site Location. Source: Google Earth*

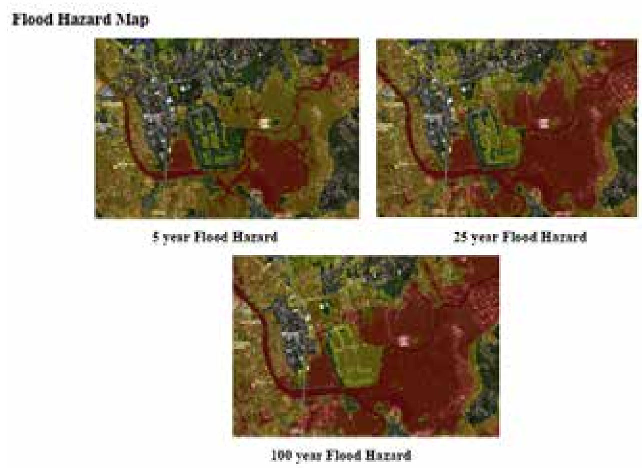

Figure 5*: Flood Hazard Maps. Source: https://noah.up.edu.ph/noah-studio*

Table 2*: Tabulation of Gathered Secondary Data*

General Topic of Concern	Data Gathered	Implication on the Study
Design Strategies	1) The usage of ecological infrastructure over conventional infrastructure	Determine the applicability of ecological infrastructure to the site.
	2) Inclusion of crops suited for the usage of the area like annual crops or rice production	Plant selection that are suited to the site conditions that will benefit the agricultural production of the area.
	3) Integration of open spaces and parks into flood protection infrastructure	Planning of activities that coincide with the open space improvements.
	4) Usage of the Sponge City concept	This concept coincides with the intent to integrate flood reduction infrastructure and stormwater reuse using ecological infrastructure.
	5) Elevated walkways	Not necessary in the study because the most parts of the site is not susceptible to flooding.
	6) Floodable spaces	Not necessary in the study because the most parts of the site is not susceptible to flooding.

General Topic of Concern	Data Gathered	Implication on the Study
Site Baseline Data	1) Flood Hazard Maps that encompass the site – shown in Figure 4.	Indicate that the site itself is not susceptible to floods creating opportunities for activities and production that will not be disrupted by floods, as well as potential to develop an area that can accommodate terracing constructed wetlands and agriculture production.
	2) Transportation accessibility – Accessible by public utility vehicles, private vehicles, bicycle.	The site 's accessibility to pedestrians and public transportation provides higher potential of users of various modes of travel.
	3) Pedestrian accessibility – the site is within 200 meters from the major municipal road.	
	4) Soil type – the site is designated to have Prensa soil type. This needs to have adequate drainage and irrigation systems, proper leveling, and contour cultivation. It needs regular addition of organic matter and fertilizer, and proper timing of cultivation and planting.	There must be consistent fertilizer and organic matter provided for the agricultural production areas. Excess fertilizer nutrients and organic matter must be cleaned prior to discharge to the river through have the drainage move through the constructed wetland. Water acquired from the river must be cleaned to an acceptable quality prior to usage for irrigation.
	5) Flood susceptibility of the municipality of the site – Moderately susceptible at 12.83%	The susceptibility of the municipality to flooding emphasizes the importance of flood reduction infrastructure to protect it from future flood events.

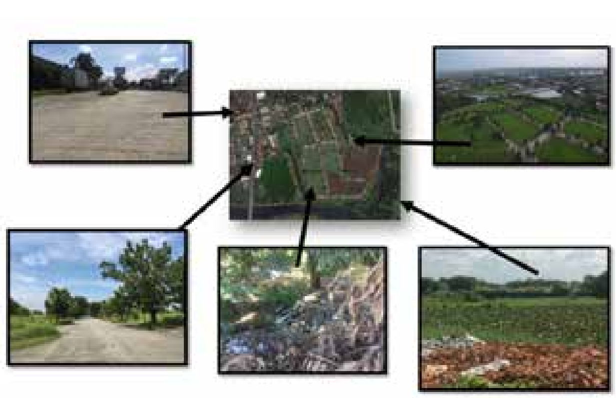

Figure 6: *Existing site photos. Source: (U-R) DJIFreelance.ph; (U-L and Bottom) Morales, Charlamaine.*

Table 3: *Tabulation of Site Observations*

Observations	Implications on the Study	
	General	Specific
1) Developments and improvements done	Applicability of existing site improvements to design strategies	Potential usability of existing site elements to reduce development costs
2) Polluted water that area passing along the river	Environmental considerations	Water gathered from the river must be cleaned to a certain quality using specific softscape materials.
3) Lack of vegetative cover in the area	Usability and comfort of the users	Addition of appropriate planting material for shade
4) Lack of designated activity spaces	Can serve as magnet for attracting visitors to the area	Integration of various activities related to the ecological infrastructure to be developed
5) Ease of arrival to the site from the main municipal road	Accessibility of the area to potential new visitors	Allow for spaces that will welcome a variety of transport modes (drop-off areas, private vehicle parking, bike racks, public transportation stop)

The tables of Secondary Data and Site Observations, Table 2 and 3 respectively, are summaries of discussions of gathered data that will be used as reference for determining the design strategies to be used. The design strategies are finally cross-checked if they are viable for the project and if they are to be included in the schematic design. The strategies are listed, then checked first if they are applicable on site. Then if it is applicable, it is determined if it is relevant to the concepts of Regenerative Developments. Lastly if it is relevant, it is coinciding with the needs of the potential users of the development.

Table 4: *Design Strategy – Regenerative Living Landscape Correlation Matrix*

Design Strategies and Applications	**Site Observation (If applicable to the area)**	**Relevance to Regenerative Developments**	**Does the strategy coincide with the users' needs?**
Floodable open spaces	Not applicable on site because it is generally not affected by flood	N/A	N/A
Terraced Constructed wetlands	Applicable because the topography of the site	This strategy manifests the potential of the area. It shifts the worldview of seeing stormwater as a resource instead of detriment. It makes the area mutually beneficial to both users and the environment. It improves value of the environment and the usage of the land. It impacts whole living systems because of the improvement of the general environment.	Yes, it will aid in reduction of stormwater runoff to drain into the river and provides a way to collect and clean water coming from the river.
Rainwater harvesting technology	Applicable if planned with the planned collecting elements	This strategy manifests the potential of the area. It shifts the worldview of seeing stormwater as a resource instead of detriment. It is mutually beneficial to the reduction in cost of water usage and stormwater runoff going towards the river system. It improves the value of the land area because it reduces water consumption for its activities. It impacts the living systems of the users in the site and the general vicinity of the site that is aided by the reduction of stormwater runoff towards the river.	Yes, it will aid in reduction and collection of stormwater runoff.
Productive landscape (Agricultural usage)	Applicable because of the soil quality of the area and the scale of the area	This strategy manifests the potential of the area. It shifts the worldview of the area as an unproductive area to a productive one. It is mutually beneficial to the LGU and users of the area. It improves the value of the area because of its production quality. It will impact the human living system because of access to additional food production.	Yes, it will aid in the economic and social aspects of the landscape.
Activity areas	Applicable because of the opportunities for developing the open spaces into robust activity areas	This strategy manifests potential of the area. It shifts worldview of the area as an occasionally usable area to a more robust use area. It is mutually beneficial to the users and the environment because there are potential activities that will allow users to tend to the environment. It improves the value of the area because of quality of experience of activities that can be done. This will impact whole living systems from the holistic health and values of users to the improvements in the environment.	Yes, the improvements of activity areas are vital for the users of the area.
Sports amenities	Applicable because of the potential for developing more formal sports areas in the site	This strategy manifests potential of the site. It shifts the worldview of the usability of the site. The strategy is not mutually beneficial because it will only benefit users and formal sports amenities would require more land area and disrupt the ideal environment of the area.	N/A

Design Strategies and Applications	Site Observation (If applicable to the area)	Relevance to Regenerative Developments	Does the strategy coincide with the users' needs?
Commercial amenities	Applicable because of its accessibility to potential consumers	This strategy manifests the potential of the area. It shifts worldview of the area as an income generating space from originally an underutilized area. It is mutually beneficial to the users and the management of the commercial amenities. The environment will have benefits from the proceeds generated. The values of the area are improved by being a source of income for the LGU and financial sustainability of the area. It impacts whole living systems because it will aid in maintaining the development functional.	Yes, the increased economic output is part of the needs of the project to be addressed.

The selected area for the case study was initially developed as a residential area but was discontinued due to issues with the developer. As seen in the flooding hazard maps, the site itself is not prone to flooding therefore, the potential open space areas can be used as evacuation infrastructure. Its terrain can also be utilized as a constructed terraced wetland that will serve as catchment for stormwater runoff, reducing the amount of water that will go directly towards the rivers system. Lower parts of the area can be developed as floodable wetland that will have water purifying flora to help reduce the pollution of the river and some of the purified water can be reused for the agricultural production areas. This study seeks to design that will serve as an initial development that will influence future developments of subsequent constructed wetland areas along the river system.

4. DISCUSSION

The research finds that the employment of constructed wetlands to integrate the living landscape concept will be able to lessen the flood in urban areas and provide more green spaces. Most of the agricultural areas in Bulacan are vulnerable to flooding hence this problem can be alleviated, through collection of stormwaters that will be reused to irrigate urban agriculture. The implementation of Regenerative Living Landscapes will help the province to reduce its floods and reuse stormwater for agricultural areas that will provide food for the urban area, giving a balance of green and gray spaces in urban sites. The data gathered allowed for the integration of constructed wetlands in the area and the arrangement of spaces and selecting of crops that is also significant for the landscape to sustain itself. This has led to the conceptualization of a landscape design solution that answers the primary concerns: environmental, economic, and social. The solution provides water retention and cleansing, usability of water for agricultural purposes, and reduction of flood risk.

Table 4: *Summary of Conceptualized Design Strategies*

Concern	Addressed Issues	Design Strategies
Environmental	• Reduced flooding risk • Water cleanliness • Reduced water pollution • Stormwater runoff reduction	• Constructed wetlands to receive and store water • Constructed wetland system to purify and clean the river water
Economic	• Agricultural opportunities • Field-to-fork scheme • Water consumption reduction • Agricultural sector vulnerability to environmental damage	• Integrating urban agricultural areas within the site • Provide opportunities for economic improvement through new establishments or increased agricultural areas • Improve groundwater recharge and reuse of stormwater • Reduce the risk to damage for urban agricultural areas
Social	• Open space for activities • Recreational opportunities • Evacuation infrastructure	• Park development in the constructed wetland system • Development of usable green spaces

***Figure** 7: Bubble Diagram. Source: Morales, Charlamaine.*

Figure 6 shows the schematic placement of spaces on the site. The arrows represent the movement of users on the site wherein the bigger arrows depict movement of general users while smaller arrows represent limited movement of essential personnel or more private persons. Economically inclined areas are the ecolodge, field-to-fork restaurant/ store, and agricultural areas. More eco-social, quality-over-quantity types of business of establishments like ecolodges and field-to-fork restaurants are preferred over mass consumption establishments to help control their environmental impact and promote the local and cultural products. Park area and recreational areas are the primary socially enhancing spaces. Constructed wetland and agricultural areas can also be accessed by the public with supervision to increase the awareness of the importance and knowledge of wetlands and agricultural systems.

The images shown in Figure 9 to 12 are schematic designs of the envisioned park and open spaces that will be developed. The design concept focuses on the integration of man-made elements with the natural technical aspects of the landscape. Jogging paths, seating, and activity areas are blended around the constructed wetland and agricultural areas that provide a pleasant experience of the environment and potential exposure and awareness to the systems that are in the site.

Figure 8: *Constructed Wetlands Schematic Perspective. Source: Morales, Charlamaine.*

Figure 9: *Retention Pond Schematic Perspective. Source: Morales, Charlamaine.*

Figure 10: Agricultural Area Schematic Perspective. Source: Morales, Charlamaine

5. CONCLUSION

Urbanization has brought economic improvements and developments in Bulacan, but these changes, the environment has deteriorated leading to increased flood risk, and worsening water quality. The utilization of a design paradigm that synergizes design strategies with regenerative development concepts and their applicability to the site and its potential users will help in the formulation of new regenerative landscapes. This research helps urban areas to potentially integrate constructed wetlands in other locations which can be utilized to adapt to the worsening effects of climate change through stormwater reuse for agriculture and reduction of risk to flooding events. The study will inspire developments toward utilizing green spaces for water cleansing and reuse, and agricultural development. Future implementations of the living landscape concept can be done along the river system to provide widescale environmental, economic, and social benefits.

REFERENCES

ADB Headquarters (May 2015) Shanghai Houtan Park: Landscape as Living System. https://events.development.asia/system/files/materials/2015/05/201505-shanghai-houtan-park-landscape -living-system.pdf

Begum, S., Rasul, M. (January 2008). Stormwater Treatment and Reuse Techniques: A Review. https://www.researchgate.net/publication/267242625.

Kotaro Iizuka, Brian A. Johnson, Akio Onishi, Damasa B. Magcale-Macandog, Isao Endo and Milben Bragais.(April 2017) Modeling Future Urban Sprawl and Landscape Change in the Laguna de Bay Area, Philippines https://www.iges.or.jp/en/publication_documents/pub/peer/en/5975/lan d-06-00026.pdf

Chithra S.V., Dr. M.V. Harindranathan Nair, Amarnarth A, Anjana N.S.(May 2015) Impacts of Impervous Surfaces on the Environment. http://www.ijesi.org/papers/Vol(4)5/E045027031.pdf

Dar, William (June 2017). Agriculture's water problems can become too big. https://www.manilatimes.net/2017/06/09/business/columnists-business/agricultures- water-problems-can-become-big/331756

Dordio, A., Palace Carvalho, A.J., Pinto P. A., (n.d.). Wetlands: Water "living filter"? https://dspace.uevora.pt/rdpc/bitstream/10174/6485/1/Dordio%20%20Wetlands%20Water%20% 20%20%20%20%20living%20filters.pdf

Gibbons, L.V., Cloutier, S.A., Coseo, P.J., Barakat, A. (April 2018). Regenerative Development as an Integrative Paradigm and Methodology for Landscape Sustainability. https://www.mdpi.com/2071-1050/10/6/1910.

Jeong S. M., Lee, J. and Rubio C. J., (December 2008) WaterResources Evaluationin the Philippines https://www.researchgate.net/publication/321606_Water_Resources_Evaluation_in_t he_Philppines

Provincial Development and Physical Framework Plan (June 2014) https://www.bulacan.gov.ph/government/ProvincialDevelopmentAn dPh ysicalFrameworkPlan(June2014).pdf

R.E. J., Callora N., Inion R., Tolentino G., (n.d.) The Practical Application of Constructed Wetlands in the Philippines. http://www.tvird.com.ph/baguio_amd_paper.pdf

Saunders, W. (January 2012). Designed Ecologies: The Landscape Architecture of Kongjian Yu. Birkhauser Architecture.

Schuengel, Frank (September, 2016). Philippines Now The 3rd MostDisaster-Prone Country According to Latest World Risk Index. https://www.wheninmanila.com/philippines-now-3rd-most-disaster- prone-countryaccording-to-latest-world-risk-index

Zhang, J. (May 2017) Assessing the Application of Sponge City to Downtown Guelp https://pdfs.semanticscholar.org/8652/b4994135b6ddd7ab60c81c61227 54bb7b223.pdf

UMassAmherst The Center for Agriculture, Food and the Environment. Water Quality for Crop Production. https://ag.umass.edu/greenhouse-floriculture/greenhouse-best-management-practices-bmp-manual/water-quality-for-crop