Sustainable Cities and Society 20 (2016) 180–198

Contents lists available at ScienceDirect

Sustainable Cities and Society

journal homepage: www.elsevier.com/locate/scs

Developing river rehabilitation scenarios by integrating landscape and hydrodynamic modeling for the Ciliwung River in Jakarta, Indonesia

Ervine Lin[a,b,*], Kashif Shaad[a,c], Christophe Girot[a,b]

[a] Future Cities Laboratory, Singapore ETH-Centre, Singapore
[b] Chair of Landscape Architecture, ETH Zurich, Switzerland
[c] Institute of Environmental Engineering, ETH Zurich, Zurich, Switzerland

ARTICLE INFO

Article history:
Received 27 February 2015
Received in revised form
17 September 2015
Accepted 20 September 2015
Available online 30 September 2015

Keywords:
Landscape modeling
Hydrodynamic modeling
Point clouds
River rehabilitation
Ciliwung River

ABSTRACT

Landscape visualization and modeling has progressively merged over the last decade providing ever increasing accuracy and realism. As powerful as visualized landscapes may be, there is a need to integrate them with numerical models to simulate real world dynamics, and by doing so, move beyond a purely visual evocative expression to one which is physically grounded in reality. In this paper, we present an approach that integrates landscape and hydrodynamic modeling through the modification and testing of point cloud data to assess the flooding of the Ciliwung River in Jakarta, Indonesia. We propose a series of 6 scenarios along the 40 km course of the river corridor ranging from the governments' "normalisation" proposal to a green infrastructure scenario by our team. Through such flood simulations we have found that the severity of the floods can only be contained by implementing the extensive normalized canal that is planned, however, the scale of the intervention at hand and the possible impacts further downstream need to be carefully weighed in. Likewise, while the green infrastructure scenario can be seen as a possible alternative to flood management, it is unlikely to mitigate the effects of the most severe of floods. In reality, a careful combination of the two extreme scenarios of a new concrete channel and a green corridor will likely provide the best balance between flood mitigation and riparian restoration. The integrated modeling approach presented here provides a possible platform to further refine such a scenario into one which best caters to all stakeholders in the Bogor, Depok and Jakarta regions.
© 2015 Elsevier Ltd. All rights reserved.

1. Introduction

Technological advancements in collection and processing of terrain information have made 3D digital data of landscapes and cities more accessible than ever before (Richter & Döllner, 2014; Shaad et al., 2016). Landscape and urban planning have long embraced these technological advancements by producing realistic three and four dimensional visualizations of our landscapes to communicate relevant issues to stakeholders and the general public. More recently, technologies such as LiDAR and image-based photogrammetry have inverted the process of obtaining geospatial data of our environment by moving away from laborious process of acquiring and manually digitizing geospatial datasets (Ervin, 2003; Lange & Bishop, 2005). More often used by engineers and surveyors, these new technologies are trickling down to landscape architects to enable them to capture the landscape with unprecedented speed and detail (Girot & Melsom, 2014; Melsom, 2014; Rekittke, Ninsalam, & Paar, 2015). After collection and processing, the resultant digitized model represents an object, space or event manifested in the form of a full color point cloud 3D model that once stored can be digitally revisited repeatedly – a digital replica of reality, no longer landscapes but "scanscapes" (Shaw & Trossel, 2014). These point cloud datasets essentially represent a digital collection of geographically positioned three-dimensional coordinates, or points, that can have additional metadata associated with each point (White, 2013) and it is using such point cloud datasets that the paper attempts to bridge between landscape and hydrodynamic modeling.

With growing public interest in our physical environment, linking of these point cloud datasets with numerical models that simulate real world dynamics (Lange, 2011) can potentially integrate scientific projections with detailed visualizations – creating a platform that can help communicate and analyze complex relationships (Mitasova, Harmon, Weaver, Lyons, & Overton, 2012) between the inhabitants and their environment. River

* Corresponding author at: Future Cities Laboratory, Singapore ETH-Centre, Singapore.
E-mail address: ervinelin@arch.ethz.ch (E. Lin).

http://dx.doi.org/10.1016/j.scs.2015.09.011
2210-6707/© 2015 Elsevier Ltd. All rights reserved.

rehabilitation is one area of science that can benefit from the increased interaction between 3D digital datasets of landscape design and numerical modeling of river hydraulics (hydrodynamic modeling). This interaction can potentially lead to more holistic solutions to some of the pressing problems of river management – balancing, for instance, concerns of flooding, ecosystem services and the recreational and scenic potential of a river. The idea of using the underlying dynamics of a hydrologic system as the initial design and planning driver is hardly novel to the field. In his seminal book Design with Nature, Ian McHarg employs a meticulous technique of gathering and overlaying pieces of data to reveal the workings of the Potomac River Basin which subsequently reveals implications for future land use and management (McHarg, 1969). Such techniques of interpreting ecological processes through a series of abstracted 2D base maps have been handed down and inherited by landscape architects and geographic information system (GIS) planners today (Danahy, 1997). In contrast to this two dimensional abstractions of existing conditions, which tends to flatten and oversimplify nuances of a physical landscape reality (Girot, 2013), we now seek to leverage on the spatial information provided by three-dimensional models (Lange, 2001). Further coupling them with hydrodynamic simulations assists in the decision making process by understanding not only the existing conditions, but more importantly systematically comparing different alternative future scenarios (Deming, 2011; Steinitz et al., 2003).

In this paper, we use the case study of the Ciliwung River in Jakarta, Indonesia to demonstrate this potential of combining landscape and hydrodynamic modeling to test different river rehabilitation possibilities that are informed by the terrain and land use along the river corridor. The current development strategy in this basin focuses on floods and flood routing which have led to plans of a uniform concrete channelization of the river. As the river is already experiencing symptoms of an "urban stream syndrome" (Walsh et al., 2005) doing so might very well further deteriorate the conditions in the river. In contrast, we propose an alternative based on urban reforestation that can serve as a template to a more holistic development of the river corridor. To demonstrate and compare these river rehabilitation scenarios, we (1) identify spatially-explicit intervention scenarios that attempt to move away from flood routing as the principle criteria for river-corridor development; (2) utilize the capability to create and modify the base point cloud dataset (first demonstrated in Lin & Girot, 2014) to create digital models of each proposed scenario – such that the modified dataset is not only visually convincing but also physically accurate; and finally (3) utilize the modified 3D point clouds to run high resolution hydrodynamic models of the river corridor which would lead to projections of the possible impacts of each proposed intervention. The results and subsequent discussion conclude that any of the developed scenarios will make a positive impact on reducing the inundation extent. This is particularly evident in the extreme case of a fully channelized river although the results also warn of the increased strain downstream which will likely result from such a proposal. It is also shown that the way in which vegetation is modeled in the simulations has very little impact on the hydrodynamic simulation results, it is likely that a more complicated model or method is require to accurately predict the effects riparian vegetation have on an urbanized river such as the Ciliwung.

2. Study area

The area of study, the Ciliwung River in Jakarta, has been at the center of human settlement in Indonesia since the 4th Century A.D. It is currently the largest and most important of the thirteen rivers flowing through the city. Unfortunately, increasing urbanization, commercial development and centuries of exploitation and neglect have transformed the Ciliwung River into one of the most polluted rivers in the world (The Jakarta Globe, 2013a). These anthropogenic factors coupled with the build-up of garbage (Texier, 2008) have been the cause of ever increasing seasonal floods. The flood damage from the January 2013 event cost the city USD$3.2 billion dollars (The Jakarta Globe, 2013b).

While informal settlements along the downstream section of the river have adapted to frequent flooding conditions (Fig. 1), they still rely on the polluted river for water, sanitation and even recreation (Vollmer & Grêt-Regamey, 2013). The current immediate action taken by the administration is to alleviate the flooding situation by dredging 11 rivers and two dams, including the Ciliwung River (The Jakarta Post, 2013). Unfortunately, the social, political and ecological complexity of the current state of the Ciliwung River has thus far resisted any other large scale remediation efforts. The proposed plan for "normalisation" of this river system will be one of the corner stones of the scenario developments presented in Section 4.

3. Terrain data processing

The work presented in this paper is derived from a multidisciplinary research group focusing on different issues at three different spatial scales, namely the catchment, corridor and site scales, where knowledge and information derived from the different scales need to be integrated cohesively (Vollmer, Costa, et al., 2015). River processes typically extend over tens of kilometers, as

Fig. 1. Photographs taken in the aftermath of the January 2013 flood showing the sedimentation and debris deposited during a major flood event and the subsequent cleaning up after (Lin 2013).

Download English Version:

https://daneshyari.com/en/article/308085

Download Persian Version:

https://daneshyari.com/article/308085

Daneshyari.com