Digital Methods and Collaborative Platforms for Informing Design Values with Science

Adrienne GRÊT-REGAMEY[1], Paulo BURLANDO[2], Christophe GIROT[3],
Ervine Shengwei LIN[4], Kashif SHAAD[4] and Derek VOLLMER[4]

[1]IRL, ETHZ, Zurich/Switzerland · gret@ethz.ch
[2]IFU, ETHZ, Zurich/Switzerland
[3]ILA, ETHZ, Zurich/Switzerland
[4]Singapore-ETH Centre, Future Cities Lab, Singapore

Abstract

While design is increasingly being recognized as common ground to bring scientific knowledge into decision making enacting landscape change, it has mostly been used to create place specific responses expressing particular values until now, rather than framing the natural and physical sciences to become more salient, find legitimation, and consequently have a greater and longer lasting effect on landscape change. Inverting the design approach by first assessing values and then modelling the functionality of the system to infer possible management strategies can better help incorporate scientific knowledge in local place making.

This contribution illustrates such an approach with a case study focusing on rehabilitating the Ciliwung River in Jakarta, Indonesia, where hydrodynamic models are framed to deliver values assessed in a discrete choice experiment. The assessed values thus frame the processes of science as well as the choices they involve, and are subsequently embodied in design outcomes. We want to show more particularly how digital methods in landscape architecture and planning can support an integrative approach, and close with discussing how embedding such approaches in a collaborative platform can help improve design and provide an interactive learning tool for various stakeholder groups.

1 Introduction

The urbanization of the world continues apace, accompanied by physical growth of urban areas, be they horizontal or vertical. As large urban landscapes are being changed, local production of services provided by the natural environment, referred to as ecosystem services (DAILY 1997), become important. In many developing world cities, rivers and their floodplains play a major role in providing such services, particularly in lower-income communities relying more directly on ecosystem services to meet basic needs (VOLLMER et al. 2013a). Yet, consumption of these services often comes along with exposure to higher flood risk and other water-related health hazards. While many growing cities are slowly beginning to rehabilitate degraded waterways, most project budgets are spent on infrastructure and construction, leaving little room for opportunities to enhance the provision of

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life-sustaining ecosystem services that balance important ecological goals with design factors such as cultural context, public amenities, and safety.

A stronger partnership between natural scientists, physical scientists and designers can significantly help better shape socially acceptable designs and their implementation. “Experimental Design”, has advocated the use of design projects in ecological experiments, (PALMER et al. 2004; FELSON & PICKETT 2005; STEENBERGEN 2008), COOK et al. (2004). Urban landscape design, for example, can be treated as an experimental substrate, to help test the ecological effects of different strategies using adaptive experimentation. NASSAUER (2007) modelled the effects of alternative landscape design and management strategies on water quality and biodiversity, and suggested a year later together with Paul Opdam the use of an analytical framework that employed process as part of research and design patterns and as a means for landscape change (NASSAUER & OPDAM 2008). SWAFFIELD (2013) shows that by beginning first with envisioning workshops that help structure a landscape strategy and its adaptation to place, a science of landscape can be framed to deliver values, rather than having values be a variable in science. In technical and business planning, such an approach of inferring information about the constituents of a system using knowledge about the behavior of the system and its structure is better known under the term `back-casting'. Actually geodesign defines itself as using science in design as well as design in science, building on new and powerful formalities as well as logical chains of reasoning, predictions, and prescription (BATTY 2013). And at the heart of such an approach lies participation in the process of understanding the potential of a place.

In this contribution, we illustrate an approach to geodesign, where the point of departure is the assessment of preferences for a certain design, and deduce from that the necessary rehabilitation strategies to provide preferred output in an interdisciplinary and trans-disciplinary case study of the Ciliwung River in Jakarta, Indonesia. We link computational parametric design methods with hydrodynamic models, and provide design outputs that are readily accessible to stakeholders and members of the public. Stakeholders register their preferences, from which we infer accepted and implementable rehabilitation strategies. Finally, such an approach, if integrated through interactive collaborative platforms, can provide important decision support systems for sustainable landscape development.

2 Case Study Area

The Ciliwung River provides a good example of a heavily urbanized tropical river catchment that bisects the megacity of Jakarta before emptying into the Java Sea. As Jakarta’s largest river, the Ciliwung is a primary source of inland flooding. Recent major floods (1996, 2002, 2007, 2013, 2014) have caused over 100 deaths and led to billions of dollars of damages to property in Jakarta. Moreover, major stretches of the Ciliwung’s riverbanks are home to informal settlements known as “kampungs”, which constrict the river channel and put residents at high risk. Jakarta’s Department of Public Works is beginning a rehabilitation project – a ~US $5 billion effort – to “restore the functions” of Jakarta’s rivers and reservoirs, including widening the channel of the Ciliwung to approximately 50m (it has narrowed to less than 10m in some areas) and building a service road alongside the river. The overarching goal is to enhance the physical capacity of the Ciliwung to channel floodwaters to the East and West Flood Canals, thus initial design concepts include concrete embankments and restricted access to the river. This approach poses certain fundamental questions pertaining to the ecology of the Ciliwung and to the relationship of local communities to the river.

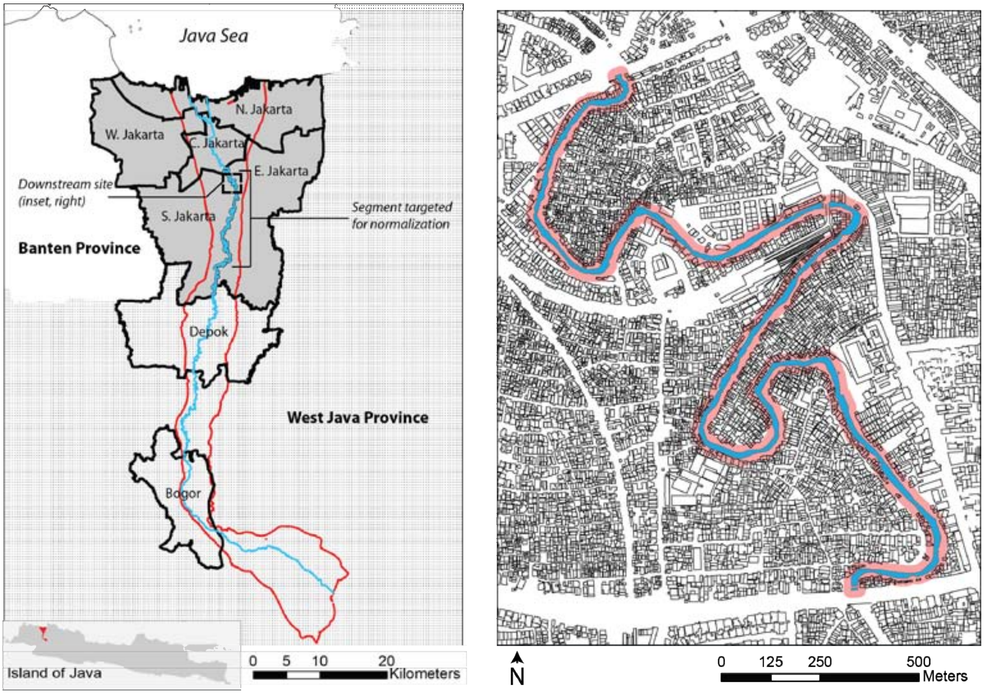

Fig. 1: Left image: Location of Ciliwung River catchment (red) and project site along the river. Right image: Downstream site of Kampung Melayu/Bukit Duri subdistricts in Jakarta and the proposed widening of the channel (pink).

3 A Backcasting Geodesign Approach

In order to frame the rehabilitation problem of the Ciliwung river in terms of values that are relevant to both enabling legislation and institutions, and to the particular places upon which action is focused, we suggest beginning by defining place preferences and values to invoke hydrological science and landscape design options in the deliberative process over future possibilities. Figure 2 shows the conceptual framework of the approach, where the point of departure is the assessment of preferences for a certain design in a stakeholder process asked to answer the question ``what shall we do today to get there?" supported by modeling approaches.

In a first step, we thus determined whether stakeholders would place a value on having vegetation and park space along the corridor, as opposed to the rectangular concrete channel currently proposed by the Ministry of Public Works. The concept of ecosystem services was applied as a common language, so that we could explicitly link biophysical changes in the river corridor to changes in residents’ preferences for a certain design and its related services. A discrete choice experiment supported by sketched visualizations was set up to ascertain residents' preferences for future changes to the river, particularly recreation and flood protection.

Unmanned aerial vehicles and close-range photogrammetry techniques were used to acquire high resolution (20cm/pixel) spatial representation of the surroundings. Processed into 3D point cloud models of chosen areas, these data represent a digital collection of three-dimensional coordinates which were used as a basis from which to modify, visualize and simulate subsequent design proposals. These scenarios provided in turn the reference digital terrain models to derive the hydraulic geometry for the hydrodynamic models, which allowed simulation of flood events to test the improvements obtained by designed river corridor landscapes.

Corridor scale hydrodynamic models provided input data to high-resolution models developed for the site, thereby including the investigation of surface-groundwater interactions, sediment and contaminant transport, and inundation. Outputs from these fine-scale models were then represented within three-dimensional and four dimensional visual models.

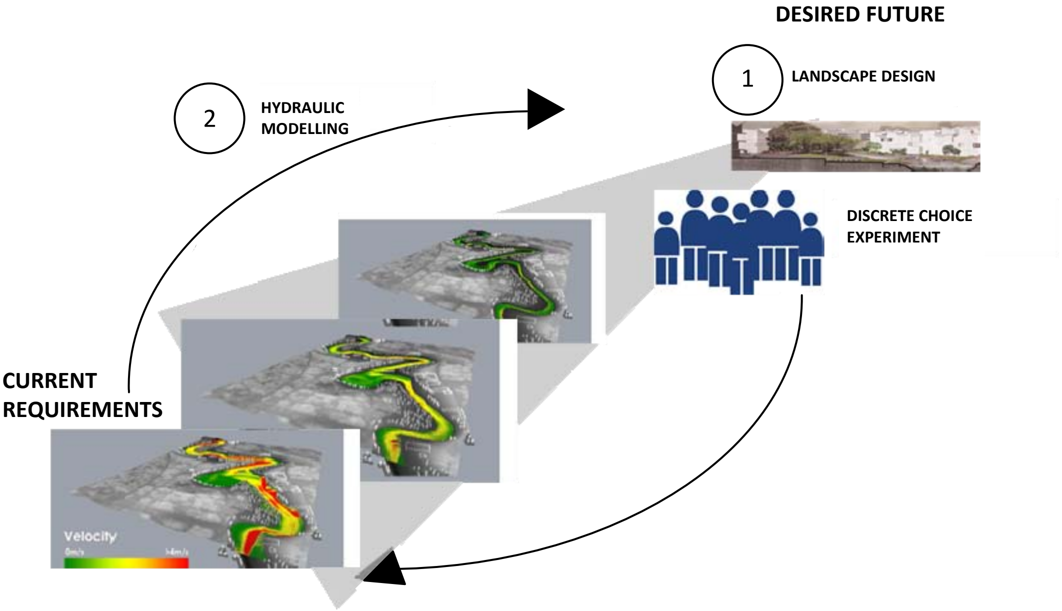

Fig. 2: Conceptual framework of the backcasting geodesign approach. It starts (1) with assessing preferences for riparian landscape through the sketch design of different rehabilitation scenarios. This provided the framing for the hydrodynamic modelling (2) and thus for inferring accepted and implementable rehabilitation strategies of the Ciliwung River.

4 Results

Results from the discrete choice experiment provided the frame for the landscape design by identifying the values people assign to the services provided by different rehabilitation scenarios of the Ciliwung river. Overall, the discrete choice experiment results suggested that restoring the Ciliwung River's ecosystem services is desired among all demographic sub-groups, and demand for these services is strongest within approximately 500m of the river. Jakarta's residents would even be willing to pay a small monthly fee to maintain a riverside park (VOLLMER et al. 2013b). Based on this input, different landscape architectural sketch designs were created and subsequently operationalized using the 3D surface model (figure 3).

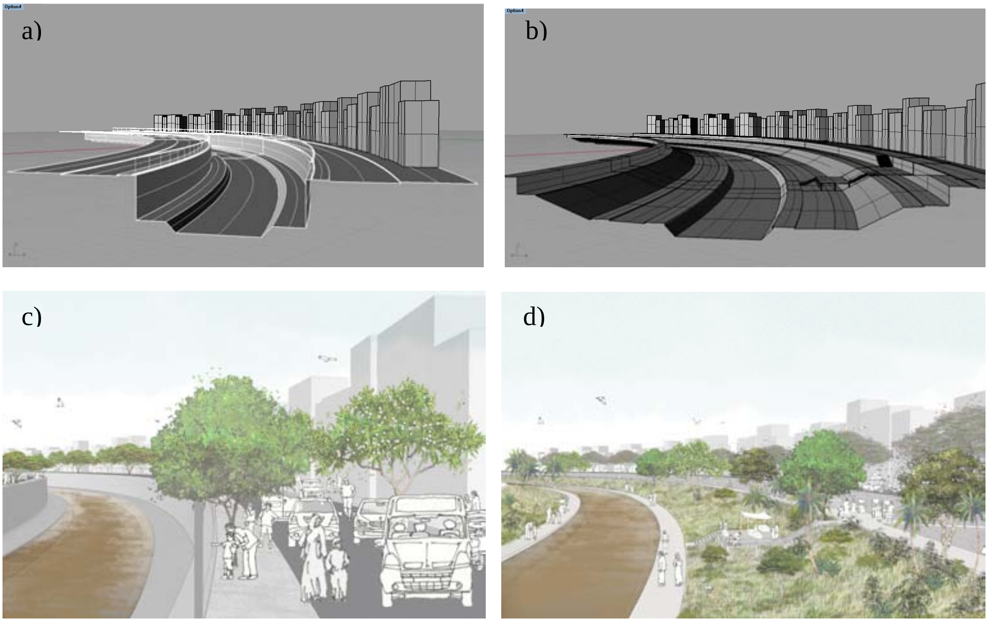

Fig. 3: Digital surface model of the proposed rectangular channel (a), and an accessible trapezoidal channel with approximately the same capacity (b). Images (c) and (d) are sketched close-ups of (a) and (b) and were used as two scenarios evaluated in a discrete choice experiment documented in VOLLMER et al. (2013b).

As a test-case of the capacity to modify point clouds and report results back and forth to hydrodynamic models, the existing river and a widened 'normalized' river channel scenario (based on Jakarta's detailed spatial plan for 2030) were subjected to the same flood simulation. The modelling results demonstrated the capability of the proposed channel widening to contain floodwaters, an initial (but site-specific) validation of the government's proposal to widen the river at our downstream site. However, the visualization method also helped reveal the drastic impact the channel widening itself would have on the existing urban fabric. Figure 4 illustrates two different morphological modification scenarios showing the flood extent and velocities for a reference and representative flood event. These tests further enabled landscape design refinements on the designated river site.

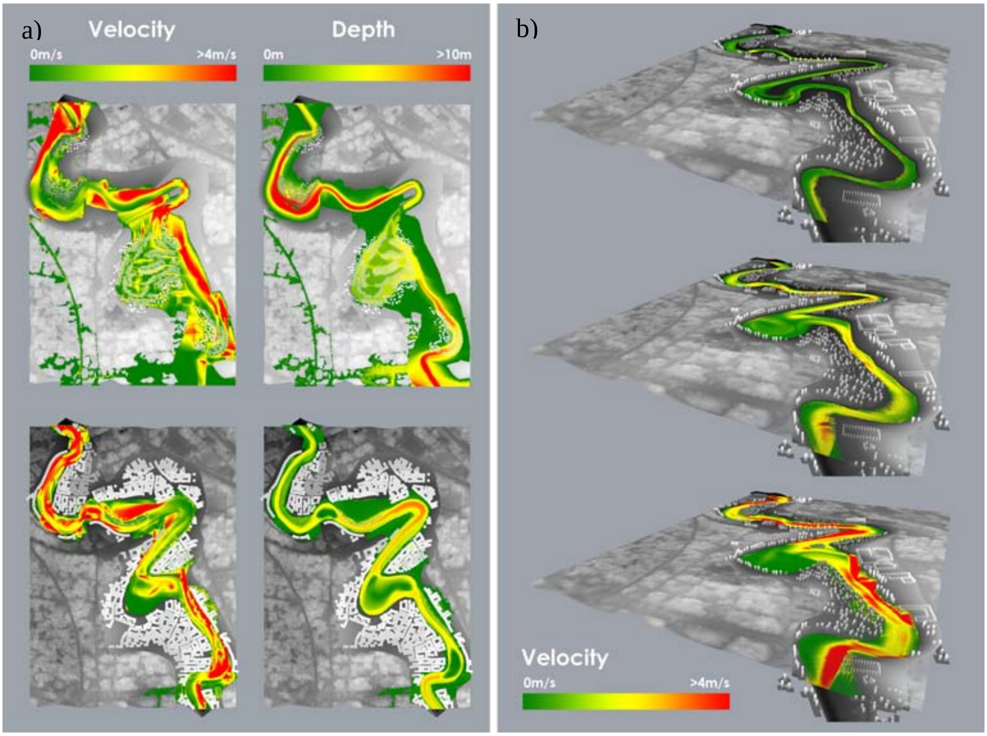

Fig. 4: (a) Maximum depth and depth-averaged velocity maps obtained from numerically modelling a flood event on terrain models generated from design scenarios. The simulated flooding event is based on the estimated peak discharge of the 2007 flood that prompted temporary evacuation of most of the site. (b) The interaction between the numerical model and designed landscape allows for visualizing propagation of flood wave and enables evaluation of interventions proposed.

As each of the individual points in the point cloud can have additional metadata attached to them, it is possible to embed colour information into them to visually represent the landscape in a photorealistic manner while simultaneously visualising the flood simulation results (Figure 5). Figure 6 shows an overall view of the Ciliwung green river corridor 3D model in Kampung Melayu Jakarta showing a diversity of plantations from riparian forest to "Pekarangang" gardens and productive plantations. The close up view shows the ecological riparian forest of the river promenade along the green river corridor. It is the result of the final design iteration after hydraulic testing, in which all landscape modifications have been embedded topologically into the model. The model planted with 20 000 3D trees from Laubwerk® (http://www.laubwerk.com/) can be used to show close ups of various situations and points of view along the river.

Fig. 5: Left: Photographs of flooding in 2013. Right: Visualization of a flood simulation run through the same sites within the point cloud models. Landscape modifications can be embedded in the point cloud model and then events simulated to compare against this base case.

Fig. 6: Landscape Design simulation of the new ecology for the Ciliwung River at Kampung Melayu (top) with a close-up view (bottom). The project proposes an alternating promenade along the river shifting from one bank to the other. The design project went through hydrological testing in the Landscape Ecology module of the FCL before being finalised by ETH students Lorraine Haussmann and Kylie Russnaik in a Design Research Studio.

5 Conclusion and Outlook

Beginning with surveys on attitudes towards infrastructure and community management, vegetation and common-use spaces, we framed the hydraulic engineering modelling techniques in suggesting rehabilitation projects of the Ciliwung river – an important ecosystem services provider for residents of dense urban settlements like Jakarta. Computational (parametric) design allowed for the coupling the landscape designs with hydrodynamic models for rapid design feedback, leading to a choice of final scenarios. The approach shows how creative action can be informed by scientific information, thus placing hydraulic engineering modelling techniques as a part of the deliberative process over future possibilities, that takes place within a value-driven process and design.

Next steps call for embedding such an approach in a learning process, where stakeholders and local residents can learn how scientific knowledge can be integrated into practice, and how management strategies can be adjusted to better support adaptation of local landscapes to future demand. The 3D visualizations of the acceptable and implementable design outputs can be fed back to stakeholders and members of the public, conveying complex hydrodynamic information in an understandable manner with resilience and aesthetic appeal.

Embedded in collaborative platforms, such computational design approaches linked to scientific knowledge can become a valuable communication tool in planning processes. Interactive decision support systems combined with 3D visualizations and further linked information is known to increase confidence in choice (HEATH & GONZALES 1995), and facilitate the communication of synergies and trade-offs between values for certain services provided by a given design (GRÊT-REGAMEY et al. 2013). Particularly, when cultural services such as landscape aesthetics have to be weighed against regulating or habitat services, interactive 3D visualization tools linked to GIS-based modeling might become key for

Fig. 7: Collaborative platform for fostering learning process on land use change

explicitly considering often unintentionally ignored ecosystem services (DANIEL et al. 2012). In this respect, Figure 7 shows such an interactive 3D GIS-based platform informing citizens about land use change. Using such an approach, scientific knowledge may become part of societal discussion on a planning level while informing design, thus supporting the production of knowledge relevant to society.

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