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Is Jakarta's New Flood Risk Reduction Strategy Transformational?

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Abstract: On a conceptual and normative level, the debate around transformation in the context of disaster risk reduction and climate change adaptation has been rising sharply over the recent years. Yet, whether and how transformation occurs in the messy realities of policy and action, and what separates it from other forms of risk reduction, is far from clear. Jakarta appears to be the perfect example to study these questions. It is amongst the cities with the highest flood risk in the world. Its flood hazard is driven by land subsidence, soil sealing, changes in river discharge, and—increasingly—sea level rise. As all of these trends are set to continue, Jakarta's flood hazard is expected to intensify in the future. Designing and implementing large-scale risk reduction and adaption measures therefore has been a priority of risk practitioners and policy-makers at city and national level. Against this background, the paper draws on a document analysis and original empirical household survey data to review and evaluate current adaptation measures and to analyze in how far they describe a path that is transformational from previous risk reduction approaches. The results show that the focus is clearly on engineering solutions, foremost in the Giant Sea Wall project. The project is likely to transform the city's flood hydrology. However, it cements rather than transforms the current risk management paradigm which gravitates around the goal of controlling flood symptoms, rather than addressing their largely anthropogenic root causes. The results also show that the planned measures are heavily contested due to concerns about ecological impacts, social costs, distributional justice, public participation, and long-term effectiveness. On the outlook, the results therefore suggest that the more the flood hazard intensifies in the future, the deeper a societal debate will be needed about the desired pathway in flood risk reduction and overall development planning—particularly with regards to the accepted levels of transformation, such as partial retreat from the most flood-affected areas.

Keywords: transformation; flood risk reduction; Jakarta; risk governance

1. Introduction

Transformation is the new star in a series of hot terms and guiding concepts in the context of disaster risk, global environmental change and development. Its proponents argue that fundamental system changes, i.e., transformations, are needed when systems (e.g., cities, economic sectors, institutions) are to be shifted from currently unsustainable development trajectories to more sustainable pathways [1]. Conceptual ideas of transformation are increasingly applied to disaster risk reduction, particularly when existing modes of risk reduction are conceived not to be capable of mitigating future risk trends to an acceptable limit, e.g., in the case of future climate change hazards [2]. Transformational adaptation which goes beyond incremental adaptation is then argued to be necessary [3].

However, despite the recent surge in conceptual contributions to the debate around transformation, e.g., [1,4–7], the literature remains still quite vague with respect to the question

of what exactly constitutes transformational adaptation or risk reduction and how it differs from non-transformational types, mostly referred to as incremental or conventional. At the same time—and related to this shortcoming—the empirical understanding of how transformation is debated in real-world cases and how it occurs—or not—is still thin [2,8]. Recent expert dialogues (e.g., during the IPCC Cities Conference in Edmonton) suggest how difficult it is to move from the conceptual and normative debate around transformation to the empirical and practical level. What does transformation mean to different groups? How does it occur and how can it be recognized? How can transformation be facilitated and governed? How can its success be assessed? Exploring such questions and moving the debate from the abstract and conceptual to the empirical and practical level might best be achieved by examining drastic cases of risk hotspots with extreme pressures for transformation.

Jakarta provides such a case. It is amongst the coastal megacities with the highest flood risk globally [9,10]. Already today, it suffers from extreme flood events, the most severe of which occur when fluvial, pluvial, and tidal flooding concur. In 2007, at least 56 died in one of the worst floods in the city's history, in which over 340,000 people had to be evacuated and more than 74,000 houses were flooded [11]. The economic damage of that flood alone, which inundated around 60 percent of the city with flooding depths of up to four meters [11], were estimated at around USD 560 million [12]. Yet, the 2007 flood was by no means a one-off event. Heavy floods also happened, for instance, in the years 2013, 2014, and 2015. It is expected that Jakarta's flood risk will further intensify in the future, given the overlapping effects of land subsidence, continued urban sprawl, sea level rise and changes in precipitation driven by climate change [9,12,13].

Given the current magnitude and an expected future increase of Jakarta's flood risk, in combination with the limited effectiveness of the existing risk management [14,15], radical changes in the city's risk reduction regime are necessary. This need calls for fundamental transformations not only in the built environment and hydraulic infrastructure but also in institutional patterns of risk governance. A first wave of considerable adaptation measures has therefore been conceived by the government, in collaboration with international partners. Yet, the question is whether they are truly transformative—as will be discussed in this paper. The currently conceived adaptation measures are primarily focused on heavy engineering solutions to regulate Jakarta's flood hydrology, leading to substantial resettlement and other—expected or already manifested—social and ecological side effects. One might thus ask whether, from an institutional perspective, the current measures in fact perpetuate rather than transform the deeper political economy of environmental degradation and social marginalization that drives much of Jakarta's current flood risk.

Against this background, the paper therefore aims at making a contribution to bridging the existing gap between conceptual debates and empirical analysis of transformational risk reduction and adaptation. It seeks to use the pressing Jakarta case study to examine whether one of the most radical flood risk reduction schemes ever conceived can—and should—be considered transformational, thereby contributing to the emerging discussion on criteria for transformation and its links to long-term sustainability.

In order to do so, the paper's next section provides a brief overview over the materials and methods used in this paper. Section 3 then reviews the existing conceptual discourse around transformation in the context of global change research in order to identify key gaps and guiding questions for the Jakarta case study. As transformational risk reduction would require tackling the drivers of flooding, Section 4 then examines the causes for and trends in Jakarta's flood risk—past, present, and future. Section 5 introduces the main flood risk adaptation measures currently planned or implemented in Jakarta. Section 6 evaluates the most important measures. Section 7 discusses the results of the evaluation and the question whether the current measures are transformational. The last section provides key conclusions and an outlook into future needs for science, policy, and action.

2. Materials and Methods

Given the heuristic nature of this paper at the interface of a conceptual debate and empirical analysis, the article draws on different types of data and methods. In Section 3, we review influential academic literature that has been shaping the scholarly debate on transformation in the context of climate change adaptation and risk reduction. We do this in order to assess the key arguments suggested for the use—and usefulness—of the concept. In Section 4, we draw on existing studies and own analysis of statistical as well as time-series remote sensing data to review and analyze the main drivers of Jakarta's flood risk and their trends. Existing studies therein include academic papers as well as government reports which speak to the drivers of Jakarta's flood risk, identified through a structured search in Scopus, Google Scholar, and Google. Our analysis of statistical data concentrates on official statistics of population, land use, and climate parameters. For the assessment of past trends in Jakarta's land use change, we further used 6 Landsat scenes and analyzed them through a supervised classification approach. The defined classes in the data were the main four land cover classes (water, built-up, vegetation, and soil). Each class was represented with a set of 20 corresponding training regions of interest (ROI) defined visually within the administrative boundaries of Jakarta. The maximum likelihood algorithm of the semi-automatic classification plugin (SCP) for QGIS, a practical and convenient open source classification tool, was used to make the supervised classifications [16,17]. As an example, a ground truth layer on the built-up cover of Jakarta for 2014 was prepared and used as a reference to evaluate the built up classification. The performance was evaluated using a stratified random sampling technique at 300 sites (pixels) and the overall accuracy for the built-up class in the processed scene exceeded 84%. Although the achieved accuracy can still be improved further by optimizing and increasing the number of the training sets, the authors consider the obtained results satisfactory for the conducted analysis, in line with other literature [18]. In Section 5, we draw on our analysis of key planning documents (e.g., the latest coastal protection plans) to present the main adaptation measures currently planned or implemented in the city and its greater metropolitan area. In Section 6, we use two sets of data to evaluate the main adaptation measures introduced in Section 5. First, we analyze published academic literature, online newspaper reports, and blog posts—a much-attended medium in Indonesia for public debate—which focus on the evaluation of the above-identified flood risk reduction measures. Relevant documents were identified through two strategic keyword searches in the Scopus database for the academic literature and Google for the online newspapers and blog posts, respectively, covering the past five years. Given the specific nature of the topic, a total of six academic papers have been identified, based on keyword searches on "Great Garuda", "Jakarta Coastal Defense Strategy", "National Capital Integrated Coastal Development Masterplan", "Giant Sea Wall", and "Coastal Protection + Jakarta" in the article title, abstract and keywords (see Section 5 for an introduction). The results include [19–24]. In addition, over 15 relevant English-language newspaper articles and blog posts have been included in the analysis, identified through a similar keyword search in Google and the LexisNexis academic newspaper database. The findings include, for example, six articles in the Jakarta Post and three in The Guardian International. Many of these articles were building on each other. In the paper, we therefore only refer to the leading articles. Second, we analyze own empirical survey data to assess the social and economic effects on the affected population in the northern part of Jakarta. The survey data was collected in two survey campaigns using structured questionnaires in 2015 and 2017. The campaign in 2015 covered 451 households, out of which 410 have been re-interviewed in 2017 to assess changes over time. Following the main types of current adaptation measures (see Section 5) the households belonged to three groups: first, households being affected by reservoir dredging projects; second, households affected by dyke construction; third, households that have been resettled. Given the comparatively large sample size and a stratified random sampling along wealth groups within each of the three groups, we assume that our sample is representative for these respective groups.

3. Transformation in the Context of Disaster Risk Reduction and Adaptation

Over the past 10 years, the notion of transformation has gained considerable traction in science and policy debates around global environmental change [5]. To a large extent, the transformation discourse originates from climate change mitigation debates. It has been used there to refer to the need for fundamental shifts of the economy, away from its heavy dependence on fossil fuels and other resources such as land and water [25]. However, more recently, the need for fundamental system shifts are also seen in the realm of climate change adaptation and risk reduction. One of the main arguments of this debate is that current modes of risk management will increasingly reach their limits in view of future risk trends, which result from the intersecting drivers of climate change and risk-prone socio-economic developments (e.g., urbanization in coasts with high exposure to natural hazards) [1–3,7,26]. This question—whether existing modes of risk reduction will suffice in the future—is also of key relevance for the case of Jakarta and the analysis of whether and how trends towards transformational changes in risk reduction can be observed.

Transformation proponents argue that the recent surge in the use of resilience concepts can be counterproductive in guiding adaptation and risk reduction. This is because resilience debates, so the argument goes, tend to emphasize the persistence and strengths of existing systems and their configurations, whilst sustainable risk reduction is argued to necessitate deep changes of system configurations [1]. A growing body of literature therefore raises concerns that many political and practical initiatives for risk reduction and resilience building concentrate on tackling superficial risk symptoms (e.g., by slum upgrading projects) rather than the deeper institutional root causes of vulnerability and risk (e.g., the political economies that lead to the production and reproduction of marginalization and vulnerability in the first place [27]). Current risk reduction and adaptation efforts therefore have been critiqued to be not sustainable—or even palliative [28]. Following this line of thinking, lasting and sustainable risk reduction thus requires the fundamental transformation of the political economy and political ecology behind the very production of risk and vulnerability. Transformation is therefore not just about technical problems but much more about agency and a societal process of visioning the future [29]. This is the way Section 6 analyzes socio-economic and ecological dimensions when evaluating current risk reduction measures, along with considerations of distributional justice, public participation, and long-term effectiveness.

Much of the literature differentiates between incremental and transformational adaptation [3,30]. Incremental adaptation is therein used to refer to the extension of actions and behavior that already exist to reduce risk in the sense of "doing slightly more of what is already being done" [3]). Transformational adaptation in contrast has been argued to include those adaptation measures which are either adopted at a large scale or intensity much beyond the previous level, or those that are truly new to a particular region or system, or those that transform places and shift locations—or a combination of the above-three properties [3]. However, even with these criteria in mind, the demarcation of transformational adaptation is difficult, especially with respect to the first criterion, i.e., the considerable increase in scale and intensity of existing measures. Existing modes of flood protection infrastructure, for instance, can be considerably improved with newly available resources, higher aspirations for security standards, and technical advances. Emerging economies such as Indonesia often provide such context conditions—as the current policies in Jakarta show (Section 4). Yet, whether the sheer scaling of existing approaches should be considered as transformational adaptation is questionable, as it appears to cement, rather than call into question and transform existing modes of risk reduction. In that sense, defining transformation simply as the consequence of large interventions does not account for the more fundamental notion of transformation, i.e., the radical shifts in how things are done and how existing risk management modalities are conceived. One of the key—and hitherto unresolved—conceptual questions of transformation is therefore whether it is and should be understood as an outcome of change, trigger of change, or process of change—or all of it.

Solecki et al, in [2], argue to rather concentrate on shifts in thinking, practices and policies as key criterion for differentiating transformational from other modes of risk reduction and adaptation.

Drawing on the context of costal megacities, the authors of [2], building on [1,6], therefore differentiate between different risk management regimes along a gradient from collapse to resistance, resilience, and transformation. A risk management regime is therein understood as "an assemblage of policies, strategies, and regulations that collectively define a dominant paradigmatic management approach (which) can be observed in any moment within a city" [2]. Risk management regimes are hence characterized by the deliberate and conscious as well as non-deliberate ways in which risk is managed. Often, formerly deliberate policy choices and paradigms become deeply entrenched institutionally or culturally, until they are no longer deliberately reflected but rather enacted "automatically". This framing of risk management regimes is of great help for the analysis Jakarta's risk management with is long history and entrenched paradigms, as the analysis in the following sections will show.

According to [2], the resistance regime is characterized by actors and institutions geared towards keeping the current system and its configurations (e.g., urban morphology) stable, despite increasing external stress, e.g., a rising frequency and intensity of flooding. It implies rising input resources; for instance, protecting the infrastructure and strengthening rigid institutional or bio-physical structures. Resistance often involves conventional engineered solutions with a focus on the built infrastructure, e.g., coastal defense systems—which is of high relevance to the Jakarta context.

In contrast, resilience entails some adjustments of the current system to improve its ability to deal with external stress. However, also here, the main system configuration is typically not being questioned. Resilience can rather be understood as an 'adjustment at the margins', which ultimately has the aim of stabilizing the core fabric of the system in the face of potential external disturbance. This does, however, not diminish the fact that resilience thinking pushes scientists and policy makers to engage with the necessity to make cities better able to deal with future hazards and crises such as flooding situations, especially in view of their increasing likelihood with climate change and other risk drivers [31].

In contrast to resilience, Solecki et al., in [2], then view transformation as a form of adaptation that fundamentally questions the setup and fit of current system configurations. The aim of transformational adaptation is to find alternative ways of system configurations that increase the system's long-term sustainability through minimizing risk or rigidity traps, and through establishing co-benefits from new development trajectories. Pelling, in [1], argues that a transformation, i.e., the fundamental reconsideration of human–environment relations, will become increasingly necessary in view of growing levels of environmental hazards, stress, and perturbation with climate change. He argues that the current focus on resilience-building is therefore insufficient as it does not engage with the necessary yet politically uncomfortable questions of radical changes, e.g., with regards to land use policies, risk insurance configurations or the overall social contract for risk reduction and social protection. By focusing too strongly on the maintenance of current system configurations, resilience-oriented paradigms are thus argued to run the risk of becoming unattainable in the mid- to long-term future, thus propelling the need for all the more radical adaptation into the future, yet at the expense of increasingly limiting the space for planned adaptation choices. Collapse then refers to the most severe outcome if no adaptation – or even maladaptation – is taken, leading to a situation in which the hazard level renders sustaining the system as impossible [2].

Solecki et al., in [2], are particularly interested in the transitions between different risk management regimes, i.e., the factors that enable or hinder actors and institutions in a given context to shift from one to the other regime. This question is of great relevance to the case of Jakarta and hence this paper. Solecki et al. emphasize that shifts towards transformation or other regimes can happen in single sub-systems (e.g., one sector such as transportation) whilst other sub-system remain in other regimes. They can also happen at different scales, e.g., where city governments engage in changing their risk management regime in directions contrasting national policy. The careful consideration of such sub-system shifts is also very relevant for understanding the Jakarta case, as the following sections will illustrate.

Transitions between the different regimes might also be related to turning points in adaptation pathways [32,33]. Protective infrastructure such as the currently planned dyke and embankment system in Jakarta (see below) might, for instance, work until a certain threshold to advance a rigid resistance level. Yet, after the threshold has been reached, the costs of retrofitting might become so high that fundamentally different alternatives might be sought, e.g., retreat from formerly protected areas. Hence, a transformation in risk management would be the result in this example.

Yet, apart from conceptual considerations, empirical observations on different types of risk management regimes and the transitions between them remain rather thin, especially with respect to questioning how changes to risk management regimes are contingent on changes in overall development policy [7]. The case study of Jakarta, one of the most flood prone cities globally with extreme adaptation pressure to change current development trajectories and major adaptation works on the way, is therefore a prime example for such a type of empirical analysis. As the analysis will show, the case study allows in particular to concentrate on the transition between resilience and transformation – which is the transition that has received most attention in the conceptual debate, as the title of Pelling's book underscores [1].

4. Jakarta's Flood Risk: Causes and Trends

Transformational risk reduction would involve an engagement with the root causes of flood risk and the consideration of expected future risk trends. Hence, examining both is key for the aim of this paper: Jakarta's floods can be pluvial, fluvial, and tidal and its flood risk results from a number of intersecting drivers. Following the common IPCC risk framing [34], risk is therein considered to result from the combination of a high hazard potential, high exposure, and high vulnerabilities. The first factor contributing to the city's flood risk is its general topography. Due to the historically good conditions for trade and agriculture, the city developed in the bay of Jakarta, into which the Ciliwung river and 12 other, smaller rivers flow, crossing today's city. Particularly the northern, coastal parts of the city are characterized by a very low-lying topography. Occasional flooding has therefore been an issue since the very early times of today's Jakarta, i.e., the harbor city Sunda Kelapa in the hinduistic Sunda kingdom and the later Batavia, the headquarters of the Dutch East India Company from 1619 onwards [14].

However, the flooding problem has been greatly intensifying over the recent decades, mostly due to anthropogenic drivers. First, the city has been experiencing a massive growth in population and economic as well as industrial activity since the second half of the 20th century. Being the capital of Indonesia and its clear center for economic, political, and cultural activities (especially during the centralistic Suharto regime) Jakarta's population has grown to well over 10 million today, from around 3 million at the early 1960s [35]. Along with this growth, the city has been experiencing an extensive spatial expansion. Figure 1 illustrates this expansion from 1972 to 2014. The analysis shows that urban land use within Jakarta's administrative boundary has increased by 276 percent over the last four decades, consuming 565 km^2 of the 674 km^2 available space, i.e., over 83 percent (Figure 2).

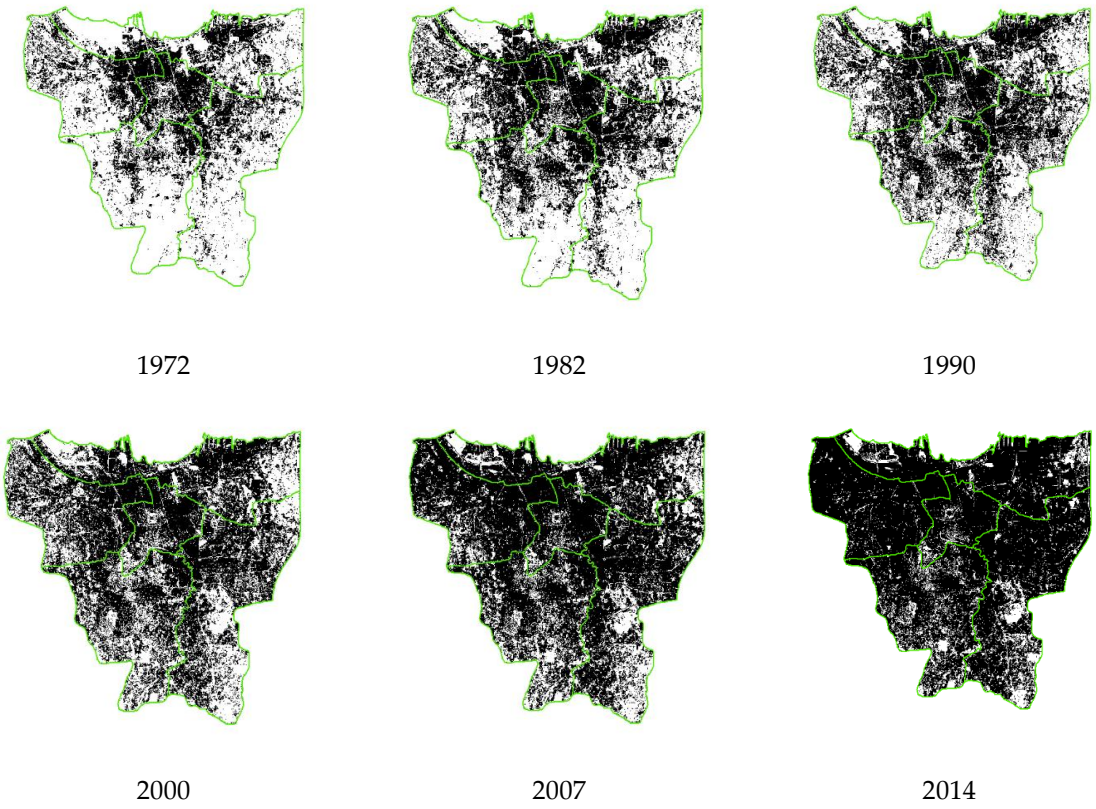


Figure 1. Maps illustrating the urban expansion, in black, in Jakarta from 1972 until 2014.

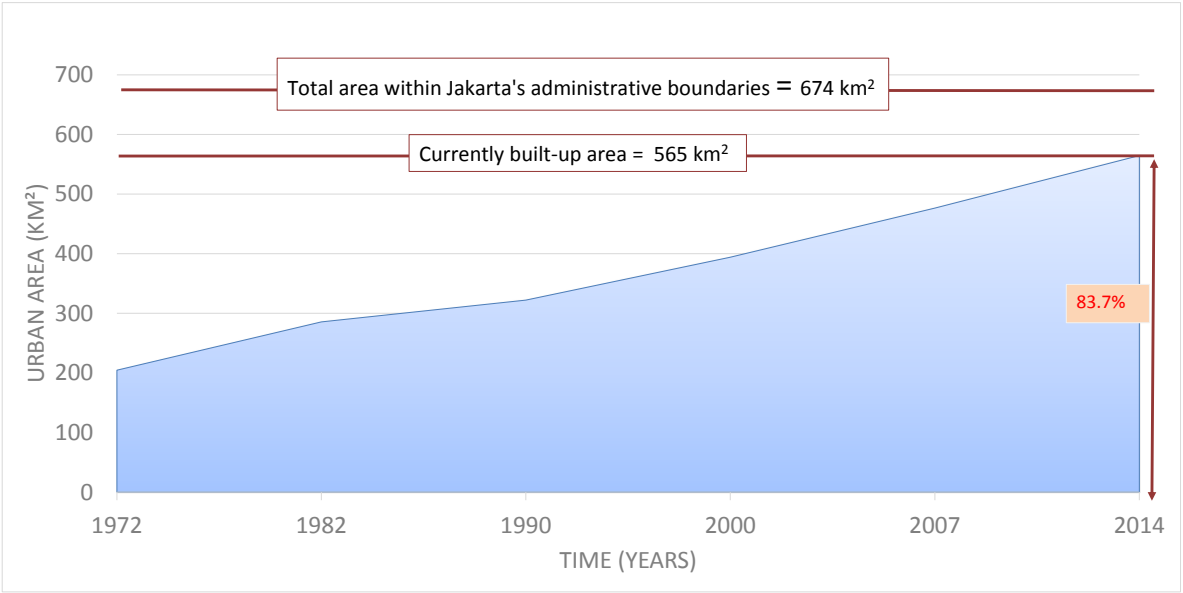


Figure 2. Graph showing the rapid increase of the land consumption within Jakarta's administrative boundaries from 1972 until 2014.

Along with this increase, the city quickly sprawled beyond its original administrative boundaries, thereby causing massive changes to run-off and flood hydrology. This sprawl has been forming an increasingly continuous mega-metropolitan area with formerly separated sub-centers in Jakarta's adjacent regencies (Kabupaten). The mega-metropolitan region has been coined Jabodetabek, in

reference to Jakarta's neighbors Bogor, Depok, Tangerang, and Bekasi. At the latest census in 2010, this region hosted 27 million people. Also here, a massive land use conversion has been taking place: the built-up area in the Jabodetabek region grew from 65 to 2015 km^2 between 1972 and 2012, i.e., by a factor of 31 [36].

Along with these massive land conversions in Jakarta and the entire Jabodetabek region, a high number of rivers, canals, and wetlands have been built-over, in effect massively reducing flood retention and discharge capacities of the entire region.

The second important factor contributing to Jakarta's flooding problem is the city's significant land subsidence. The rates of subsidence vary across time and space, but some parts of the city have been experiencing rates of up to 25 cm per year in extreme periods [37]. Long-term measurements reveal that some parts of the city were sinking by a total of up to 4 m between 1974 and 2010 [37]. The most affected areas are largely located within the coastal fringe in the north of the city, i.e., the area featuring the lowest topography but also some of the highest industrial activity.

Subsidence is driven by three main factors: (1) massive—mostly uncontrolled—groundwater extraction for private and industrial purposes; (2) the natural sediment compaction which is not compensated for due to the interruption of natural sedimentation replenishment; and (3) the substantial compaction loads from buildings and other infrastructure [13]. The detailed quantification of these factors' contribution is difficult and a field for further investigation. Nevertheless, most studies agree that groundwater extraction is by far the most important driver for the observed subsidence.

A third factor contributing to Jakarta's flood risk is the fact that many of the rivers and drainage canals are poorly maintained and clogged with waste and sediments [13].

On top of existing flooding problems, the city might quite likely experience a further increase in flood risk in the future, as the result of (1) continued growth and land conversion; (2) continued land subsidence; (3) an increase in sea level due to climate change; and (4) an increase in the intensity and frequency of storm and heavy precipitation events. Assuming a business-as-usual progression in sea level rise, subsidence, and population growth, modeling suggests that, in the absence of adaptation, the population exposed to a 100-year return period extreme flooding event would rise by 350 percent by 2070, to then over 2.2 million [10].

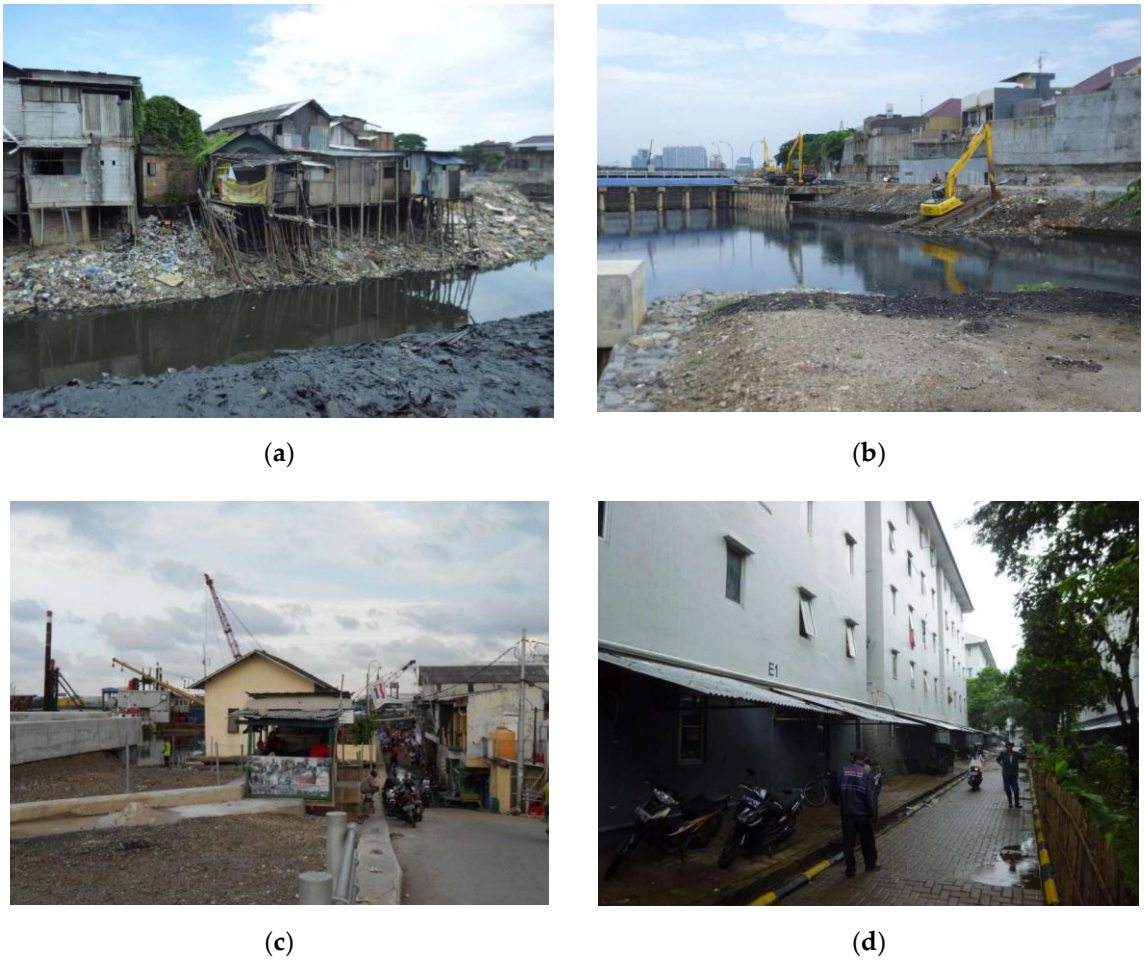
5. Risk Reduction and Adaptation Measures

Given Jakarta's high current and future flood risk, the question of options for risk reduction and adaptation is pressing—in fact, a transformational change in course appears necessary. Yet, despite the recent surge in flood risk, the quest for flood risk reduction solutions is not new. Particularly under Dutch colonial rule, the city has seen some quite sophisticated flood protection measures. Soon after the formal establishment of Batavia as the headquarters of the Dutch East India Company in 1619, the Dutch started to implement a structured canal system in the city, similar to the ones in Dutch cities of the time [38]. In addition, a major canal—the so-called Western Canal—was put into service in 1725 to divert parts of the Ciliwung's discharge around the city. This type of infrastructure-based diversions were further intensified in the following years, in an attempt to gain ever more control over the city's hydrology. Integrating these measures into an overarching and comprehensive plan for the entire city, the so-called van-Breens-Plan (named after the project's leading engineer) was issued in 1917, in response to a devastating flood event. This plan comprised major structural measures, including additional diversion canals in the city's west (Western Banjir) and east (Eastern Banjir). The plan's strong focus on engineering solutions provided the major paradigm for other plans to follow over the next decades, notably in 1965, 1973, and 1984 [14,38].

Despite this long tradition in flood protection measures for the city, the extreme event of 2007 lead to a significant intensification of the debate around flood risk reduction and a substantial reconsideration of the respective toolbox—not only in Jakarta but in Indonesia at large [39]. This reconsideration has been triggered by the new flooding context, which manifested itself during the 2007 flood. The extreme flood levels of that year had been caused by the confluence of heavy precipitation

and discharge with a particularly strong spring tide. Hence, water was pushed into the city not only by the rivers from the south, but also from the sea. This rather new situation shifted the emphasis of flood protection quite drastically. While the focus had hitherto been on diverting the discharge of the upstream Ciliwung catchment area around the city and into the sea, the focus now shifted to also include coastal protection, alongside with attempts to expand the retention capacities within the city. As a result, the Jakarta Coastal Defense Strategy (JCDS) was conceived by a joint consortium of Indonesian and Dutch partners under the patronage of the then governor Fauzi Bowo. The strategy was completed and formally adopted in 2011.

Since that time, flood risk reduction has been comprising three main groups of measures: First, a strong emphasis has been on the river and canal regulation, the broadening of water ways and the clearance of river banks, which are frequently encroached by informal settlers (Figure 3a). Second, attention has been given to the refurbishment and expansion of flood reservoirs, especially in the city's northern parts (Figure 3b). Third, a new coastal flood protection wall has been under construction (Figure 3c).



(**a**) (**b**)

(**c**) (**d**)

Figure 3. Pictures showing an encroached river bank (**a**); the widening of reservoir (**b**); the construction of a new sea wall (**c**) and resettlement housing (**d**).

As all of these measures need space, a significant amount of resettlement has been necessary over the past years (Figure 3d). The vast majority of affected dwellings belong to low-income households which had been settling informally on the banks of rivers and reservoirs, given their lacking financial and institutional capital to access land in other parts of the city. The regulation of the Ciliwung alone triggered the resettlement of 15,000 people, i.e., 4000 households, over the last five years.

The Jakarta Coastal Defense Strategy has been continuously revised and expanded since 2011, leading to the so-called National Capital Integrated Coastal Development Masterplan (NCICD) in 2014 [40]. At its core, the plan builds on the idea to block the bay of Jakarta off from the sea, by means of a so-called 'giant sea wall'. The project is also known as the "Great Garuda Project" as the project's aerial view resembles the shape of a Garuda, the national bird of Indonesia (see Figure 4). The project has been conceived by a consortium of Dutch and Indonesian planning consultancies, sponsored to a large extent by the Dutch government. Its planned engineering dimensions are quite enormous: The planned sea dyke has a total length of 25 km. Behind it, the former bay shall be converted into a sealed reservoir, the water table of which ought to be regulated so as to remain below sea level in the future, thus allowing for the controlled flood drainage of the city. To achieve this, the largest pumping station installation ever built in one project is planned at a capacity of 730 cubic meters per second in order to pump the water from the reservoir out into the sea [40]. In addition, the plan includes upgrades and expansions to the existing flood protection infrastructures in the city, foremost the retention reservoirs, drainage canals, flood protection walls along the main waterways and the coastal dam.

In order to finance these measures, the plan envisages to combine flood protection with the development of new estates for commercial and residential purposes [22]. Within the reservoir massive land reclamation projects are planned to provide space for a new central business district (CBD) and residential area. Together with upgrading planned for the existing parts of northern Jakarta, the plan aims to generate residences for an additional 650,000 people and attract businesses with 350,000 new jobs [40]. In addition, a new harbor and airport are planned toward the east of the embanked area. The total costs of the project are estimated at around 40 billion USD [41]. The implementation is planned to span across three phases with the completion of the sea dyke being targeted for 2022 [40]. Despite the high costs, modeling suggests that the protective function of the project could in fact safe and build economic values in the city, considerably beyond the original costs [19,20].

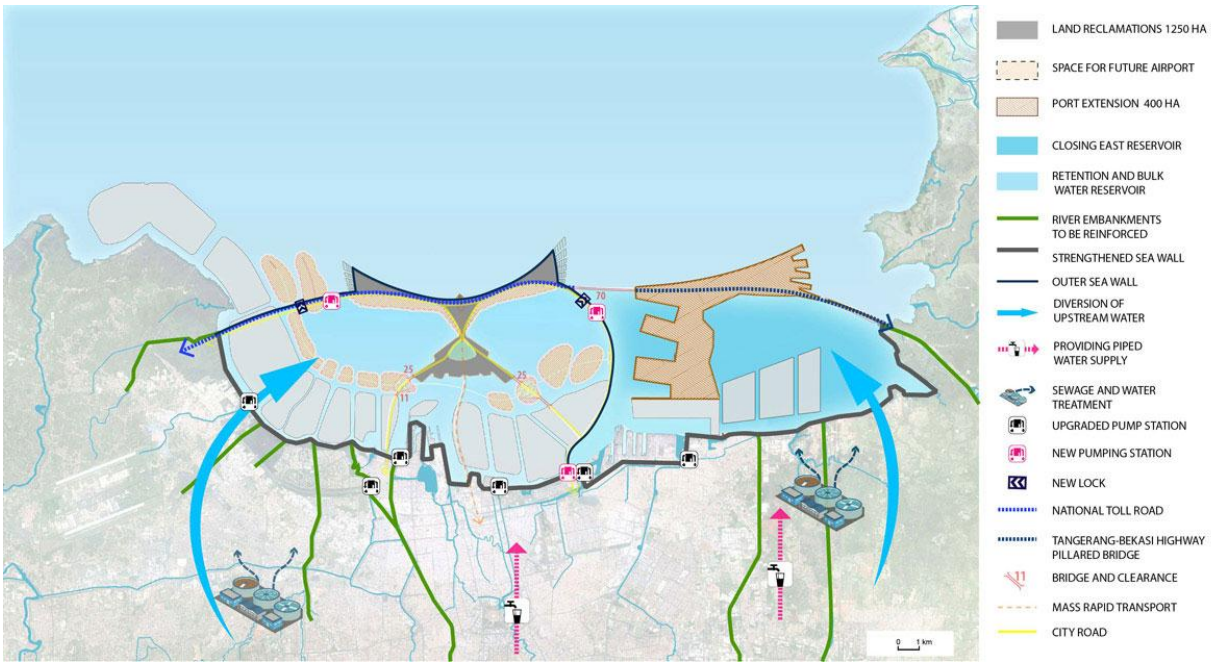


Figure 4. Map of the Great Garuda project [42].

Similar to the earlier JCDS, also the NCICD was developed by a consortium of Indonesian and Dutch organization, including government planning agencies, research institutes and consultancy firms. The leading executive agency is the Coordinating Ministry for Economic Affairs of Indonesia, with strong contributions by the Government of the Special Capital Region of Jakarta, the National

Development Planning Agency and the Ministry of Public Works. However, despite the large number of involved agencies, civil society groups and households affected by the plan have raised strong concerns that the drafting of the plan has been lacking participatory elements and opportunities for getting involved in the planning (see Section 6).

Next to the formal adaptation measures foreseen in the NCICD, flood-affected communities and households in Jakarta heavily engage in small-scale and informal adaptation measures [15,43,44]. These include individual as well as collective measures, e.g., raising the housing levels or constructing small-scale water barriers around settlements. However, empirical analysis has shown that these measures are limited in effectiveness to combat the larger floods and their trend towards intensification. The need for more effective, larger-scale flood risk reduction measures governed by formal actors has therefore been stressed [43]. Hence, the focus of this paper is clearly on formal measures—yet not devaluing the important role of informal small-scale adaptation and the role it can, in accumulation, play for regime shifts at the larger policy level.

6. Evaluating Current Adaptation Measures

Given the profound—maybe transformational—nature of the conceived adaptation measures, questions regarding their evaluation are pressing. The following section therefore addresses the evaluation of the current measures, locking into ecological as well as socio-economic criteria. On these grounds, many, if not most, of the currently planned or implemented adaptation measures are greatly contested and have caused heated debates in Jakarta and beyond. Conflict has lately erupted in particular over the Great Garuda project. The interview data as well as the analysis of newspaper articles and blog posts show that a major concern, especially of Jakarta's coastal population, is that the embankment is expected to lead to substantial environmental degradation in the bay of Jakarta, thereby causing great damage to local fisheries which provides a major income source for coastal fishing communities (e.g., [41,45]). Critics back their worries, for instance, by a study of the Maritime Affairs and Fisheries Ministry, published in 2015 [46]. First, the study cautions that the massive embankment through the sea dyke is likely to trap polluted water discharged from the city and its hinterland, hence, contributing to the contamination and, ultimately, eutrophication of the new reservoir [45]. Second, the reservoir is expected to trap sediment, hence, leading to a fast sedimentation of the sea bed [45]. Third, the new reclamations require considerable amounts of sand—altogether around 300 million cubic meters [40]—which needs to be pumped largely from the local sea bed. All of the above three effects are expected to have negative impacts on the local ecology and fish stocks, causing ripple-on problems for local fishing communities whose livelihoods depend on them [45]. In addition, the sea dyke is expected to even alter local currents to an extent that will cause the erosion of entire islands currently neighboring the planned reservoir [23,45].

All these concerns have been taken up in fierce political debates. Most notably, the promise to stop the project had been a central element of the election campaign of Anies Baswedan, the new governor of Jakarta since October 2017. Already in 2016, a moratorium had temporarily stopped the project on the basis of environmental concerns and corruption allegations. However, the moratorium has recently been repealed by the national government, underscoring that conflicts exist not only between different interest groups but also between different levels of government [45,47]. The future is therefore likely to see conflicts over the issue continue.

Moreover, both the survey data as well as the document analysis clearly show that criticism is mounting with regards to the perceived social injustice in terms of how the costs and benefits of the project are shared. While the expected benefits of the Great Garuda project, such as the newly developed apartments or the planned business district, will mainly be geared towards middle and upper income groups, the environmental, economic, and social costs are largely borne by lower income groups. Overall, our survey data reveals that over two-thirds of the households which have been directly affected by infrastructure measures (e.g., the coastal protection wall or reservoir widening) or even needed to be resettled reported negative socio-economic effects due to the measures (see Figure 5).

The highest economic impacts have been reported by the households who needed to be resettled. Within this group, the loss has been most drastic amongst former fishing households who needed to be resettled inland and now have to rely on sporadic and informal income generation.

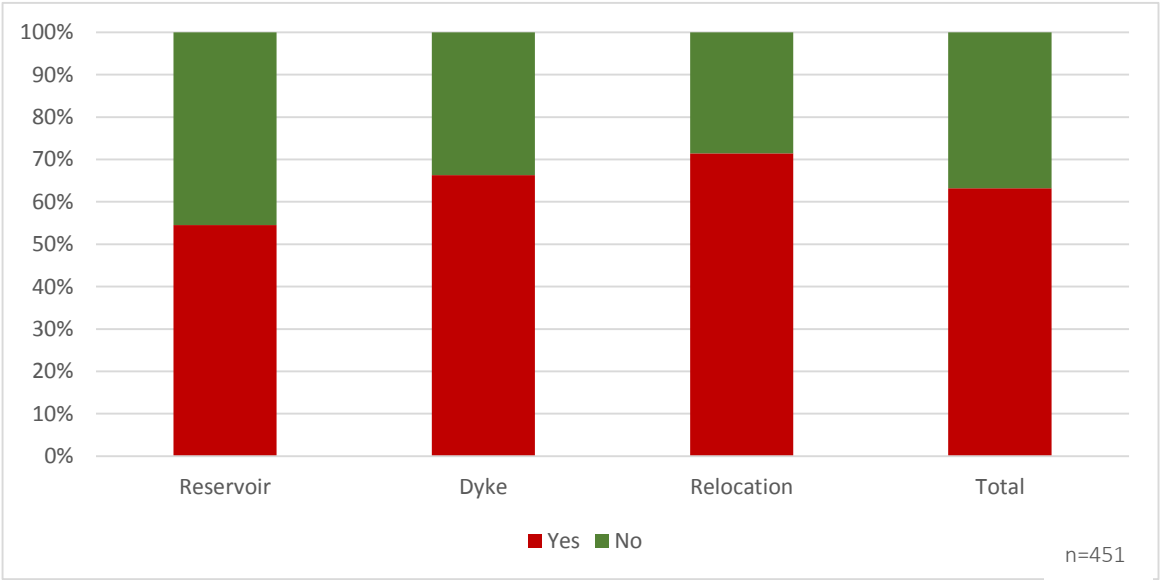


Figure 5. Percentage of households having experienced job loss and/or income loss and/or livelihood degradation as an effect of the implementation of adaptation measures.

The repeated survey panels (in 2015 and then 2017 in the same households) also showed the many early hopes in the adaptation measures did not hold the test of reality. That is, while a considerable amount of households expected the adaptation measures to lead to an increase in the self-capacity to cope with future flood hazards, this expectation was not confirmed in the second panel. In fact, a decrease in the perceived self-capacity can be observed (see Figure 6).

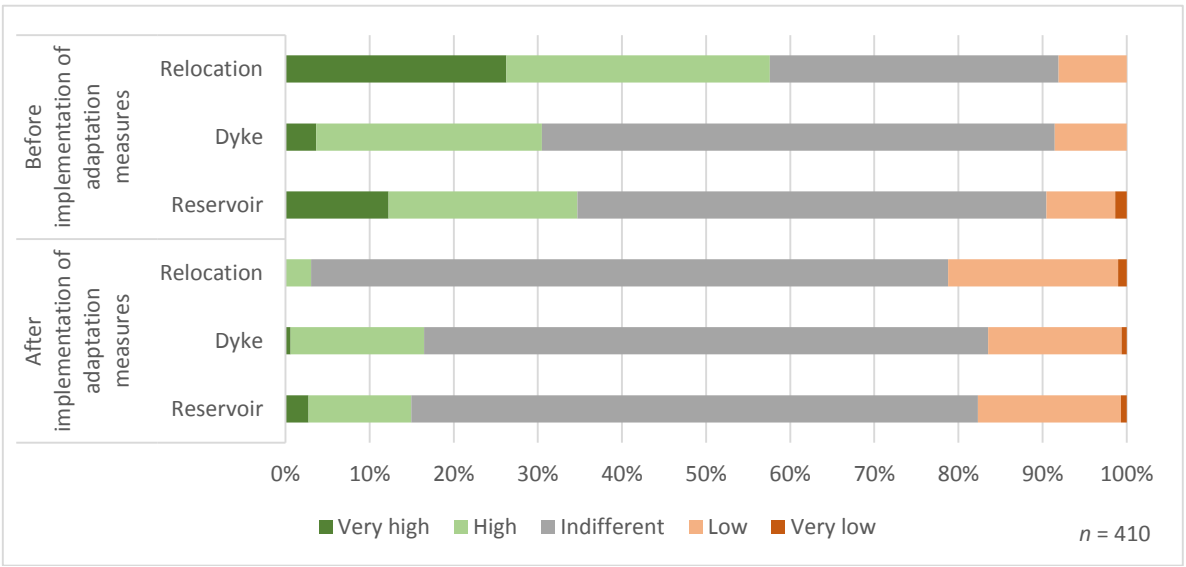


Figure 6. Perceived self-capacity to cope with future floods before and after the implementation of adaptation measures.

The analysis also reveals that a decline in the self-capacity perception significantly correlates with a perceived decline in social cohesion after the implementation of the adaptation measure, particularly in the case of resettlement where former social ties have been disrupted. In this line, Figure 7 illustrates the decline in perceived mutual assistance at the neighborhood level across all three major types of measures.

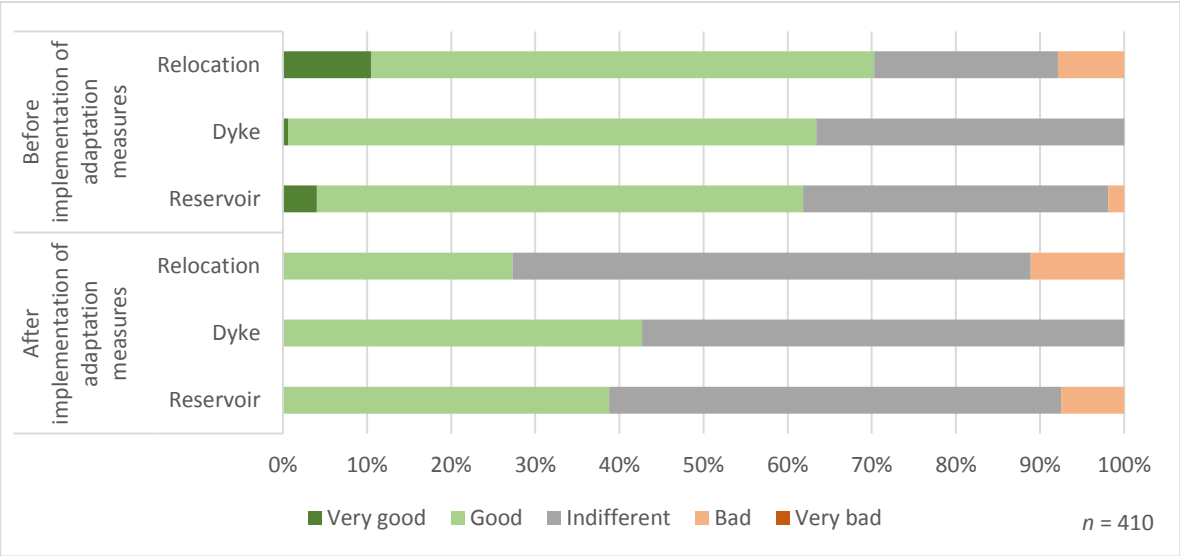


Figure 7. Perceived quality of mutual assistance within the neighborhood before and after the implementation of different adaptation measures.

Moreover, the survey results clearly show that households affected by formal adaptation measures in most cases felt cut off from information and disempowered or voiceless with respect to the design, planning, and implementation of the adaptation measures. Even more so, Figure 8 illustrates that most of the affected households have not even been receiving information on the implementation of the project. These findings are in line with other empirical studies which also found that the opportunities for participation has been weak amongst the population in Northern Jakarta affected by formal measures of coastal protection and flood risk reduction [24].

Of great importance for the assessment of transformation, critics also complain that the Great Garuda project only addresses flood symptoms, but does nothing to tackle the major cause of the city's flooding problem: its massive land subsidence [48,49]. The project therefore is challenged in two ways in the eyes of its critics: if the project is implemented without addressing land subsidence, it is doomed to fail as it cannot effectively combat an ever increasing flood risk in the long run, whilst producing a host of negative side effects. Yet, if the land subsidence were to be tackled effectively, the Great Garuda project might prove unnecessary and its negative effects could be averted. At the same time, however, earlier empirical research suggests that experts from Indonesia as well as from abroad doubt that unregulated ground water extraction and, hence, land subsidence could be effectively combated any time soon, due in particular to poor regulation and law enforcement [21]. Ironically, these skepticisms are used by the project's proponents as one of the main arguments of why the project is necessary, allegedly presenting the best of the remaining options [21].

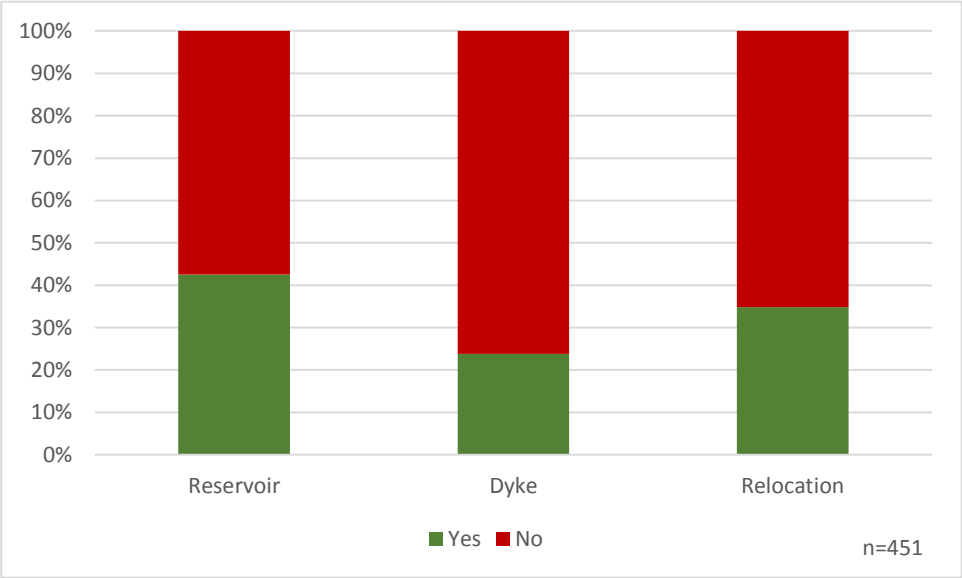


Figure 8. Perception of affected households having received information on the implementation of the adaptation measure.

7. Discussion

The empirical observations from Jakarta can make an important contribution to complement and enrich the emerging conceptual debate of transformation, particularly in coastal megacities which are set to experience increasing climate change impacts along with local environmental changes and continued growth. The flooding problem, particularly in northern Jakarta, has been on the rise so severely that the functionality threshold of the city might soon be surpassed. For instance, industrial firms which are clustered in the most flood-affected areas might soon feel forced to relocate, leading to a potential collapse of the industrial sector in this part of Jakarta, with severe implications for the overall development trajectory [50]. At the same time, the growth and sprawl of the city is set to continue in the future, thus heavily contributing to the further intensification of the city's flood problem, along with climatic change impacts. The case study therefore shows how closely paradigms of risk reduction are related to policy debates around overall development trajectories and climate change adaptation in those cities.

The experiences of recent flood events, particularly the extreme flood of 2007, have led to a step change in the way how flood risk management for the city is conceived. The National Capital Integrated Coastal Development Masterplan (NCICD) and its Great Garuda—or Giant Sea Wall—project is the largest of its type ever conceived in Indonesia, perhaps globally. It foresees solutions which are highly transformational in terms of the fundamental changes they will trigger in the city's hydrology and morphology.

However, these changes are not going along with an equal transformation in the way risk reduction is conceived and managed. Rather, the opposite is the case: the current measures cement a long-established paradigm of taming 'nature', in this case flood hydrology, in Jakarta. In that sense, they rather support a resistance or resilience paradigm, bulking the city up against future sea level rise and flood risk. Yet, they do nothing to transform the deeply entrenched development visions and patterns of land acquisition, sprawl and resource exploitation. In particular, they do not engage with one of the main drivers of Jakarta's flood risk problem: the largely unregulated ground water extraction and resulting sinking of the city.

Cynics might therefore argue that, in contrast to statements by many neo-classical development donors and practitioners, the biggest challenge for transformation is not to be found in the realm of financial or engineering limits—the project's financial costs, for instance, are unprecedented and yet

the project is being implemented. The main challenge rather is to be found in the changes needed in institutional rules and cultural behavior (e.g., radical changes in ground water regulation and a culture of strict law enforcement). Linking these findings back to the conceptual debate, the case study of Jakarta clearly suggests that transformational risk reduction should be primarily demarcated from other forms of risk reduction based on the consideration of whether or not it fundamentally reorients the understanding of a problem and the cognitive and institutional modes thinking about that problem and the respective solution space.

In addition, the Jakarta case clearly shows that massive engineering-based solutions are also doomed to fail politically and socially, if the costs and benefits are not shared according to the perceived standards of equity and distributional fairness by all affected social groups. The widespread protests had already once lead to temporary moratorium. The empirical data from our two-time-step household surveys has further shown the importance to consider the long-term livelihood and vulnerability effects for social groups who are affected by secondary effects from adaptation measures. The fact that the dispute over the project has been a core issue in the latest election of Jakarta's governor therefore shows that the topic of flood risk reduction is no longer a side issue but has arrived at the core of political debate about Jakarta's future.

8. Conclusions and Outlook

Jakarta provides an extreme example of how high the pressure for transformational changes can become in view of growing risks, driven by the confluence of unsustainable development trajectories and climate change impacts. The city counts itself among the coastal megacities with the most severe current and future flood risk. At the same time, it is amongst the global leaders in terms planning for bold adaptation measures. In this sense, it can serve as an insightful case study for informing the larger debate on transformation.

The case of Jakarta clearly shows the great social and political challenges that emerge when established development trajectories and their ingrained human–environment relations are reaching the limits of their sustainability and new trajectories have to be sought. The sheer magnitude of the city's flooding problem calls for transformational solutions, which are capable of fundamentally altering the currently engrained modes of development and risk regulation—both of which greatly contribute to the ongoing intensification of the city's flood risk. However, the case of Jakarta also underscores how difficult it is to move from the conceptual calls for transformation to practical solutions in the real world. The analysis clearly reveals that the most challenging hurdle is not to be found in the financial or engineering limits to adaptation. Despite the unprecedented volume of the Great Garuda project, the implementation is currently not being held back by questions of financing or technical barriers, to which solutions have been found. Rather, the biggest challenge is to be found in the societal and political negotiation of conflicting visions and paradigms for risk reduction, and especially the burden-sharing of negative side-effects.

Looking ahead, the Jakarta case therefore underscores that questions of governance are the main challenge within the field of risk reduction, transformation, and development at large. Fundamental transformations in development patterns and risk reduction regimes will be needed in cases like the one of Jakarta in order to enable some sort of long-term sustainability. However, the experiences from Jakarta serve as a clear warning signal that the question of how such changes can be designed and achieved is none to be tackled by technocrats and engineers alone. Rather, they need to be moved into the explicit focus of an inclusive societal debate. This becomes all the more important as risk reduction will increasingly set the boundaries for urban development and sustainability at large, especially in coastal cities exposed to future climate change risks. The Great Garuda project, for example, is designed to provide protection until the year 2080, assuming a mid-range land subsidence and sea level rise over this time-frame [40]. Considering the possibility of more rapid trends in both hazards, the threshold could be exceeded already much earlier. Hence, the question whether other even more transformational responses—such as partial retreat—will be needed, tolerated, or even

actively fostered is only postponed, at most. This question will eventually penetrate the deep tensions between sustaining and letting go of long-established and cherished urban morphologies and their functions and values. The weighing of different contested options therefore deserves to be pro-actively moved into the spotlight of societal and political debate. It is not a topic that can be solved at the drawing boards of technical experts alone.

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