Floods in (post-) New Order Jakarta

A political ecology of urbanization

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POLITICISING LAND SUBSIDENCE IN JAKARTA: HOW LAND SUBSIDENCE IS THE OUTCOME OF UNEVEN SOCIOSPATIAL AND SOCIONATURAL PROCESSES OF CAPITALIST URBANIZATION[21]

Abstract: Jakarta is sinking dramatically because of land subsidence, which in turn increases its vulnerability to tidal flooding. The explanation of land subsidence's cause and the design of solutions is led by geoscientists and engineers, who tend to treat it as largely a technical problem. This paper takes issue with this. It sets out to contribute to politicizing land subsidence by analysing it as part of the sociospatial and socionatural transformations that characterize processes of urbanization. We propose an approach that allows showing how subsidence happens through urbanization's interconnected moments of concentration, extension, and differentiation – the weight of the built environment, the expansion of deep groundwater wells, and the remaking of the city (and beyond). By investigating the sociospatial correlation between land subsidence and the development of buildings, and the temporal correlation between land subsidence and the increase of groundwater wells we illustrate how land subsidence is intrinsic to (post-) New Order

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capitalism (1965-1998 and 1998-now). We also show that it proceeds in uneven ways: those who cause subsidence are not the ones who suffer most from it. Through a serious treatment of soil-water dynamics, our socionatural theorization also helps appreciate how urbanization is always co-shaped by interactions between human and more-than-human processes.

Keywords: land subsidence, urbanization, sociospatial, socionatural, Jakarta.

5.1 THE SINKING CITY: POLITICISING JAKARTA'S LAND SUBSIDENCE

A new type of flooding is occurring in Jakarta:[22] tidal flooding. It is a form of flooding that was first observed in November 2007, when sea tides hitting the northern part of Indonesia's capital city caused existing dikes to overflow. Sea water inundated the northern part of the city, leaving low income neighbourhoods flooded for almost a month. The flood also forced the closure of the highway connecting the city to its airport (Kompas, 2007). According to hydrologists (Brinkman and Marco, 2009) the occurrence of higher tides for the period of 2005-2010 can be explained by this period's correspondence to the phase in which the moon orbits more closely around the earth, exerting a strong gravitational pull. Yet, while happening in cycles of 18.5 years, tidal floods had not previously caused the city to flood. The 2007 vulnerability of the city to tidal flooding was caused by land subsidence: the fact that the city was, and still is sinking below sea-level.

Land subsidence is increasing flood vulnerability not only in Jakarta, but also in many other coastal cities (Syvitski et al., 2009; Nicholls et al., 2021). This is why subsidence is of growing policy concern, ever more often making its appearance on climate adaptation agendas. In Jakarta, critical scholars' attempts to politicise the cause of this phenomenon are largely following geoscientists' and engineers' explanations (see, van Voorst and Hellman [2015]; Padawangi and Douglas [2015]; Colven [2017]; Wade [2018]; Sheppard [2018]; Saputra [2019]), with attempts showing, for example, how the issue of land subsidence is used to support the development of giant infrastructure (Octavianti and

[22] The city of Jakarta is governed as a special capital region (DKI, *Daerah Khusus Ibukota*). By 2020, the total population of DKI Jakarta is 10.5 million people. On the ground, it is hard to separate the DKI itself from the urban agglomeration of Jabodetabek, whose name is taken from the initial letters of cities of Jakarta, Bogor, Depok, Tangerang and Bekasi. In 2010, the total population of Jabodetabek was around 28 million (Rukmana, 2013).

Charles, 2018), how it is enmeshed within the uneven socionatural transformation of the city (Goh, 2019a), and how the "invisibility" of groundwater makes it difficult to assess its relation to subsidence (Colven, 2020). We respect all of their attempts of trying to make sense the cause of land subsidence.

The on-going conversation about land subsidence in Jakarta among engineers and geoscientists revolves around identifying the relative importance of the two most important causes of land subsidence: the weight of buildings and the extraction of groundwater. The two are interrelated. The over-extraction of deep groundwater increases the 'compactability' of the soil, exacerbating the consolidating effect of the weight of buildings. In Jakarta, there is a clear divide between geoscientists and engineers who mainly blame the weight of buildings (the Jakarta Mining Agency as quoted in Rukmana [2008]; Ramdhan and Hutasoit [2008]) and those who attribute land subsidence mainly to the extraction of groundwater (Abidin et al., 2001; Ministry of Public Works, 2011; NCICD Master Plan, 2014; Deltares, 2016). Proposals to stop or slow land subsidence tend to be limited to technocratic or infrastructural measures or calls for regulation (see, Nicholls et al. [2021]). Engineers' and geoscientists' explanations recognize urbanization or "urban development" as a cause of land subsidence (Abidin et al., 2011), but dedicate little effort to further unpacking the uneven societal processes of urbanization that cause groundwater over-extraction and development of ever more buildings that added weight to the soil in the first place.

In this article, we take issue with this. This is because leaving analyses and calculations of the causes of subsidence to 'the natural' or 'engineering' domains, considering these as separate and separable from the 'social' or 'human' domains is a distinct act of "technification (rendering technical)" (Joy et al., 2014: 7; Li, 2007) that contributes to the de-politicisation of floods and their management (Joy et al., 2014). Treating subsidence as a more or less naturally occurring phenomenon in need of a technical solution makes it difficult to recognize how it is part of and entangled with uneven processes of urbanization, with those who are most responsible for causing subsidence often not themselves being most vulnerable to the risks of flooding. With this line of argumentation, we subscribe to the desire articulated by Wang to thematise subterranean geopolitics (Wang, 2020). Yet, our main aim in this article is not so much to further theorize the politics of the underground. Instead, we mobilize critical geographer's insights about 'the political (or social) of the natural and technical' (Joy et al., 2014; Swyngedouw, 1996) to further politicise explanations of land subsidence in Jakarta.

Our strategy for doing this is based on ontologically re-defining subsidence as a problem that is simultaneously technical, social and political. This is importantly inspired by the concept of socionature (Swyngedouw, 1996). Joy et al. (2014: 9) explain for water more generally that (re-)politicisation "implies understanding the complex social-environmental processes and socio-political relationships that constitute and surround" water. They emphasize that doing this requires interdisciplinary approaches. Our effort to

(re-)politicize subsidence in Jakarta consists of two interconnected moves. First, we insert land subsidence in sociospatial and socionatural theories of urbanization to explain how the sinking of soils in Jakarta is a distinct part of (post-) New Order capitalism. Doing this shows that solving or dealing with subsidence necessarily entails asking questions about the form of capitalism and the processes of uneven urbanization that it generates and relies on. Second, we critically engage with the knowledge (tools, maps) about subsidence as produced by engineers and geoscientists, both to open up their explanations and analyses for critical scrutiny and to help understand how processes of subsidence can be traced and linked to ongoing processes of uneven urbanization.

The premise of the first part of our analysis is that a city like Jakarta, as Harvey (1996: 50) puts it, is a "thing" that comes out through processes of "urbanization". We set out to show that land subsidence is intrinsic to such processes, with the phenomenon as well as current solutions to it being produced by and themselves productive of unevenness. Hence, our politicisation of Jakarta's land subsidence consists of explaining it as the product of particular entanglements between nature, urbanization, and a specific form of capitalism. To do this, we rely on historical data that show how the rate of Jakarta's land subsidence started to accelerate and become problematic from 1975 onwards (JICA, 2017: 22), precisely with the advent of Indonesia's New Order regime (1967-1998) and beyond (1998-now), or (post-) New Order – a specific form of state capitalism consisting of a mixture of centralized social, political, and economic power led by general Suharto (Hiariej, 2003). (Post-) New Order capitalism rested on and promoted urban agglomeration in and around the core of Jakarta (Kusno, 2013). By systematically tracing how land subsidence is entangled with and part of this agglomerating process, we aspire to open up the broad category of 'the social' or "human activities" as figuring in an analysis of sinking delta cities around the world (Syvitski et al., 2009: 681). In particular, by showing how land subsidence is historically embedded in Jakarta's capitalist urbanization, we specify which processes and whose activities are to be held responsible for fundamentally transforming the city, its water and rocks.

Where the first part of our politicisation of land subsidence consists of opening up 'the social', the second part of it entails opening up 'the technical' (or 'the natural'). Our effort here resonates with an emerging stream of critical physical geography scholarship which calls for "unsettling" (Lave et al., 2014: 4) the monopoly of engineers and natural scientists in producing data about and explaining everything that is categorized as biophysical. Instead of treating subsidence as something that merely provides the 'natural' or 'biophysical' context to the unfolding of uneven urbanization unfold, we aspire to instead treat the sinking of soils as a distinct form of "agency" (Bakker, 2012: 621) that co-shapes the form and direction of urbanization processes. Critically but seriously engaging with the knowledge produced by engineers and geoscientists about subsidence – their descriptions, model, predictions – is central to this effort. The acknowledgement

of the agency of nature in creating land subsidence is in line with the expanded conception of capitalism proposed by some scholars (most notably Fraser [2014] and Moore [2015]), with land subsidence appearing as a manifestation of the 'natural' limits to Jakarta's capitalist growth-urbanization trajectory.

Our overall analysis takes inspiration from and makes use of sociospatial theory as developed by Brenner and Schmid (2015), which they proposed as a critique of definitions of urbanization as consisting of the growth of cities. Their "new epistemology of the urban" instead theorizes urbanization as the sociospatial processes through which the urban is produced under contemporary (1980s onwards) capitalism. They distinguish three interrelated moments of urbanization. The first, concentrated urbanization, refers to the spatially coming together or clustering of the means of production and labor power, making the exploitation of surplus-value and surplus easier for capitalist (see, Marx, 1867[1982]: 772-81; Smith 1984[2008]: 60-8; Harvey [2012]: 3-66; Merrifield [2013]: 74). The second, extended urbanization, refers to how ever more resources and people outside of (or indeed under) the city are mobilized to make concentrated production within the city possible. And thirdly, differential urbanization is the uneven outcome of concentrated and extended urbanization together. It refers to the creative destruction of existing sociospatial arrangements to allow for the acquisition of new spaces that enable a new round of capital accumulation.

We mobilize this categorization in three moments of urbanization as a useful heuristic device to tell the different yet interconnected stories of land subsidence in Jakarta. A first story is about the subsidence caused by soil compaction, which happens as part of concentrated urbanization: the horizontal spatial growth of Jakarta, extending into the urban agglomeration of Jabodetabek. A second story is that of the subsidence caused by the increase in the number of groundwater wells. This form of subsidence happens as part of a vertical form of above- (Saitluanga, 2017; Liong et al., 2020) and below-the-ground (Wang, 2020) extended urbanization needed to sustain above-the-ground processes of surplus extraction. Lefebvre (1991: 325) already pointed to the "underground" as part of the capitalist production of space. Extended urbanization in terms of water therefore does not just happen in a horizontal direction, by taking water from hinterlands that are spatially far from the city (Gandy, 2002; Swyngedouw, 2004; Kaika, 2005 and 2006), but it also happens vertically. Finally, the moment of differentiation relates to how incidences and rates of subsidence as well as solutions to it are distributed across the city and beyond. It also crucially entails identifying who are behind land conversions or the intensification of groundwater extraction, and showing how their actions are part of and produce deeply uneven social relations.

We complement Brenner and Schmidt's theoretical proposal with Swyngedouw's (1996) concept of socionature to allow better appreciating the role of non-humans – in our case complex soil-water dynamics – in co-causing land subsidence. Swyngedouw proposed the term socionature to remedy the tendency of Marxist analyses to prioritize the wage-

labour process in explaining the production of surplus-value under capitalism. According to him, capitalist processes are also importantly shaped and marked by 'nature' or non-wage-labour (for example: care, land, water). To denote the inseparability of the social and the natural under capitalism, Swyngedouw and others mobilize the term socionatural transformation (Swyngedouw, 1996; Heynen, Kaika, and Swyngedouw, 2006; Tzaninis et al., 2020). The terms socionature and socionatural transformations help make 'nature' integral to the analysis of the linkages between urbanization and land subsidence in a way that does not force nature back into a separate and separable ontological entity, one that remains outside of 'the political'. Rather than explaining 'natural' behaviours by referring to 'natural' qualities and 'social' behaviours by referring to 'social' qualities, the term socionature forces attention towards how the social and the natural always form 'hybrids'.

5.2 METHODOLOGY: OPERATIONALIZING SOCIONATURES

How to translate and operationalize the theoretical insights explained above into a methodology that enables representing and understanding land subsidence as the outcome of deeply entangled social and natural processes? We decided to use engineering and geophysical maps of land subsidence as our empirical starting points. We used these maps to proceed in a step-by-step approach to establish the sociospatial correlation between land subsidence and the development of buildings as well as the temporal correlation between land subsidence and groundwater extractions. We then mobilized these correlations to trace the people behind the buildings and groundwater extractions that primarily cause subsidence, as a way to link subsidence to the particular operations of (post-) New Order capitalism in Jakarta.

As for the first, analysing how the growth of the built environment and land subsidence are sociospatially connected, we modelled Jakarta's land subsidence on the basis of published GPS-measurements. Provided by Abidin et al. (2008), these measurements were gathered through eight surveys of elevation from 26 locations over the period of 1997-2005. Abidin et al. (2008) calculate land subsidence rates by subtracting consecutive measurement data. For example, the total land subsidence in one particular location/station is calculated by subtracting the second (29-30 June 1999) and the first measurement (24-26 December 1997). Iteratively repeating this same process seven times, allowed them to come up with the difference between the second and first measurement, between the third (31 May – 3 June 2000) and second, etc. all the way to the difference between the eighth (21-25 September 2005) and the seventh measurement (21-26 December 2002). They published the outcomes of this exercise in the form of a table and separate maps (Table 2 and Figure 8 of Abidin et al. [2008]: 27 and 29). We used this data set to map subsidence rates (as measured in cm/time) over 1997-2005, for each of the 26 stations. Using *ArcGIS* to digitize the station's locations (in Figure 3 of Abidin et al. [2008]: 25), we then plotted the total elevation differences (land subsidence) in each

station and interpolated the total land subsidence values to generate a contour map of land subsidence. Our intention behind this interpolation is to connect the different parts of the city that have similar total land subsidence values. The map represents these connections in different colours (map at Figure 5-1). In this way, the map shows the spatial pattern of land subsidence.

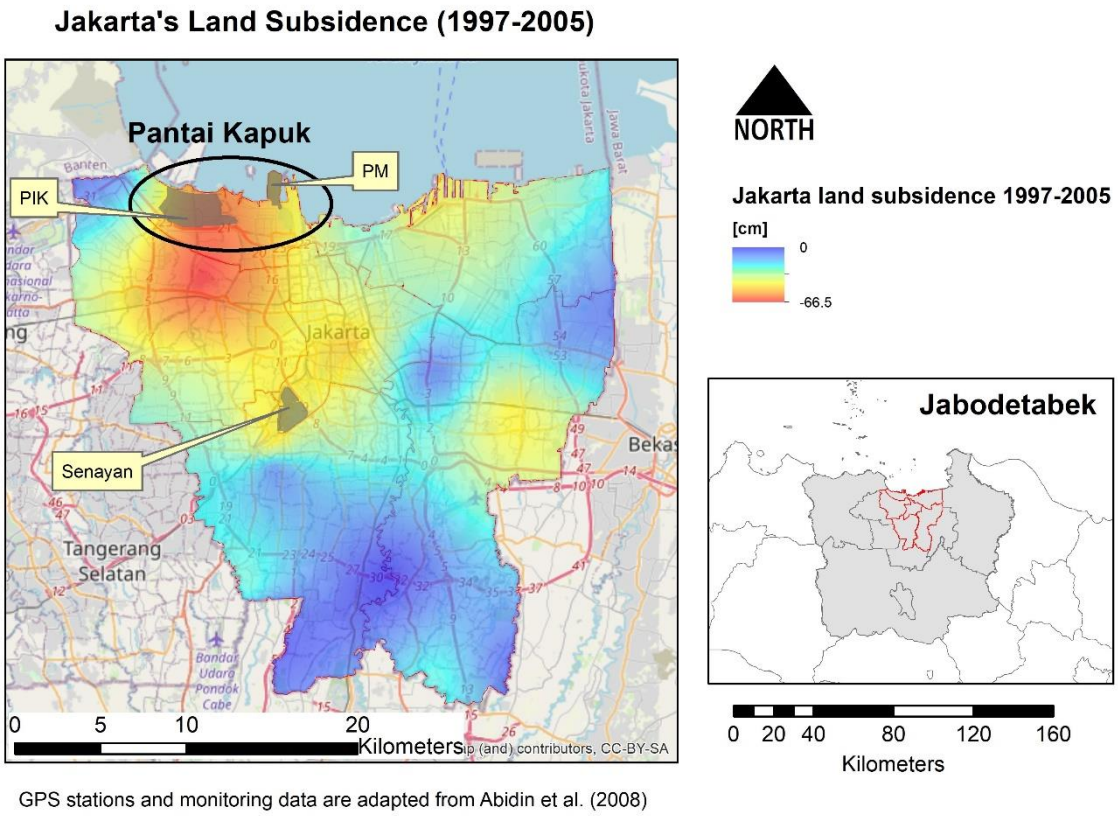

Figure 5-1: Jakarta's land subsidence (1997-2005). Basemap: OpenStreetMap.

To illustrate the link between this spatial map of land subsidence to ongoing processes of capitalist urbanization of the (post-) New Order regime, we used *OpenStreetMap* and *World Imagery* maps to connect differential rates of land subsidence with the spatial growth of buildings within the city. Here, we took land conversions and the development of the built urban environment as manifestations of capitalist urbanization. We draw on existing data sets – historical data from secondary sources and news articles (Figure 5-2) – that show that it is primarily members of the New Order regime network of crony capitalists who built on hydrologically sensitive lands. They are, thereby, identifiable as the causers of land subsidence.

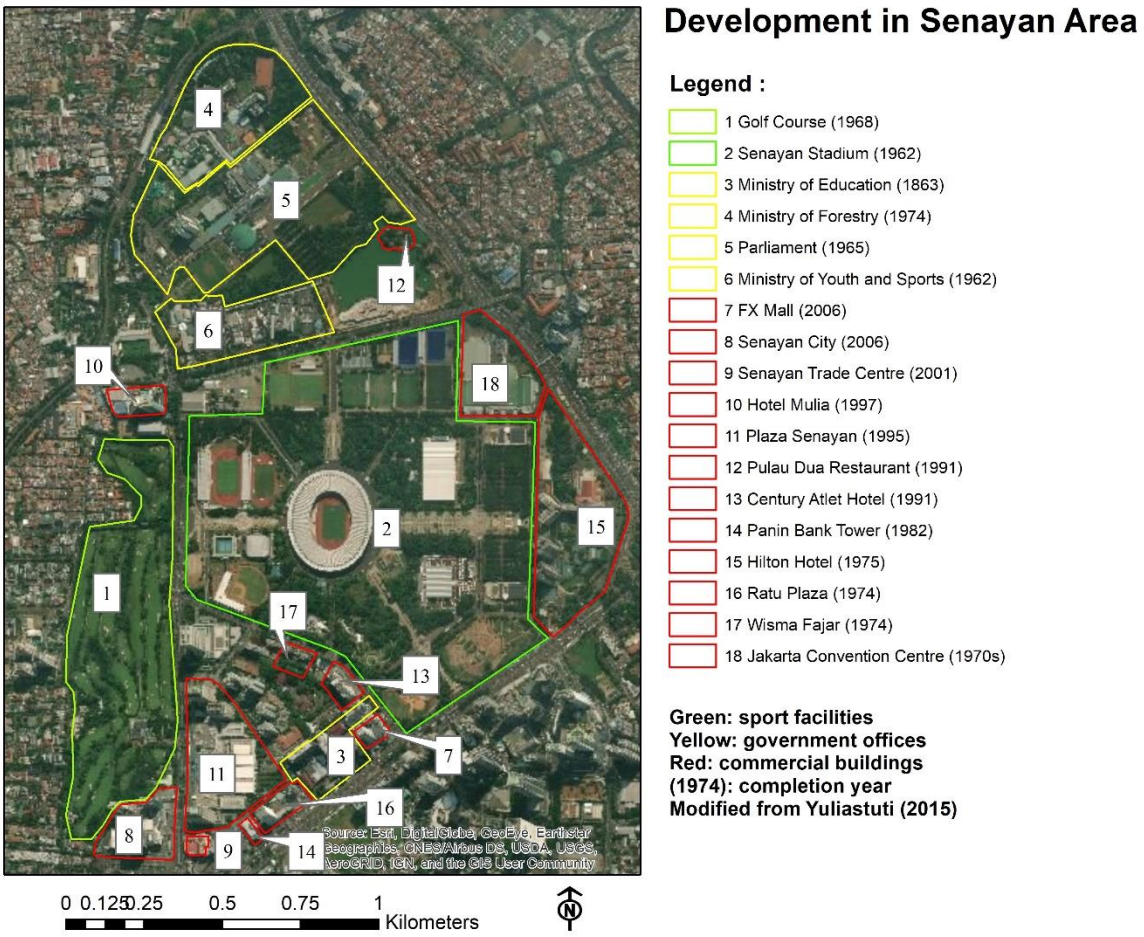

Figure 5-2: Development in Senayan area. Basemap: World Imagery.

The second component of our methodological puzzle was to link land subsidence to aquifer depletion. We did this by tracing the temporal correlation between groundwater extraction and the New Order regime. We identified how the total registered number of groundwater wells increased under the New Order regime, making use of secondary material. Kagabu et al.'s (2013) graph of 1879-2007 registered groundwater wells in Jakarta allows identifying the number of registered groundwater wells under the New Order regime. Since Kagabu et al.'s (2013) graph does not publish the exact number of wells, we extracted it by means of *getdata-graph-digitizer* software.[23]

We compare deep and shallow groundwater in terms of the extracted volume, cost of making, total number of wells, and how they cause land subsidence to understand vertical

[23] The software is available at: http://getdata-graph-digitizer.com/download.php; (accessed: February 5th, 2018).

unevenness. Here, we make use of data produced by the DKI Jakarta Water Agency about the volume of extracted shallow and deep groundwater. The official data notoriously under-report actual extracted volumes of water, as they ignore the myriad of unregistered wells in Jakarta. We therefore compared the government's data to estimates made by non-governmental organizations. We also compared the costs of making deep groundwater wells – with data obtained from secondary sources and through interviews with a well driller from our on-going research in Semarang, the capital of Central Java Province – with that of constructing shallow groundwater wells – with data obtained through interviews with shallow groundwater users. We interviewed Jakarta based engineers about the total number of groundwater wells in the city, and discussed problems in monitoring groundwater extraction with them. In addition, we used geological reports and publications to understand how the specific characteristics of Jakarta's soils and aquifers co-shape patterns and rates of land subsidence.

5.3 WEIGHT OF THE BUILT ENVIRONMENT: CONCENTRATED CAPITALIST URBANIZATION

Tracing who were behind the conversion of hydrologically sensitive areas (green and blue belt) into large scale commercial land development is a first way to illustrate the connection between (post-) New Order capitalism and subsidence. Jakarta's 1985-2005 Spatial Plan clearly marks specific land areas as critical for water retention and catchment, therefore delineating them as protected areas. The implication is that these are areas should not be used for real estate development. Yet, Rukmana (2015) documents how around 4,000 hectares (ha) of land in these hydrologically sensitive areas were used for the development of supermarkets, luxurious settlements, hotels, apartments, malls, schools, and hospitals. We zoom in on two specific locations as our attempt to follow the relative north-south spatial distribution of land subsidence in our map (Figure 5-1) and to capture the details of how buildings in these areas came about, focusing on how they are linked to the workings of the (post-) New Order regime: the Pantai Kapuk (PK, it is circled in map at Figure 5-1) development in the north-west part of the city and the Senayan development in the city centre.

The PK in northwest Jakarta, where Pantai Indah Kapuk (PIK) development now stands, used to be a mangrove forest (Padawangi, 2008: 52). The forest provided a water retention area, able to retain up to 16 million m^3 of water (Majalah Tempo, 2007: 108-109). In the early 1990s, this area was transformed into Pantai Indah Kapuk (PIK), consisting of a golf course (76.2 ha), sport and recreation facilities (20.43 ha), a park (86.5 ha), housing (368.34 ha), industrial warehousing (17.48 ha), a business area (88.18 ha), and others (57.5 ha) (Kompas, 1993a).To make this possible, more than 700 hectares of the mangrove forest had to be drained and filled. The main figure behind this conversion was the renowned Chinese-Indonesian property developer Ciputra (Leaf 2015) who is closely

linked to Sudono Salim, the right hand of New Order leader, Suharto (Robison, 1986[2009]: 271-322; Borsuk and Chng, 2014). Still at the PK, to the east of PIK, one finds the Pantai Mutiara (PM) luxury residential areas, covering 110 ha (Properti.kompas.com, 2010). This land was developed in the 1990s through land reclamation. In this case, property development was led by Intiland, a company owned by Suhargo Gondokusumo, a member of Yayasan Prasetiya Mulya (Kompas, 1993), a foundation led by Sudono Salim (Aditjondro, 2006: 201-202; Borsuk and Chng, 2014: 240-247). Both developers, Ciputra and Suhargo Gondokusumo, and their guru, Sudono Salim, are at the core of Suharto's New Order capitalism (Hiariej, 2003: 64).

The relations between these two developments and land subsidence is similar: the weight of the new buildings caused the compacting of the alluvial soils. Our land subsidence map (Figure 5-1) indeed clearly illustrates that the areas of PIK and PM sunk around 60 cm and 50 cm respectively (land subsidence values and the total sinking between 1997-2005 are taken at the centre of polygons). We conclude that this form of land subsidence is the product of and integral to a horizontal form of concentrated urbanization of the (post-) New Order. This is not just a sociospatial process, but also a socionatural one in how it irreversibly transforms the density of the soil, making it sink and changing its water retention capacities.

Moving now to the second area (Figure 5-2) in the city centre; the Senayan development. In 1962, in the early days of Indonesia's independence, this area of 279 ha was protected from development through its designation as a national heritage site. This is why Betawi people, group with most legitimate claims to be Jakarta's native population, who lived in this area were forcefully evicted (Yuliastuti, 2015: 44-5; Ahmady et al., 2010: 129). The area both had a recreational function by serving as a sporting area, and an ecological function: the huge green area helped intercept and absorb rainwater. However, following the change in the political regime from the nationalist-left of Sukarno to the pro-capital New Order Suharto in 1965, land in the greenbelt was slowly converted into commercial real estate. At present, only 40 ha of green area are remaining.

Many developments in Senayan area (Figure 5-2) can be directly traced to New Order regime crony capitalists. The iconic superblock of the Hilton Hotel and the Jakarta Convention Center were for instance developed in the 1970's by PT Indobuildco. This is a company owned by Ibnu Sutowo (Kompas, 1974; 1992a; 2007a), a former army general appointed by Suharto as the director of Pertamina, the state-owned oil company that funded the army during the early phase of New Order consolidation (Crouch, 1978[2007]: 275). The superblock of Plaza Senayan was developed in the 1990's by PT. Aditya Wirabakti, the joint company of Suharto's fourth daughter, Titi Prabowo and her brother in-law Hashim Djojohadikusumo (Kompas, 1995b). Members of the Suharto family, namely his third son Bambang Trihatmojo, also figured in the development of the adjacent Mulia hotel in 1997 (Kompas, 1998; Yuliastuti, 2015). Not only did the Mulia

Hotel violate the horizontal spatial regulations of the city by building on a cultural heritage site and green space, it also violated the vertical regulations, with its building height far exceeding permissions (Kompas, 1997). Also here, the relation between new real estate development and subsidence is undeniable: our map (Figure 5-1) shows that the Senayan area has sunk around 44 cm.

These two stories provide an important empirical foundation for our suggestion that explaining Jakarta's land subsidence requires going beyond geology. Although understanding it does entail a serious engagement with engineering and geoscientific data, to understand why subsidence occurs such data need to be complemented with and inserted in a critical understanding of processes of urbanization. Doing this reveals that subsidence is a specific manifestation of a form of capitalist urbanisation that is highly uneven. The case of the Senayan city centre is a particularly stark illustration of how subsidence is deeply political: first, native people living in this area were evicted to make place for green and blue lands, only to later allow members of the network of New Order crony capitalists to appropriate it for commercial developments. The increased weight eventually caused the compaction and sinking of the soil.

It is important to emphasize that land conversions in the north-west and centre of the city not just consist of sociospatial, but also of socionatural or socioecological transformations, in which soils and waters interact in specific ways with human interventions to co-determine the character and direction of urbanization. This happens in three different but interrelated ways. First, more buildings reduce the soil's water absorption capacity, thereby also reducing water stored in the ground. This in turn, empties the pores of some strata of underground rock formations, making them more vulnerable to compaction and subsidence. Second, their weight together with, third, the extraction of groundwater from the contained aquifer, both lead to further compaction and subsidence. In the following section we examine in more detail how the extraction of groundwater from the contained aquifer can be temporally traced to the workings of (post-) New Order capitalist urbanization, and is useful to further understand the materiality of the non-human in the uneven production of land subsidence.

5.4 EXTRACTION OF GROUNDWATER: EXTENDED CAPITALIST URBANIZATION

The extraction of groundwater from the contained aquifer below Jakarta is the second significant cause of subsidence, and therefore a second important way in which sociospatial processes of urbanization are simultaneously socionatural. Biophysically, the hollowing out of the aquifer that happens by removing water increases its 'compactability' (Ramdhan and Hutasoit, 2008). In what follows, we describe examples of groundwater extraction and soil compaction processes as a specific vertical form of extended capitalist urbanization. In doing this, we once again highlight that the relation between the

extraction of groundwater and subsidence illustrates the distinctly socionatural character of urbanization. First, available quantities of groundwater change through the development of the built environment because of how buildings reduce recharge and the soil's water retention and absorption capacity. Second, also the biochemical properties of groundwater change because of how industrial and domestic wastewater and runoff negatively affect groundwater quality, increasing the amount of contaminants in it (Martosuparno, Suherman and Kagabu, 2014). Reversely, humans are affected – importantly in terms of health – by changes in groundwater's physical, biophysical, and biochemical properties. In Jakarta, 60% of the population are not connected to the piped water network of the privatized water company, and the majority of them rely on groundwater for daily use (Hidayat and Lin, 2018).

A second and more indirect way in which society co-evolves with nature has to do with the tension between the difficulty to monitor extraction rates and the ease of extraction. Hydrogeologists have long tried to model Jakarta's aquifer (see, Deltares [2016a] for a review), with the objective of using the model as a tool for better monitoring extraction and governing groundwater. However modelled representations so far inherently fail to accurately capture the complexities of reality. The most widely accepted model (Fachri et al. 2002) divides the approximately 250 m of sedimentary deposit of the aquifer into 4 layers: from the depth of 0-40 m is the shallow uncontained aquifer; 40-140 m is the thick aquitard (aquifer with low water content); 140-230 m the second layer of contained aquifer, and; for the depth of more than 230 m another layer of aquitard. Yet, this representation of aquifer layers ill captures spatial variations across the city. There are for instance places where there are no discrete layers, but rather "intercalated" small sand "lenses", making it "almost impossible to trace specific clay or sand layers" (Deltares, 2016: 12).

In contrast to the difficulties of modelling and knowing the aquifer characteristics, the extraction of groundwater is relatively easy for those with the capital to afford pumping technology and energy costs. This ease of extraction has led to an increase in groundwater use, particularly since the New Order (Kagabu et al., 2013: 5). In 1879 there were only 42 groundwater wells in Jakarta, while there were 352 in 1968. Hence, in 89 years the number of groundwater wells grew with 310, or 8.3 times. The number of registered groundwater wells increased even more sharply (10 times) during the 30 years period of the New Order regime, from 352 in the 1968 into 3,626 in the 1998 (Kagabu et al., 2013: 5). Kagabu et al. (2013) do not specify whether the counted registered wells are deep or shallow wells. After the New Order regime, between 1998 and 2016 the reported increase in registered wells is smaller, amounting to a total of 4,551 registered wells. Of these, 1,945 are shallow wells with an annual extraction of around 1.2 million cubic meter and 2,606 are deep wells with much higher extracted volumes of around 5.9 million cubic meter of groundwater annually (DKI Jakarta Water Resources Agency/WRA, 2017,

unpublished data). Deep groundwater wells extract five times more than shallow groundwater wells. The small increase in terms of the total number of groundwater wells after the New Order regime, however, is not likely to be caused by a reduction in the number of people starting to drill wells. It is more likely to be explained by the fact that owners simply do not register their wells, to avoid paying tax, and avoid the setting of volumetric limits to extraction[24] (see also Wahyono and Wardiat [2012]). An engineer working at the DKI Jakarta Industry and Energy Agency estimates the total number of wells in the city to be at least 15,000![25]

Given the high number of unregistered wells, it is almost impossible to accurately measure the total volume of water extracted from the contained aquifer. Based on 2016 registered wells data, the government reported that the groundwater extracted by both deep and shallow wells was 7.1 million m^3 (DKI Jakarta WRA 2017, unpublished data). This is bound to be a massive under-estimation. Research conducted by civil society groups calculated the total water needs of the city and compared this with the volume provided through centralized piped supply. Based on this calculation, they came to an estimated annual volume of groundwater extraction of 548.2 million cubic metre (Tifa and Amrta, 2013).

This groundwater extraction is vertically uneven, which is related to the cost of making a well. Extracting deep groundwater (from > 40 m depths) requires a lot more money than extracting shallow groundwater (< 40 m). In Jakarta, deep well development can cost a billion of Indonesian Rupiah/IDR (see Hidayat and Lin [2018]).[26] Development of a shallow groundwater well, meanwhile, costs only around IDR 1.5 million.[27]

Unsurprisingly, those primarily responsible for extracting cleaner deep groundwater from the contained aquifer are industries as well as those belonging to the political and social

[24] Interview with DKI Jakarta Industry and Energy Agency (June 5th, 2017).

[25] This estimate is based on the total number of buildings in the city. It's a common practice in Jakarta, even though a building has connection to piped water network, people still drill their own wells (JICA, 2017: 47; KPK. 2017, unpublished data) to anticipate if the flow in the pipes is down.

[26] Hidayat and Lin (2020) interviewed an engineer who mentioned the cost of making recharge deep wells to inject water into deep aquifer. We predict the cost of developing deep groundwater wells to pump water out from aquifer is not so much different. As a matter of comparison, in Yogyakarta, a city in the central part of Java, the cost of making a deep groundwater well is about IDR 400-500 million (Amrta Institute, 2017, 2); in Semarang, the capital of Central Java Province, the cost of making a deep groundwater well is about IDR 200 million (interview with a deep groundwater driller in Semarang, 12 and 13/8/2019). We follow engineers' categorisation about the deep and shallow wells.

[27] Interview with user in Jakarta's urban poor settlement of Bukit Duri, September 2016

elites. Prominent deep groundwater users are factories, government-offices, foreign embassies (Malaysia, Netherlands, Switzerland, Poland, England, and Saudi Arabia), and the houses of elites such as that of the 1998-9 President of Indonesia, B.J. Habiebie (Indonesia's Corruption Eradication Commission/KPK 2017, unpublished data) and that of the 2017-8 DKI Jakarta deputy governor who run as vice president candidate in 2019 presidential election (The Jakarta Post 2018a) and is now appointed as the Minister of Tourism and Creative Economy (2020-now), Sandiaga Uno. Also the vast majority of the new real estates discussed in the previous section rely on groundwater that is pumped up from the deep aquifer through privately paid for infrastructure (Rusdiyanto and Pratomo, 2007; JICA, 2017: 47). Instead, Jakarta's urban poor mostly rely on the more contaminated shallow groundwater.

As discussed and shown, there is a direct temporal relation between groundwater extraction and land subsidence: both increased under the New Order period. Yet, subsidence is caused by more-than-human factors; also rock and geological characteristics come into play. The rock in the northern part of the city has the highest percentage of sand vs. clay, which means that the sub-surface water storage capacity here is larger (Deltares, 2016a: 8-14). When groundwater continues to be sucked out, it is these sand layers (or lenses) that will be compacted the most. Hence, the distinct material characteristics of nature – here the composition of the rock, the distribution of sand layers, and the resulting water storage capacities – importantly co-determine the pattern and rate of land subsidence.

Groundwater is over-extracted from the deep aquifer when the rate of extraction exceeds that of recharge. This is how the deep aquifer in the northern part of Jakarta has been transformed, from an area of "seepage" in 1900 into a "sink" in 1992: water which used to flow upwards, from the deepest layer of the aquifer to the top, now flows downwards, from the shallow uncontained layer to the bottom (Deltares, 2016a). The technical meaning of this is that the deep aquifer is hollowed-out, and compacted. We already discussed that those primarily responsible for doing this are those who are able to invest large amounts of money in the drilling of deep wells to obtain access to cleaner water. The cheaper shallow groundwater wells used by the urban poor that extract less clean water do not have as big an impact on compaction and subsidence. New models of the aquifer flow system predict that stopping land subsidence will require another 10-25 years after – if – extraction of groundwater is completely stopped.[28]

[28] Engineer's presentation at *Knowledge Stakeholder Open Workshop* at Ministry of Public of Work office, Jakarta (June 7th, 2017).

5.5 CONCLUSION/DISCUSSION: RE-IMAGINING A MORE SUSTAINABLE AND JUST

In this paper we contribute to the politicisation of land subsidence, emphasizing that it should be considered as a more-than-natural phenomenon. We show why it is dangerous to leave the analysis of and the design of solutions for land subsidence to engineers and geo-scientists as this renders invisible both the processes of urbanization and the individuals that primarily cause it. Our proposal to politicize land subsidence uses the case of Jakarta to show how subsidence can be interpreted as intrinsic to a particular form of urbanization consisting of intertwined sociospatial and socionatural transformations. Interactions between land conversions, the development of buildings and deep groundwater extraction made possible by the political economic relations of the (post-) New Order regime network of crony capitalists on the one hand and hydro(geo)logical processes on the other are effectively destroying the city of Jakarta and its subterranean space, producing water-related risks both above and below ground. Those primarily responsible for causing this destruction remain systematically less vulnerable to these risks than Jakarta's urban poor (as we show through the case of flooded low income neighbourhood at the opening section), even when plans to tackle subsidence often entail their re-location.

We have argued and shown that subsidence is 'more-than-natural', but at the same time we also emphasize that it is 'more-than-social' (or political). This latter argument stems from our concern that critical analyses implicitly go along with and accept engineers' and geoscientists' explanations about the causes of land subsidence by treating it as consisting of primarily 'natural' or 'biophysical processes'. The effect of this is that land subsidence figures either as the 'background', appears as an 'elsewhere' or 'context', or is theorized in terms of resources of limited supply. This makes it difficult to recognize how nature itself (re-)acts and behaves, and of how processes of capitalist urbanization are shaped by continued interactions and entanglements between the 'natural' and the 'social'. Our theorization of land subsidence as a socionatural process in which the continuous interactions between humans and other-than-humans are treated as internal to capitalist urbanization allowed making visible how also nature – in our case the behaviour of 'underground' rocks and waters (the 'sand vs. clay' composition, the spatial distribution of aquifer layers, the relative 'compactability' of soils when water is taken out and when they are under heavy weight, the relative reduction in water percolation rates when soils are compacted) – co-shapes patterns and rates of land subsidence.

We operationalized our theorization by developing a methodology for tracing and mapping the connections between processes of land subsidence and human behaviours, in our case focusing particularly on the actions and investments of members of the (post-) New Order crony capitalist network. We collected, re-arranged, re-interpreted and visualized existing data on subsidence, combining these with data on land conversions

which we could link to particular investors and members of Jakarta's political and economic elites. We showed the sociospatial reconfigurations that happened by clearing protected green areas from its former inhabitants to make place for New Order capitalist cronies. Their land conversions not just deteriorated the land's water retention and absorption capacities, but the weight of the new buildings that they developed also irreversibly compacted the soil. They relied on extracting water from ever deeper layers of the aquifer to provide clean water to the users of these new edifices, thereby increasing the soil's 'compactability' and causing it to sink even further. Thus identifying how subsidence is caused by particular processes and individuals allows for its politicization in that it makes it possible to hold them (rather than those living in poor urban settlements) accountable for Jakarta's increased vulnerability to floods that is the effect of subsidence.

While land subsidence can be interpreted as posing one of the limits to Jakarta's capitalist growth-urbanization trajectory, the currently favoured solution to subsidence – the re-location of the capital city to Kalimantan/Borneo Island, announced by the President in 2019 (Bappenas, 2021: 4) – is one that will only allow capital accumulation to further accelerate, producing yet another round of uneven sociospatial and socionatural transformations. The total cost of moving the capital is of IDR 466 trillion (almost 30 billion Euro), involving around 180,965 ha of land that will be 'developed' mainly by the non-state investors. Hence, one again the property developers and land concession holders are the ones who stand to benefit most, at the expense of the communities who currently live where this new capital will be erected (Johansyah et al., 2019).

In this way, these new plans only serve to underscore our main message: it is dangerous to treat floods and land subsidence as primarily technical problems and follow analyses or the design of solutions proposed by geoscientists and engineers. Just like the plan to relocate the capital, proposed solutions such as the construction of giant flood protection infrastructures (see, Colven [2017]) or deep artificial recharging wells will further strengthen capitalist urbanization and its protagonists – causing further socioecological damage and injustice in the process. Our analysis instead points to the critical importance of questioning the very logic of capitalist urbanization that makes deeply uneven sociospatial and socionatural transformations appear as 'progress'. Rather than glorifying members of powerful political and economic elites who are responsible for causing these transformations as heroes of progress, a more political socionatural analysis of subsidence can help hold them accountable for their damage and serve as the basis for re-imagining societal dealings with land and water in more sustainable and just ways.