TECHNICAL Briefing

OCTOBER 2013

Climate vulnerability and adaptation in the Semarang Metropolitan Area: a spatial and demographic analysis

Understanding the relationship between population dynamics and vulnerability to climate change is critical for developing more targeted and effective adaptation policies and actions. The effects of increased frequency and intensity of climatic hazards is magnified in rapidly growing urban centres, such as Semarang, a city in Central Java, Indonesia. The city has historically faced hazards such as drought, land subsidence, landslides and floods, many of which are likely to become more severe and frequent as a result of climate change. The demographic and spatial analysis presented in this technical briefing, and in the full report from which it is derived,[1] highlights areas of Semarang where exposure to climate-related hazards coincides with social and demographic characteristics that exacerbate vulnerability. This information can be used to target policies and initiatives that more effectively reduce the impacts of climate change.

URBAN GROWTH IN THE SEMARANG METROPOLITAN AREA

The Semarang Metropolitan Area (SMA) — also known as Kedungsapur as an abbreviation of the names of its constituent cities and regencies (Kendal-Demak-Ungaran-Salatiga-Semarang-Purwodadi) — has a population of almost 5.5 million residents, including approximately 1.5 million people who live in Semarang City itself.[2] The spatial analysis in this technical briefing focuses specifically on Semarang City and Semarang District (directly south of the city) as these are among the largest and fastest growing districts in Kedungsapur, with a combined population of almost 2.5 million people. This growth is associated with a shifting spatial distribution of population — while the SMA as a whole is experiencing annual population growth of 0.7 per cent, Semarang City itself is growing at 1.4 per cent. In addition to population size and growth, various other demographic characteristics can influence vulnerability, including the proportion of elderly and young people living in an area, the proportion of female-headed households, and the different patterns of migration and mobility displayed by different age and gender groups.

CLIMATE HAZARDS AND VULNERABILITY IN SEMARANG CITY

In Semarang, global climate change will result in increased surface temperatures, increased rainfall intensity, rising sea levels and changing extreme weather patterns. The most tangible evidence of the occurrence of climate change in Semarang is the increase in monthly average surface temperatures over the last 100 years. Sea levels have risen since 1985 and are expected to rise by a further 40 to 80 cm in the next 100 years — expanding the potential inundation area inland by between 1.7 and 3 km.[3] Changing rainfall patterns contribute to existing problems with flooding, landslides, drought and water scarcity; while rising sea levels and land subsidence will contribute to coastal erosion and tidal flooding.[4] Also, longer dry seasons and droughts have led to crop harvests failing.

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Figure 1. The study area: The District of Semarang and Semarang City

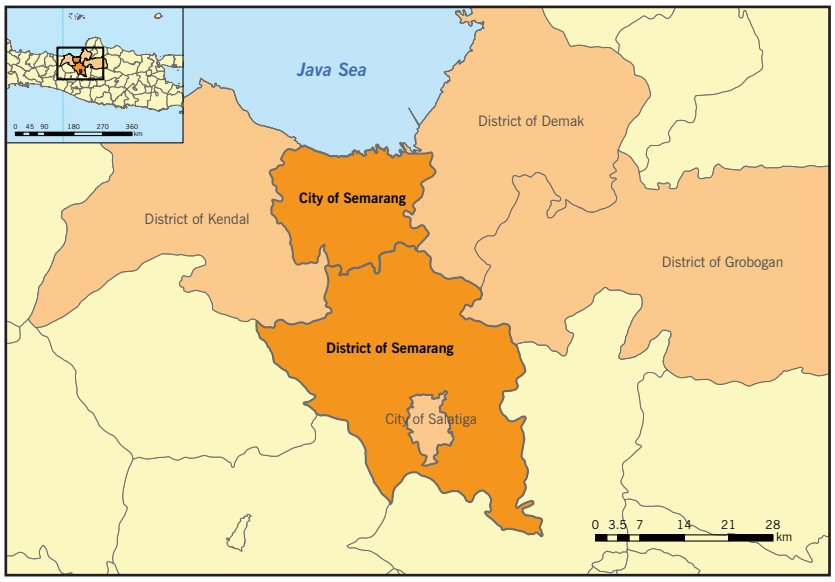
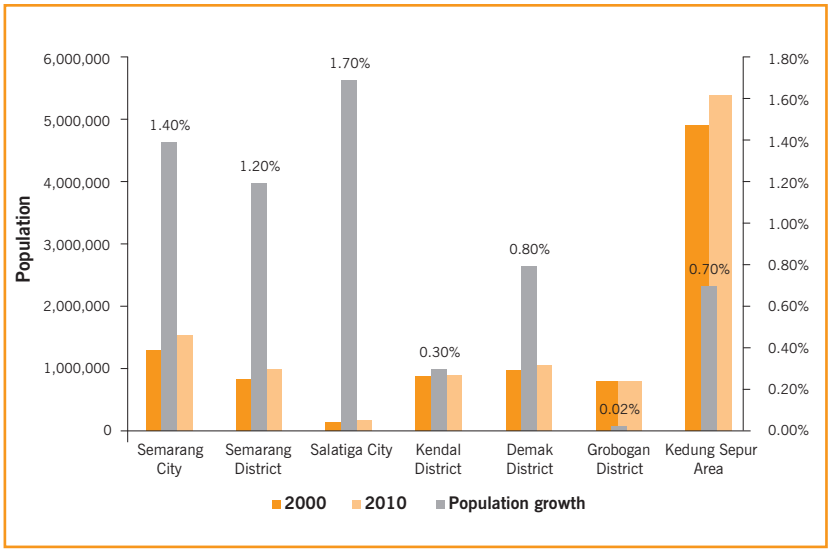


Figure 2. Urban growth in the Semarang Metropolitan Area, 2000-2010. Source: Ministry of Public Works (2012) Technical Report on Semarang Metropolitan Area



Specific areas within Semarang have been identified as being particularly vulnerable to climate change:[4]

- lowland regions affected by coastal flooding and sea level rise
- settlement areas located in riverbeds exposed to flooding
- hilly areas exposed to high winds
- areas affected by land movement and landslides
- residential areas on the city outskirts distant from water sources
- nodes of movement and transportation (airports, seaports, train stations, terminals)
- functional central business districts (particularly areas of trade and industry)
- historical areas and cultural assets.

POPULATION DYNAMICS AND VULNERABILITY IN SEMARANG

Analysis of demographic and hazard data. Demographic and spatial analysis of the SMA is intended to show the geographical correspondence between demographic characteristics and exposure to particular hazards. The analysis uses Hazard Maps produced by the National Agency for Disaster Management (BNPB) and Census and Village Potential Data from Statistics Indonesia (BPS). ArcGIS software was used to construct maps that display the spatial distribution of risk for particular hazards (as defined by BNPB), specifically flooding and landslide risks, which are likely to become more frequent and intense as a result of climate change. Each of these hazard maps was overlaid on the village boundaries within Semarang, and the average level of risk within each village was calculated for each hazard type.

Data from the 2010 Indonesia Census was used to identify information that shapes the sensitivity and adaptive capacity of individuals and neighbourhoods, including:

- The dependency ratio reflects the age structure of neighbourhoods by comparing the dependent population (those under the age of 15 and over the age of 64) with the productive population (those aged 15-64)
- The adjusted Secure Tenure Index (STI) is based on four specific indicators of general vulnerability - the percentage of residents in each village with access to piped water; without earthen floors; with improved toilets; and with electricity as the main source of lighting
- Population density.

The census also includes data on education, migration, female-headed households and economic activity, all factors that influence a population's adaptive capacity.

EXPOSURE TO COASTAL FLOODING

The coastal location of the SMA, in conjunction with its low elevation, renders much of the region particularly susceptible to flooding associated with rising sea levels and changing weather patterns. A large portion of Semarang City falls within the Low Elevation Coastal Zone (LECZ), defined here as those areas with an elevation of less than 10 metres above sea level. In Semarang, almost 840,000 people live within the LECZ resulting in a high average population density of 10,201 people per square kilometre.

High flood risk + dependency ratio. The dependency ratio is high in some of the SMA areas that are at highest risk of flooding, including Kranggan and Bugangan (located near to a flood canal), and Bangetayu Kulon, Tlogomulyo and Penggaron Kidul in the southeast of Semarang city (see Figure 3). There are also coastal villages at high risk of flooding that have a high dependency ratio. These areas are particularly vulnerable as the very young and the elderly are susceptible to the results of flooding and waterlogging — evacuation can pose particular challenges, and water-borne and water-washed diseases are potentially more harmful.

Figure 3. High flood risk + dependency ratio

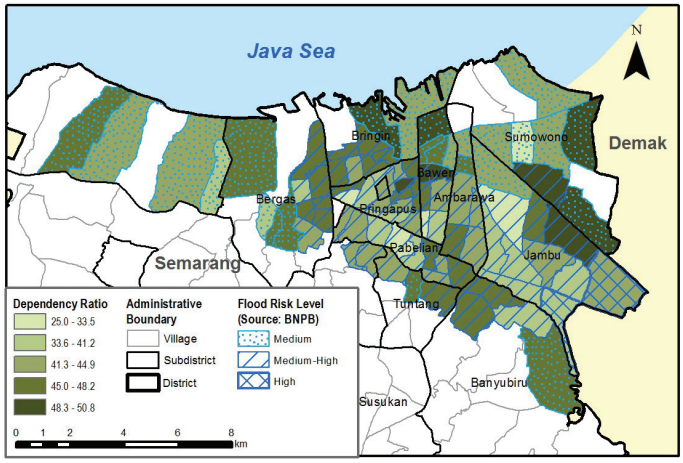


Figure 4. High flood risk + STI

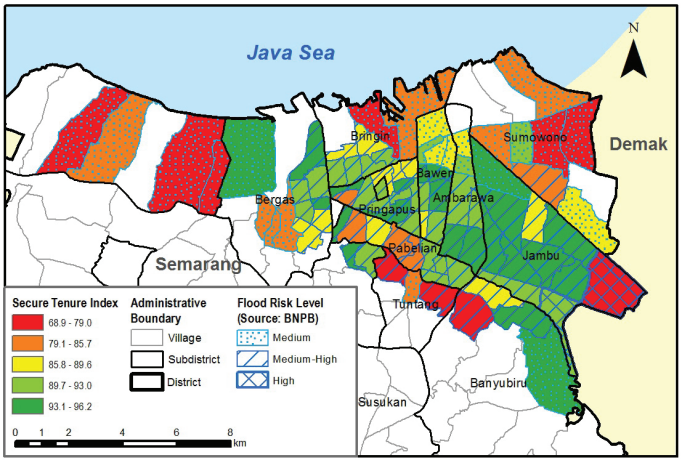


Figure 5. High flood risk + population density

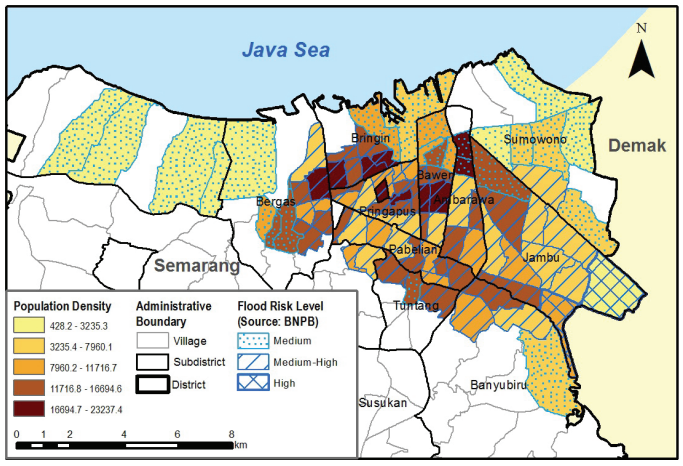
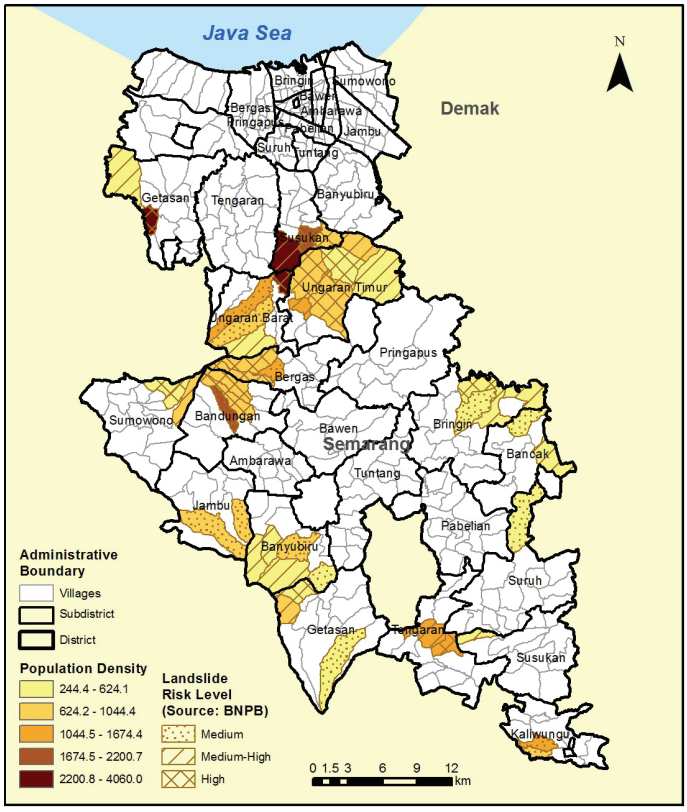


Figure 6. High landslide risk + population density



High flood risk + Secure Tenure Index. A low value for the adjusted STI indicates an area with relatively poor quality housing, and therefore more vulnerable to the adverse effects of climate-related disasters. Fortunately, a relatively small number of villages with a low STI are exposed to high levels of flood risk. Indeed, many villages in the centre of Semarang have relatively high STI values. But Penggaron Kidul, Tandang, Jomblang and Tegalsari on the outskirts of the city have low STI values combined with a medium to high flood risk, and so are less able to cope with the effects of flooding (Figure 4).

High flood risk + population density. Many villages with high population density are located near the coastal area and city centre of Semarang, including Bangunharjo, Gabahan, Jagalan, Sarirejo and Rejosari — all old settlements with large and densely settled populations (Figure 5). Flooding in these areas would therefore have implications for evacuation strategies and the provision of emergency shelters.

High landslide risk + population density. Changes in rainfall and temperature could have significant impacts on land stability and may increase the frequency of landslides.[5] For the majority of the SMA, the risk posed by landslides is relatively low but in some more mountainous regions of central Semarang (mostly located in Kabupaten Semarang), the risk is significant. Figure 6 shows that most villages prone to landslides in Semarang District are located in the urban fringe and have relatively low population densities.

ADAPTIVE CAPACITY

Population characteristics such as education, migration, household composition and economic activity, can also influence an area's capacity to adapt to the effects of climate change.

Education. The ability to adapt to the consequences of climate change requires hazard analysis and planning for potential risks. Education can provide individuals with information about the risks associated with climate change, the training necessary for adjusting to these risks, and the job skills useful in the changing employment structures associated with the impacts of climate change. In Semarang, there is a correlation between higher levels of educational attainment and higher levels of risk — in part, this may be due to high urbanisation in these areas

resulting in greater employment opportunities for those with higher levels of education.

Migration. Migration is likely to affect the adaptive capacity of individuals and communities because new arrivals to an urban area may have fewer housing opportunities available to them, forcing them to live in precarious housing in high-risk areas. Recent migrants may also be less resilient to these climate hazards as their shorter time in the community is often associated with limited social integration and restricted knowledge of the community-specific risks. Given that informal social safety nets are an important mechanism for adapting to hazards, new migrants without established social networks are likely to adapt less effectively to the challenges associated with climate change.[4] Overall, the proportion of current Semarang residents who lived outside Central Java five years ago is relatively small at only 1.74 per cent. Those communities with higher rates of migration tend to be located in the higher-risk northern areas of Semarang.

Female-headed households. Women's assumed domestic role often constrains their ability to adapt to climate hazards as it can imply lower levels of educational attainment and labour force participation.[4] The subsequent lack of information, skills and economic means can limit the adaptive capacity of female-headed households compared with male-headed households. The data showed a concentration of communities with a relatively high portion of female-headed households around the central city in the municipality of Semarang, an area also highly exposed to climate-related hazards.

Economic activity. In addition to the factors described above, the ability of individuals to adapt to climate change is closely linked to poverty. Individuals living in poverty often lack the economic resources that would allow proactive adaptation to climate change. Unfortunately, the census data does not include income levels but it does include whether individuals were working the week prior to the census, so lack of work is used here as a proxy for poverty. Overall, 57 per cent of Semarang residents aged 10 and over were working in the week prior to the 2010 census. But the portion of residents who are economically active is relatively low in communities in the high-risk northern areas. The highest levels of work were found in rural and lower-risk areas. This may be because finding employment in the rural agricultural sector is easier than in the urban economy.

CONCLUSION

The findings suggest that significant portions of the population of Semarang City and District are vulnerable to climate change and may lack the resources to adapt effectively to its impacts. Addressing this will require the coordinated efforts of various stakeholders — of which the national and local governments are among the most significant.

A number of key findings stand out. First, many high-risk areas also have relatively high levels of adaptive capacity, suggested by the relatively high adjusted STI values and levels of educational attainment. Importantly, though, in the high-risk area of Semarang City, relatively low levels of engagement in economic activity and the high proportion of female-headed households may limit this capacity. Beyond the urban areas of Semarang, vulnerability is especially high in the agriculturally dependent villages in some east central parts of the study area where significant drought risk and a lack of piped water may threaten residents' agricultural livelihoods.

Climate change policy must recognise how population dynamics contribute to vulnerability and influence communities' adaptive capacity. To be most effective, programmes should prioritise high-risk areas with demographic characteristics that make them particularly vulnerable and limit adaptation. The specific characteristics that constitute vulnerability are likely to vary based on the type of hazard a community faces. In order to be responsive to this variation, policies must be flexible and developed in close partnership with local communities and officials. By understanding the spatial relationship between exposure to hazards and the potential for local populations to adapt, future policies and initiatives can be developed in a more targeted and effective manner.

There are limits to this approach, particularly when used on its own. Reliance on aggregated data ignores those individuals or households who may be particularly vulnerable but are located in a neighbourhood that displays less overall vulnerability. Social networks and support mechanisms could play a vital role in reducing such pockets of vulnerability, but further research is needed to understand their potential.

A critical advantage of this study is that it relies on data from the 2010 Indonesian Census, meaning that data inputs had already been collected ready for analysis. The study can therefore be replicated for any area across Indonesia at low cost, providing significant benefits for existing vulnerability assessments and adaptation planning.

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This is the fourth in a series of Technical Briefings prepared by UNFPA and IIED on urbanization and emerging population issues.

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