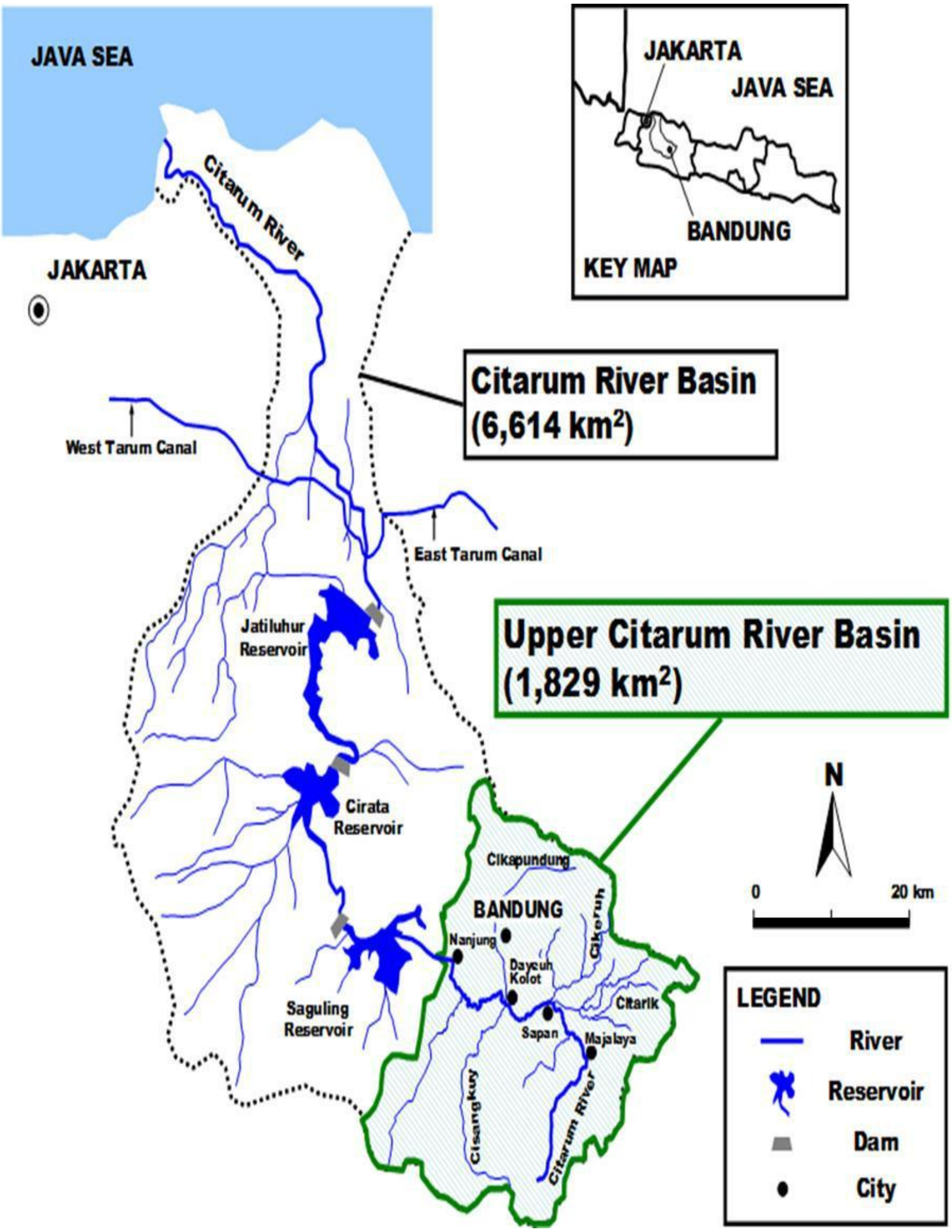


Project Location and Area

Problem description Dayeuhkolot

The Upper Citarum basin (figure 2.1) is located in West-Java, Indonesia. The Upper Citarum area drains into Saguling reservoir. The basin contains the city of Bandung, which is the third largest city in Indonesia.

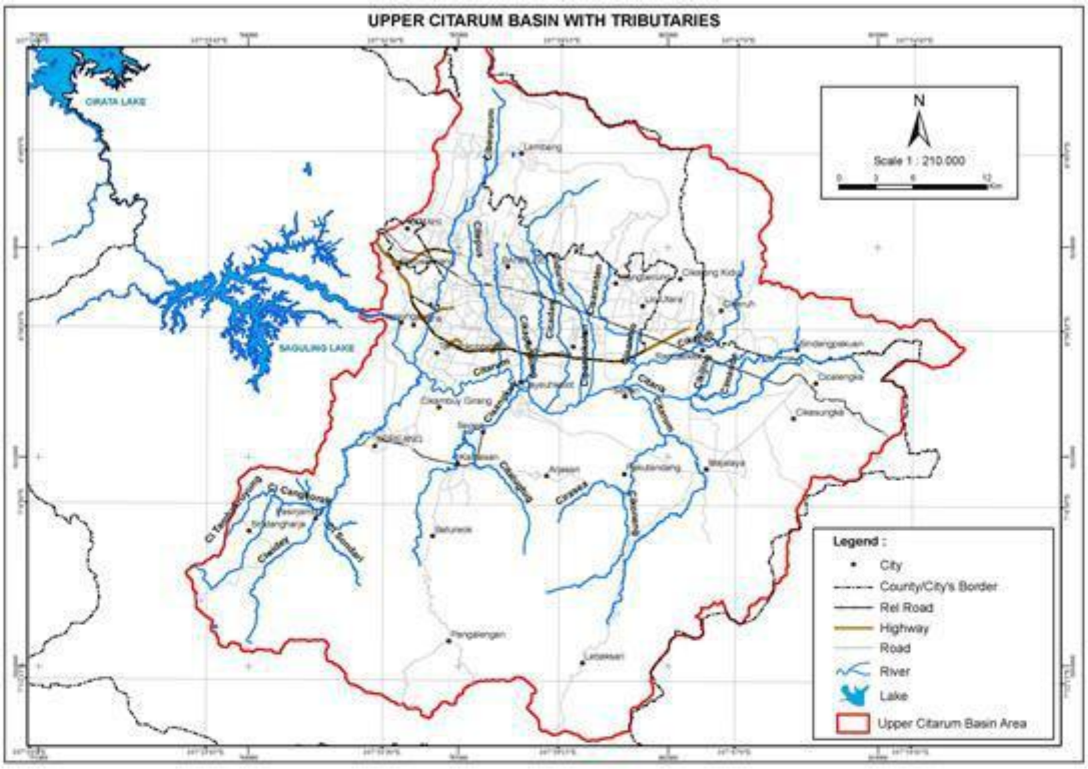


Figure 2.1: Upper Citarum basin

About 50,000 to 16,000 years ago the plains in the Upper Citarum area were permanently flooded, as they formed the bottom of a large lake enclosed by high mountain ridges in the North, East and South and a lower ridge in the North-West. Erosion of volcanic clays on the mountain slopes over the years filled up the lake, until the bottom leveled with the outlet at Curug Jompong, which is just upstream of Saguling reservoir. The lake disappeared and the river network in the plain developed. Some geographical names still refer to the lake history of the area, for instance Gedebage (literally ‘lake’ in Sundanese) and Rancaekek (Ranca meaning ‘swamp’ in Sundanese).

Because of the lake history of the Upper Citarum area, the former lake sediments form an important characteristic of the flood plain. The sediments easily compact when they dry. And this is currently the case since groundwater resources in the basin are overexploited and groundwater levels in large part of the basin are drawdown between 20 and 60 meters. Therefore land subsidence is a widespread occurring phenomenon in Bandung basin.

Bandung City is located on the mild slopes of the Northern hills and mostly experiences short pluvial floodings due to local rainfall. The larger scale fluvial or river floodings are located in the Bandung plain area along the main Citarum river and some of its tributaries. Suburbs like Dayeuhkolot, Gedebage and some areas near Rancaekek quite often experience fluvial flooding.

The Dayeuhkolot area south of Bandung City (see figure 2.2) is among the most frequently flooded areas in the Upper Citarum Basin. Floods occur almost every year. Serious flooding in the whole Bandung basin occurred in 1986, 2002, 2005, March 2010 and December 2014. Also recently the Dayeuhkolot area was again flooded (March 2016). Near Dayeuhkolot, the Cikapundung and Cisangkuy River flow into the main Citarum River.

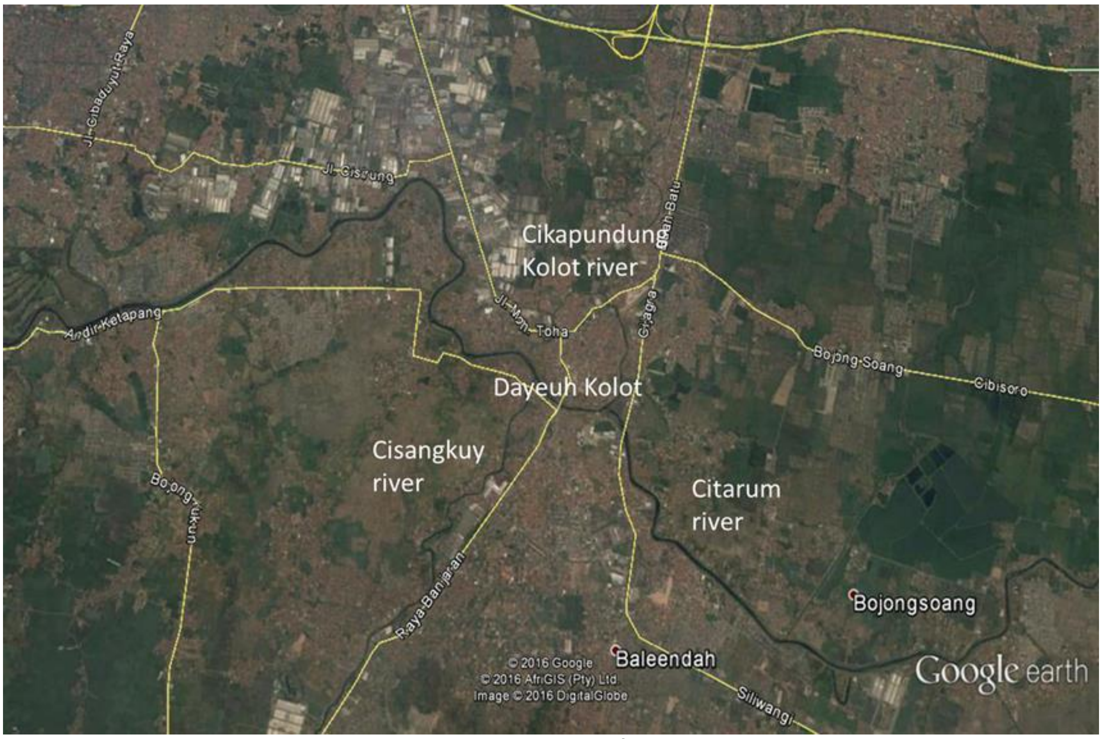


Figure 2.2: Dayeuhkolot area (from Google Earth)

The main reasons for the frequent flooding in the Dayueh Kolot area, occurring after heavy rainfall in Dayeuhkolot and upstream areas are:

- the subsidence in the Dayeuhkolot area;
- the sedimention in the Citarum river, reducing the river capacity and leading to higher water levels;
- lacking dredging maintenance works;
- lacking or incomplete dike protection near Dayeuhkolot; and
- high water levels in Citarum river which hamper drainage from the local area.

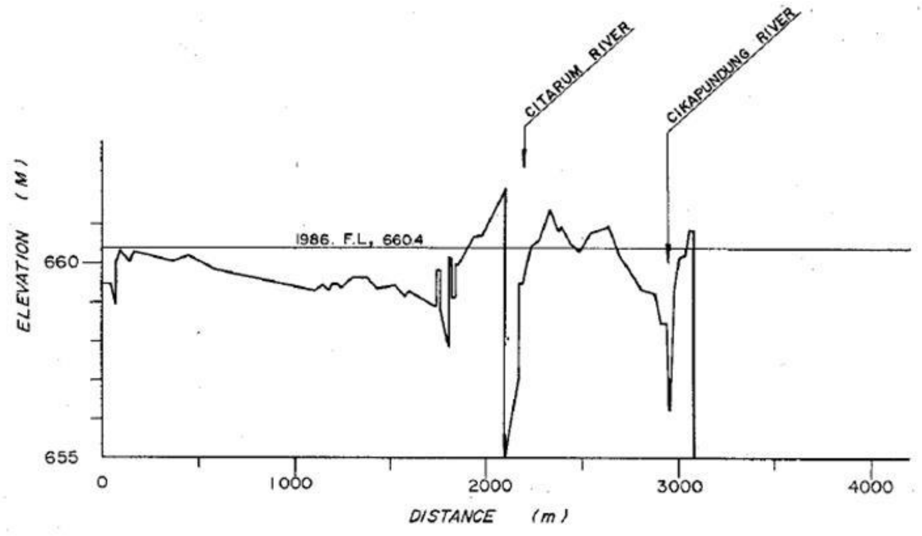
These aspects are discussed in the following paragraphs.

Because of the sedimentation in the Citarum river the lowest river bed level relatively rises compared to the surrounding subsidence area. However the embankments do not rise, they face subsidence like the whole area. The combination of these facts leads to regular overtopping of the Citarum River near Dayeuhkolot. Furthermore, even after water levels in the Citarum have dropped below the embankment levels, they typically remain high for a couple of days such that local drainage by gravity is not possible because of the subsidence.

Subsidence

In the eighties of the previous century, the river bed elevation near Dayeuhkolot was approximately 653.5 m, the high water level was 659.5 m, and the land elevation at that time was clearly higher than the high water level of the river. The road at Dayeuhkolot was at an elevation of 662m. A transect of Dayeuhkolot area as shown in figure 2.3 (taken from JICA

1988 study) shows indeed that part of the area at Dayeuhkolot was still clearly higher than the 1986 flood level of 660.4m, but also that part of the area is already lower.



Source: JICA 1988 Study, Supporting Report Fig. D.6, Page D-10

Figure 2.3. Section of Dayeuhkolot including adjacent floodplain (1988 JICA Study Report)

In 2007/2008, due to subsidence the elevation of the road had dropped to about 658 m and the land area above the 1986 high water level is sharply reduced. Even though there may be some discussion on the exact values of the elevations, it is clear that subsidence is a major issue in the Dayeuhkolot area. This has also dramatically influenced both the frequency and the consequences of flooding at Dayeuhkolot.

The JICA 2007 Detailed Design study (further referred to as 2007D/D) and JICA 2010 Preparatory Survey (further referred to as 2010PS) report historical subsidence values in the same range, i.e. up to 1 m subsidence in 5 years. A survey along the Citarum River indicated that in a range of approximately 10 km around Dayeuhkolot the land subsidence varies from 0 to 1.75m in 10 years.

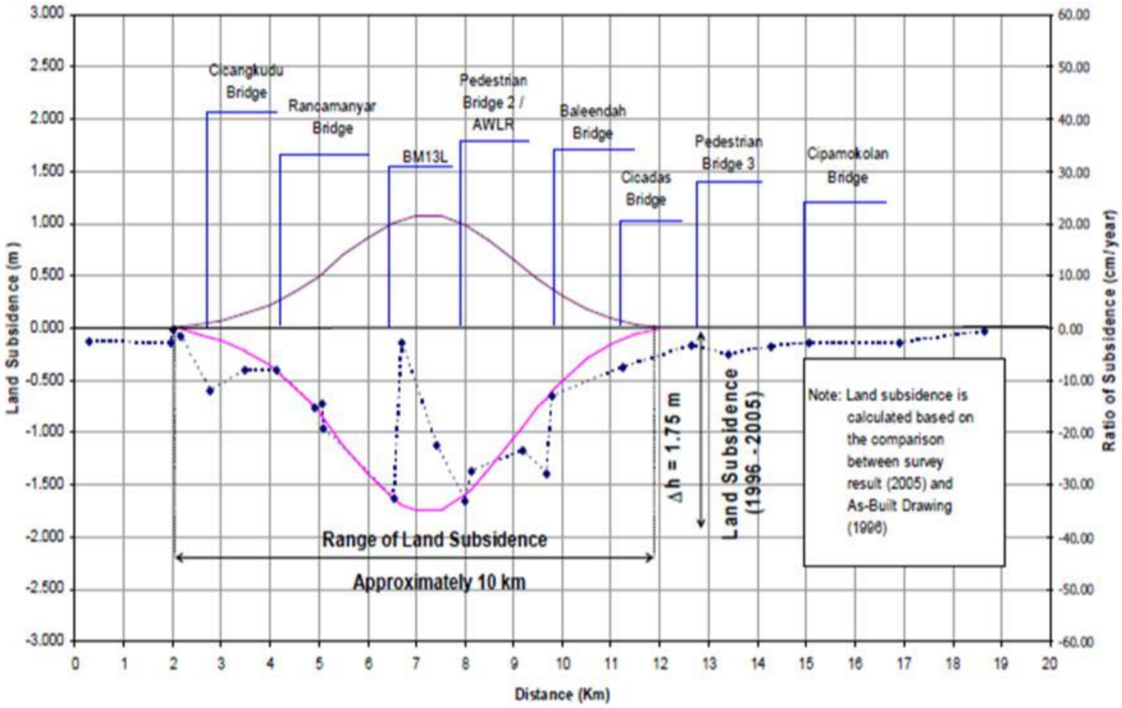


Figure 2.4: Subsidence 1996-2005 along Citarum River, Dayeuhkolot (from JICA 2010PS, figure 3.8)

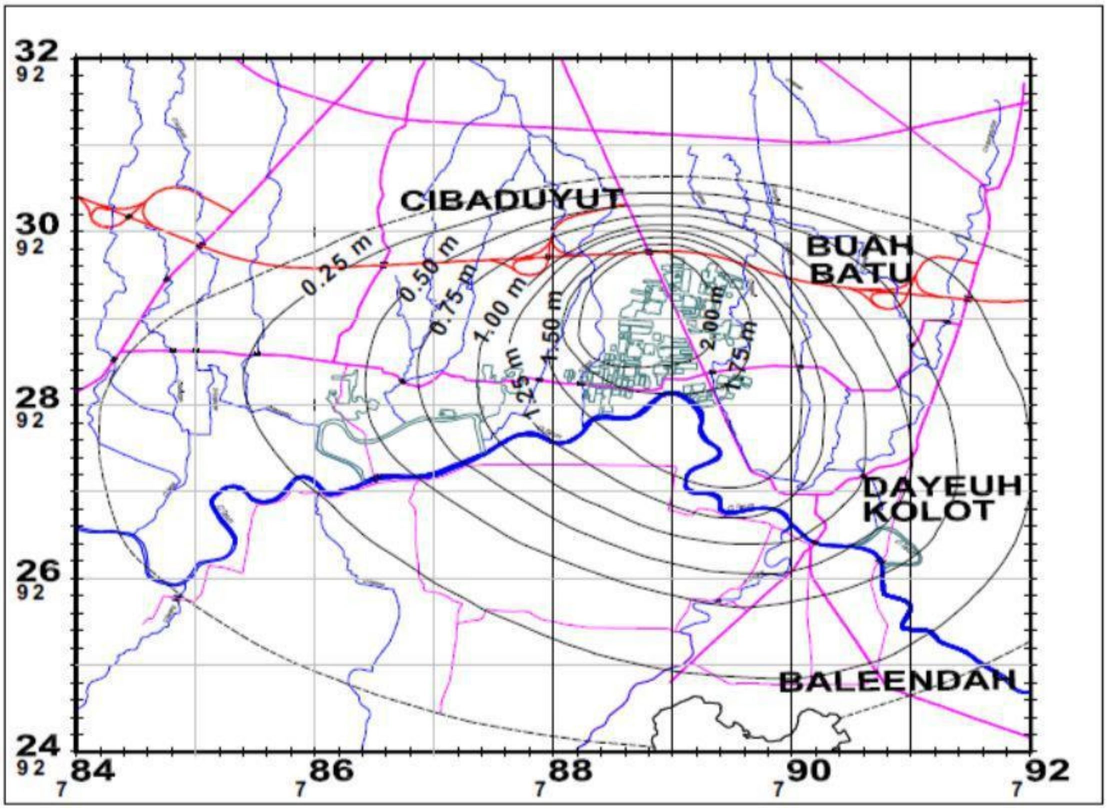


Figure 2.5: Subsidence from 1996-2006 in the Dayeuhkolot area (from JICA 2010PS, figure 3.10)

The ADB project Integrated Citarum Water Resources Management Project (ICWRMP) component C, Upper Citarum Basin Flood Management (further referred to as the ADB UCBFM project) derived a subsidence map for the 1999-2010 period for the whole Upper Citarum basin based on GPS elevation surveys, INSAR satellite measurements, JICA leveling data and geological information. This map is shown in figure 2.6.

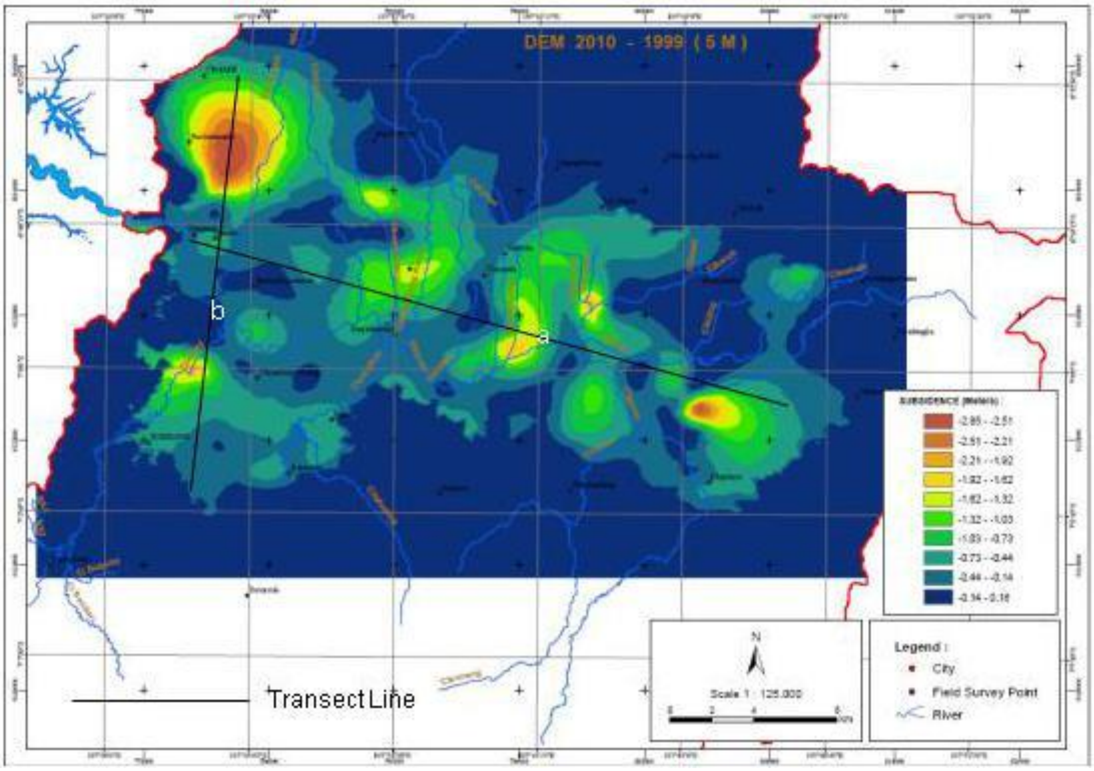


Figure 2.6: Land subsidence in Upper Citarum Basin (ADB project, Annex F, figure 18)

Figure 2.6 shows several ‘hot spots’ of subsidence. The most severe and extended subsidence according to this map is in the Cimahi area. The Dayeuhkolot area and Gedebage-Sapan area are clearly visible. Southeast, in the eastern Majalaya area there seems to be a hotspot as well. Furthermore, in the north east the Rancaekek area near the provincial road (Cikijing and Cimande rivers) is visible. In the southwestern Ciwidey catchment area (Kopo) there is also some subsidence.

For the west to east transect a in this figure, a profile along this transect shows several dips (figure 2.7). The dip near km 10 corresponds to Dayeuhkolot, the dip near km 16 is the Sapan/Gadebage area, and the dip near km 26 is near Majalaya.

Figure 2.7: Land subsidence along transect a (ADB project, Annex F, figure 19)

The subsidence also has its impact on the Citarum River. This is illustrated by the longitudinal profiles for the years 1986, 1994 and 2005. The profiles show subsidence especially from km 15 to km 30. Dayeuhkolot is approximately at km 18-20, while km 30 is upstream Sapan (where the Citarum Hulu, Citarik and Cikeruh River come together).

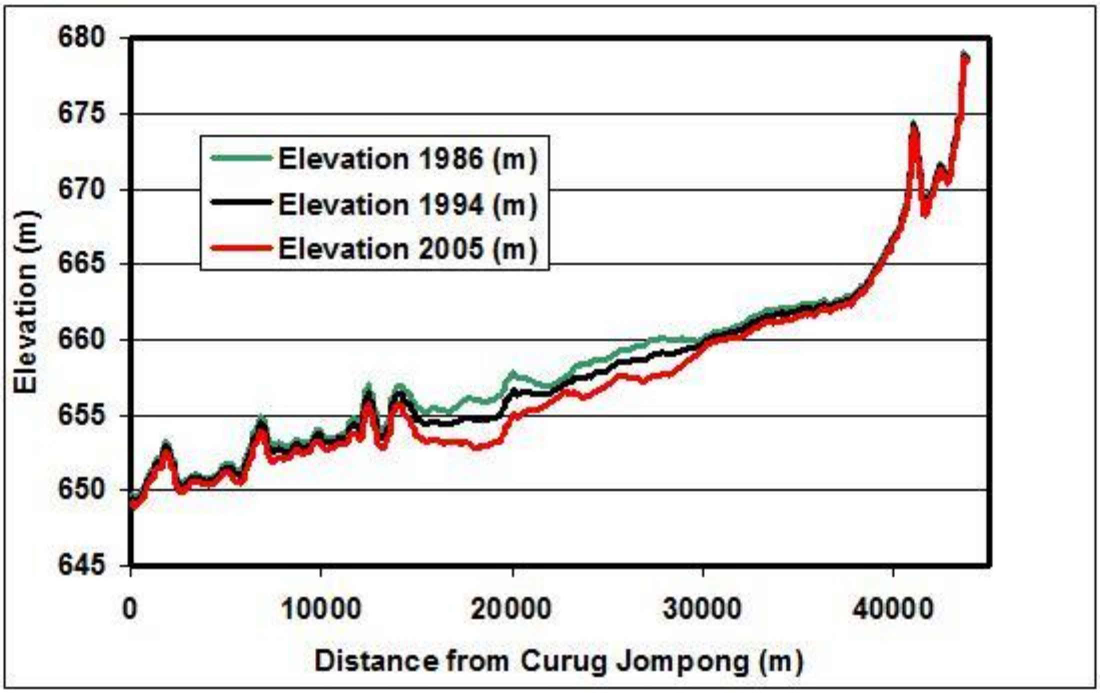


Figure 2.8: Longitudinal views of Citarum River (from ADB project, Vol. I, figure 3.48)

The present project has collected more recent subsidence and elevation information. However, from the information of previous studies it is already clear that subsidence is not only occurring in the Dayeuhkolot area, but also at other locations in the Upper Citarum basin.

As can be explained by the ‘lake’ history of the Bandung plain, there is a close correlation of subsidence with groundwater use. Previous studies have shown a clear correlation of location of subsidence areas with areas of high groundwater use by (often textile) industries in Cimahi, Dayeuhkolot and along the provincial road near Rancaekek. The drawdown of the groundwater level table is at some locations more than 60m. This causes severe compaction of the easily compactable former lake sediments. Natural compaction also adds to the subsidence, but to a far smaller scale. As the groundwater abstraction is not equally distributed over the basin, the subsidence is not equally distributed over the basin and exhibits cone depressions. These cones have a serious impact on the hydraulics of the river system as it causes depressions in the longitudinal profiles of the river (figure 2.8) leading to flooding problems at the subsidence areas.

Sedimentation

The ADB project states (based on the 6Ci’s project component B2) that the sediment generation in the Upper Citarum catchment has strongly increased over the last decades. Sediment generation in the catchment was estimated 26 million ton/year in 1982, and the 2008 estimate was 62 million ton/year. The main reason behind this increase is the strong increase of erosion in the upstream catchments due to continued agricultural expansion and intensification, further deforestation and urbanization.

Furthermore the Sediment Delivery Ratio (SDR) has increased. The ADB project estimated that the sediment load in the river stretch Nanjung-Sapan has increased from 2.6 million ton/year to about 10 million ton/year in 2010. This obviously has strong consequences for sedimentation in the river system. In natural conditions, most of the sediments are deposited in the flood plain during large annual floods, and a lot of sediment is transported via shallow rivers downstream. With the introduction of the flood control measures, large scale floodplain flooding has been reduced considerably since water is contained in the river channel. With the water also the sediments are contained and concentrated in the river system, which leads to larger sedimentation rates in the river system itself (sediments that would normally be deposited in the flood plain now appear in the river system, resulting in a higher SDR).

Because of the normalization measures of JICA stage I and II the flow rates have been increased and therefore sediment transport capacity increased, but the present siltation indicates that this increased sediment transport capacity is outweighed by the increased sediment load (higher sediment generation on the catchment surfaces and a higher SDR).

The ADB project estimated from the channel reconstructions and observed siltation that about 5 million/ton of sediment has been deposited in the river stretch Nanjung-Sapan over the period 1999-2009, equivalent with an average of 0.5 Million ton/year. This means that this stretch of the river traps on average about 5 % of the sediment load in the river channel.

Finally, depressions in the river system (e.g. due to subsidence) slow down the flow rate and at these places sedimentation rates increase. The river system around Dayeuhkolot clearly shows the effects of subsidence on hydraulics and sedimentation (re-enforced by a natural subsurface soft rock ridge just downstream Dayeuhkolot). The ADB project estimated that over the years 1999-2009 (after rehabilitation in 1999) about 3-4 meters of sediments returned in the Dayeuhkolot river stretch.

The impact of several years lack of maintenance dredging is illustrated in figure 2.9, which show the state of the river at Dayeuhkolot in 2009 (no maintenance) and in 1999 (after rehabilitation).

Figure 2.9: Citarum at Dayeuhkolot, in 2009 (left) and 1999 (right) (ADB UCBFM, Vol I, figure 3.46-3.47)

After the recent river dredging works in 2012-2013 no maintenance dredging has been performed. This means the river bed in the Dayeuhkolot area is most likely already much higher than the after-dredging cross-sections suggest, due to sedimentation after 2013. This is confirmed by a comparison of cross-sections measured near Dayeuhkolot in June 2016 with the after-dredging 2013 cross-section. Figure 2.10 shows sedimentation of about 2 meters in 3 years has occurred. Even the subsidence of embankments seems to be visible in the shown cross-sections. This figure shows a typical example which is reflected at all cross-sections measured in the main Citarum river near Dayeuhkolot. It is clear that such sedimentation has immediate consequences for the frequency, extent and depths of flooding.

Figure 2.10: Cross-sections from 2013 and 2016 near Dayeuhkolot, downstream Cisangkuy confluence (dark blue = 2016 cross-section, green and orange are the upstream and downstream 2013 cross-sections)

Embankments

As part of the JICA stage I and II works, along some parts of the river a flood wall or a dike is constructed. An example is the wall near Cieunteung area on the southern river bank just after the confluence of Citarum and Cikapundung River where a local drain is flowing into the Citarum River (figure 2.11). However, not all areas are protected by a wall. As already visible in figure 2.11, the area on the right side of the drain is not protected from flooding by the Citarum since there is no flood wall or dike there. This means that during high water levels of the Citarum River, the river will overflow the bank at these locations and flood the low-lying area behind the river bank, since in the Dayeuhkolot area the land elevation for large areas is below the Citarum high water levels due to some low embankments along the river and the subsidence.

The pictures below show that the floodwall ends near a bridge which is some 10 meter downstream of a gate in the local drain (figure 2.12 and 2.13). The top level of the gate and the land level behind are much lower than the level of floodwall. During the March 2016 floods this resulted in inundations in the Cieunteung area, not because the flood wall was overtopped, but because the Citarum water just entered the area near the gate (overtopping of the gate and river bank at the end of the floodwall, and/or no timely closure of the gate).

Protection by a dike or flood wall can prevent the Citarum to overtop the river bank and protect low lying areas.

Figure 2.11: Flood wall along Citarum river near Cieunteung (March 2016)

Figure 2.12: End of flood wall near Cieunteung with the gate top level about 1 m lower (March 2016)

Figure 2.13: Gate in drain at Cieunteung (March 2016)

Local drainage

The pictures shown in figure 2.11 to figure 2.13 also make clear that a high water level in Citarum river is obstructing drainage from the hinterland area. The photos were taken on March 12, 2016. At that time, the water level of Citarum level was lower than the days before and not overtopping anymore, but the gate could still not be opened since the Citarum water levels were still higher than the water level in the drain.

For several low lying areas like Cieunteung, a polder system solution with some retention and pumps is required to be able to discharge excess water from local rainfall and small drains to the Citarum river. The gravity discharge to the Citarum river can be blocked for several days when the Citarum water level is high.

The conclusion is that the construction of a flood wall is not enough for the subsidence areas with typical elevations below the high water level of the river. For the areas where the drainage of local rainfall to the Citarum River is blocked for longer periods, additional measures like local retention area and pumps are needed to reduce flooding.

For the subsidence areas, the flood wall or dike prevents flooding from the main Citarum river (fluvial flooding), while the issue of local flooding due to heavy rainfall (pluvial flooding) can be reduced by having local retention areas and/or pumps.