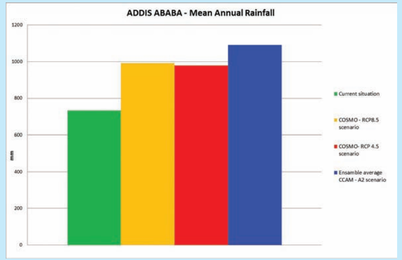
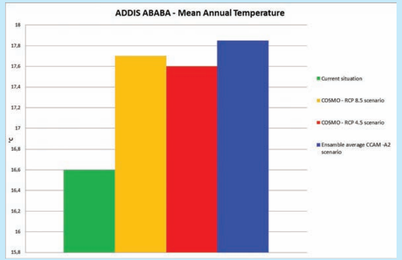
ADDIS ABABA
Ethiopia

CLIMATE CHARACTERISTICS

Addis Ababa has a pronounced rainfall peak during the boreal summer (July to August) and exhibits a rainfall minimum during the boreal winter (December to February). The city has a temperate climate due to its high-altitude location in the subtropics. Average monthly temperatures vary between 10 and 20 °C, and are the lowest during summer, due to the prevailing cloud cover experienced during this season.
The results of climate simulations for the period 2010-2050 suggest that:
– mean annual rainfall could increase by 35% - 50% with respect to the current situation;
– an increase of at least 1.5 °C in mean annual temperature is expected.

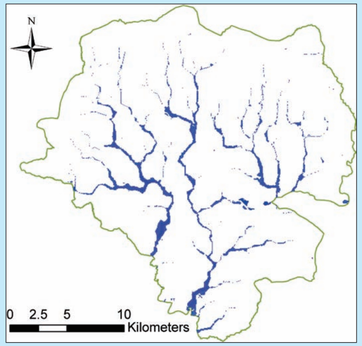




CLIMATE RELATED HAZARDS

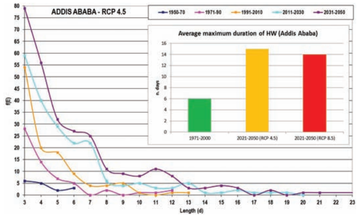
Floods
The analysis of Extreme Rainfall Events, based on climate projections data until 2050, suggests that the intensity of Extreme Rainfall Events is expected to decrease, although an increase of the frequency of Extreme Rainfall Events is envisioned.
However, assuming a business as usual scenario of population growth, runoff of rainwaters is expected to increase due to the decrease of the permeability of the urban environment.

Drought
The analysis of the monthly average rainfall clearly shows that the current condition is extremely dry. Analysis based on climate projections reveals that this condition is expected to continue in the next 40 years with an increase of the duration of dry periods.



Map of Topographic Wetness Index for Addis Ababa (areas more susceptible to flooding phenomena based on a geomorphological criterion).

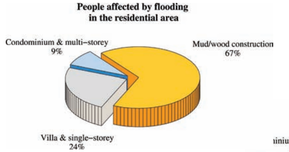
Heat waves
Analysis of climate projections for Addis Ababa reveals a strict correlation between heat wave duration and hot days number. The length of heat wave episodes shows a mean value increasing from 6 to 14 (RCP8.5)-15(RCP4.5) days. The frequency distribution plot of hot days duration for four separate bi-decadal periods (see figure) shows the temporal change of heat wave characteristics. This distribution has become longer tailed with time. For example the number of events with maximum length lasting 5 days could increase from 2 to 32 (40 for RCP8.5) over 100 years (from 1950-70 to 2030-2050).
The expected persistence of long-lived heat waves lasting approximately 1.5-2 weeks is clearly longer with respect to the climatological period (1961-1990). During 100 years, short lived but more intense waves are more than doubled in duration. It is evident the needs for the national health services to develop strategies for the mitigation of the heat wave effects, to enhance the resilience of the population, particularly the elder people.

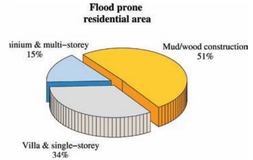


Average maximum duration of Heat Wave phenomena and frequency distribution plot of hot days duration for four separate bi-decadal periods.

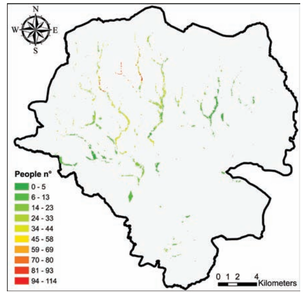
URBAN CHARACTERIZATION AND GREEN STRUCTURE MAPPING

The 67% of the population in the flood prone residential area lives in mud and wood constructions that are particularly vulnerable to flood action.
The "mud and wood" residential type constitutes around 51% of the flood prone residential buildings.

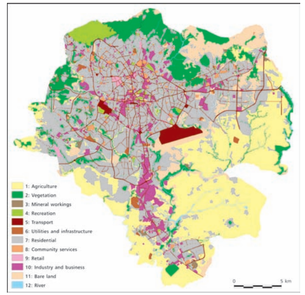




Losses of green structures in the urban core and peri-urban areas in Addis Ababa are evident, in particular a dramatic reduction in agricultural land is estimated.
A business as usual scenario (i.e. continued low density development including flood prone areas) modelled to 2025 suggests that the spatial extent of the urban zone could increase by around half again from 2011 and around a third of the city's agricultural land and almost a quarter of its other vegetated areas would be lost.
It would be also expected that a further 31% of the riverine corridor of 2011 would be lost, thus exacerbating problems of flooding, e.g. through the introduction of impervious cover and as a result of the increased exposure of the population within flood prone areas.
Both climate change and urban development are expected to change surface temperatures. However, land surface cover differences are associated with land surface temperature ranges of more than 25°C, whereas the range for climate change projections is less than 1.5°C.



The urban residential hot spots for flooding in Addis Ababa.



Urban Morphology Types in Addis Ababa.

FINDINGS ON SOCIAL VULNERABILITY ASSESSMENT

Findings on social vulnerability for the communities of Peacock Park, Mekanisa and Akaki have been grouped according to four main vulnerability dimensions:

Asset vulnerability	
Peacock Park	Source of income/employment: families working the urban agriculture Dominant ethnic group: "Gurage" Main health issues: hygiene concerns, as the river is used as a garbage disposal.
Mekanisa	Source of income/employment: production of vegetables. Field workers, day laborers and small business workers. Dominating ethnic group: "Gurage", known for their entrepreneurship. Main health issues: pollution.
Akaki	Source of income/employment: Presence of industries, production of vegetables and decoration grass. The location is habited by a farming community, Metal factory and residential houses. Dominating ethnic group: no visible dominance of a single ethnic group Main health issues: Asthma, Physiological problems related to the flooding incidents, some cases of malaria and pollution related problems.
Physical vulnerability	
Peacock Park	The density of community is slightly growing because the first family's children start their own families and move in the compound of their Parents. However due to the government's plan for Central park, there are no new constructions and settlers are even afraid of being relocated.
Mekanisa	The density of community is constant. The area has good accesses to social infrastructure. However there is deficiency of physical infrastructures such as proper access road and private tap water. The green infrastructure of the area is very good as households plant trees to shade the agricultural products and demarcate the ownership of their plots.
Akaki	This area has very poor physical infrastructure as well as social infrastructure; lack of access roads, water supply, and social services. However the green infrastructure is good as planting is used as a coping mechanism.
Institutional vulnerability	
Peacock Park	Farming community organized as a Community Based Organization (CBO) attempting to control and response to disasters. Local community based organizations like Eder and Ikub as well as the Firefighting and disaster management agency of Addis Ababa would respond to any disasters.
Mekanisa	Local community based organizations that assist families and individuals in bad time in terms of labor and finance (Eder and Ikub)
Akaki	Community members organized in different types of social groups which respond in time of disaster. However Industries like Ethiopian still and Iron factory relay on insurances for time of disaster.
Attitudinal vulnerability	
Peacock Park	Local and national organizations respond to disasters (traditional CBOs) assisting financially morally and in labor, the local government with equipment donation (blanket, cooking pots tent etc.)
Mekanisa	Area well integrated with the city with houses and establishments (urban agriculture) not older than 10 years. The climate related risk in the area is flood. In addition to the government and local CBOs, the community cooperates in helping those with problem through the ethnic tie.
Akaki	The farming area is away from the residential houses which makes it difficult to organize help from the local community. In time of disaster only the police, sub city and members of the community respond. However the residential houses are supported by other members of the community, local CBOs, and the sub city. On the other hand factories are insured and use planned preventing methods.

SPECIFIC RECOMMENDATIONS

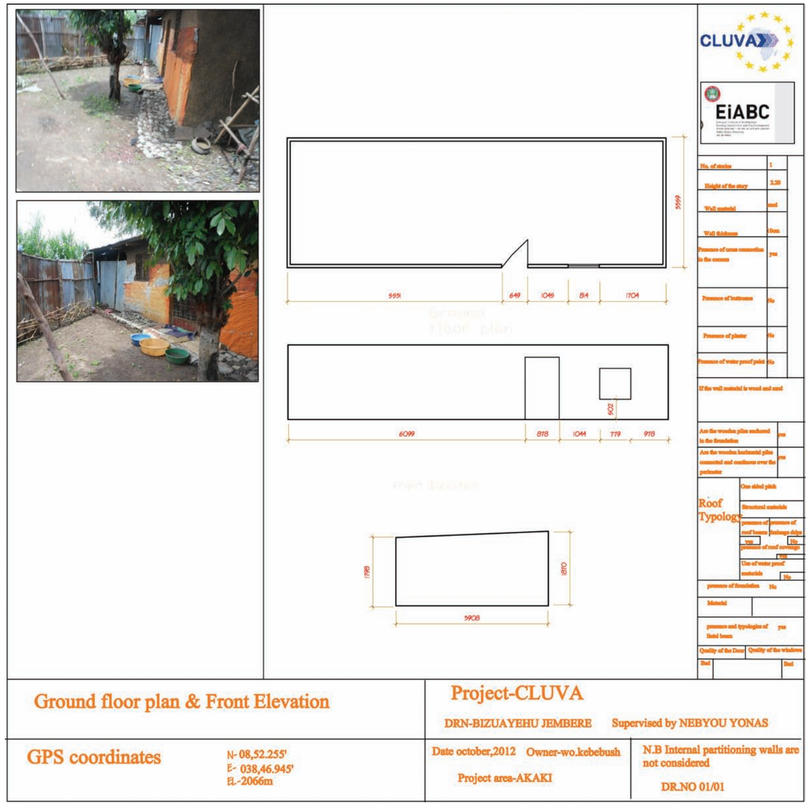
Recommendation to decrease structural vulnerability: Addis Ababa (08° 52.255' N 38° 46.945' E)

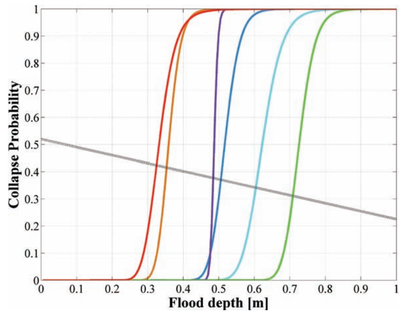
Structural Material: Mud & Wood; Self weight (γ): 6 to 8 KN/m3; Elastic modulus (E): 12 to 15 GPa; Compression strength (f_c): 10 to 20 MPa; Shear strength (f_v): 5 to 10 MPa; Flexural strength (f): 2 to 3 MPa;
Loading: Hydrodynamic, hydrostatic and debris impact;
Restraint: The wall panel is considered hinged at the base and hinged in the sides;
As-is (default) configuration: Vulnerability of the structure to collapse is represented by the fragility curve (probability of collapse vs. flood height). The fragility curve for the *as-is* configuration is plotted as case 0 (orange). The annual risk of collapse (fragility integrated with hazard) is shown as a percentage next to the legend.
Effective mitigation strategies: The following low-cost mitigation strategies lead to an improvement (although non-sufficient) in the structural performance:

1. Water-proofing the walls (protect the mud from contact with water, case 4, purple, annual risk of collapse= 31%)
2. Making sure that the wooden poles are sufficiently anchored in the foundation (case 2, blue, annual risk of collapse = 30.7%)
3. Adding an internal wall* (case 3, cyan, annual risk of collapse = 28.5%)
4. Adding a platform of 40cm (case 4, green, annual risk of collapse = 26.3%)

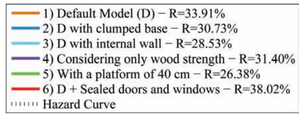
* The position of the internal wall can affect the results significantly. Therefore, its presence may sometimes lead to unfavorable results.

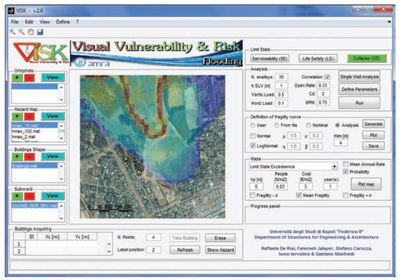
The as is building is assumed not to have sufficiently water-tight doors and windows. Moreover, it is assumed that the mud is washed out by the flow and the wood strength is degraded due to direct contact with water. If the windows and doors are sealed (case 6, red), the overall risk of collapse is going to increase (from 33.91% to 38.02%, due to the fact that also hydrostatical forces are going to be exerted).





The fragility curve can be read as: *the building is going to collapse with 50% probability due to a flood height of around 0.35m and it is going to collapse with 100% probability* due to a flood height of around 0.45m.*
Risk can be interpreted as: *There is around 34% probability that the building is going to collapse in a one year time frame.*
* The 100% probability is based on the working assumptions made.





Specific recommendations for Addis Ababa

- Mainstream climate change adaptation, water management, reducing vulnerability etc. into main city plans like the structure plan, sector plans etc.
- Identify and include important stakeholders across sectors and levels in a continuous process towards a broad adaptation effort.
- Develop an 'integrated water management' plan for Addis Ababa that addresses flooding, drought and pollution by watershed protection, designation and management of a buffer zone and also include the coordination of 'integrated local projects' that address local waste management, drainage solutions and social issues.
- Adopt urban development strategies aiming at avoiding a large increasing of surface impermeability, and consequently of floods' intensity, caused by large settlement expansion at the expense of mainly agricultural land and other vegetated areas. This can be obtained by increasing current settlements'density in a well-balanced manner in order not to have negative impacts on living conditions.

GENERAL PRESENTATION

Addis Ababa is the capital and by far the largest city of Ethiopia with 2,740,000 inhabitants based on the 2007 Census conducted by the Central Statistical Agency of Ethiopia (CSA), approximately 4 million based on the estimation of the UN-HABITAT Urban Profile (2008).
Despite a low population growth rate of 2.1%, Addis Ababa is expected to reach between 6-7 million by 2015. The capital covers an area of about 540 km² from which 290 km² is covered. The city is a self-governing chartered city with its own city council. It is divided into 10 Sub-Cities. Among them, KolfeKeranio located west of the city features the highest number of habitants in contrast to AkakiKaliti in the South with the lowest population.
Despite a diversified city economy, a low level of income persists and progress is uneven across different social groups. This leads in turn to restricted access to health and education.
69% of all employment in Addis Ababa is informal and 69% of households in Addis Ababa are located in slum areas.

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