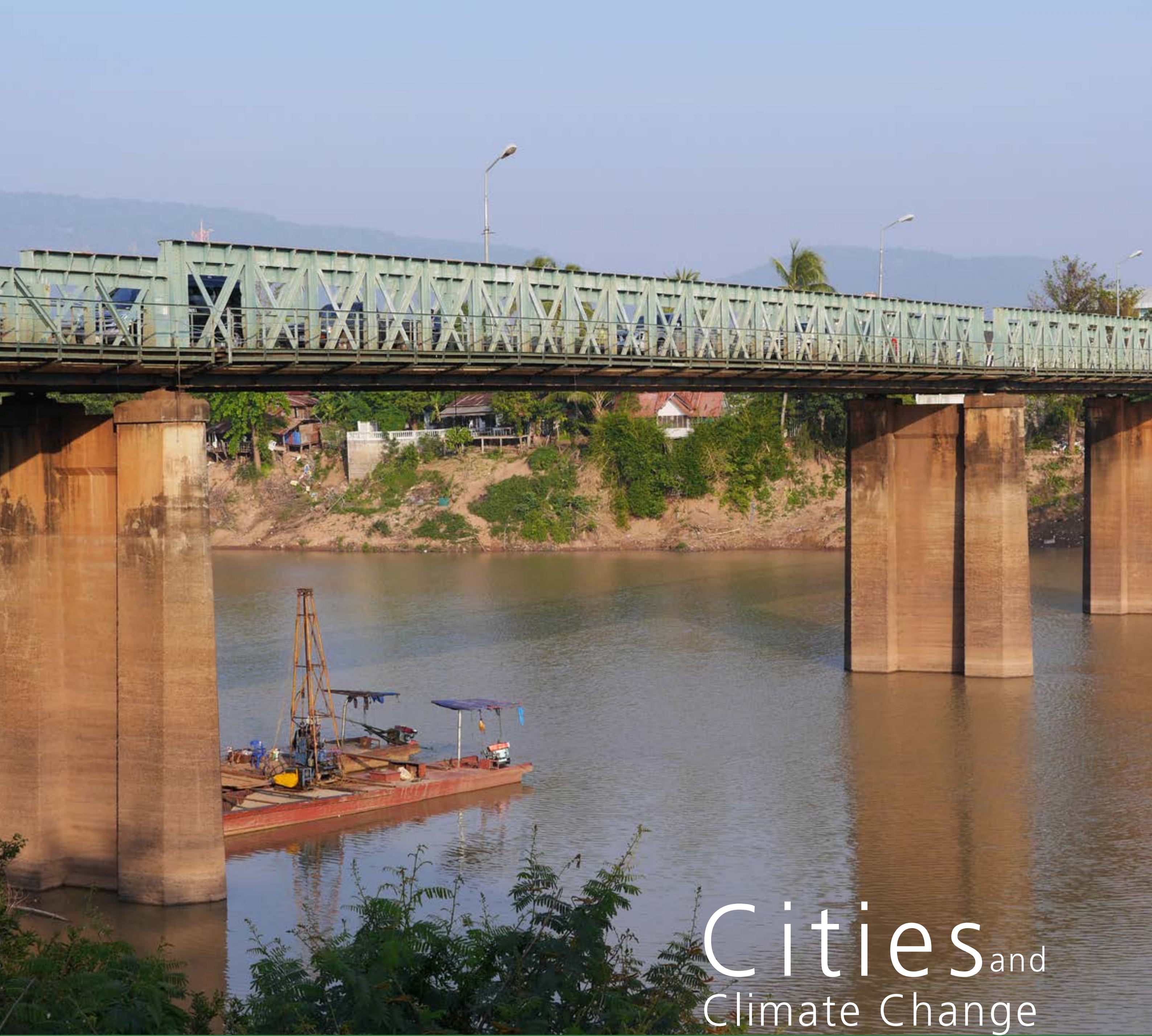

Cities and Climate Change Initiative

ABRIDGED REPORT

Pakse
Lao People's Democratic Republic

Climate Change Vulnerability Assessment

UN-HABITAT
FOR A BETTER URBAN FUTURE

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Climate Change Vulnerability Assessment

UN HABITAT

Pakse, Lao People's Democratic Republic - Climate Change Vulnerability Assessment

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01

Introduction

1.1 Cities and Climate Change

Urban areas around the world continue to grow in population and in 2008 the landmark figure of more than 50 per cent of the world population living in urban areas was passed.[1] At the same time the rate of global climate change has been very rapid indeed. Rapid urbanisation offers the benefits of larger economies, increased human resources, and potentially more development opportunities, however, unplanned rapid growth can also strain public services and infrastructure, invite casualisation of labour and unsafe informal sector employment, causes pollution and overwhelm ecosystems, and leads to traffic congestion. As a result of climate change, we expect that storm frequency and intensity will increase, flooding will become more serious and droughts will affect food production in rural areas, which has damaging knock-on effects in urban areas. Coastal areas are threatened by inundation from sea-level rise, and other urban challenges.

Climate change is already affecting millions of people worldwide. In urban areas, which are typically characterised by significantly higher population density, climate change will exacerbate and compound existing vulnerabilities, especially for the urban poor.

1.2 UN-Habitat's Cities and Climate Change Initiative

In this context of rapidly growing cities in the developing world, and accelerating global warming, the United Nations Human Settlements Programme (UN-Habitat) established the Cities and Climate Change Initiative (CCCI). The CCCI was developed to promote the mitigation of, and adaptation to, climate change in developing countries. The Initiative supports the development of pro-poor innovative approaches to climate change policies and strategies. It builds on UN-Habitat's rich experience of sustainable urban development (through the Environmental Planning and Management approach of the Sustainable Cities and Agenda 21 Programmes) as well as on internationally recognised capacity building tools.

The UN-Habitat Asia-Pacific Strategy 2011-2015 has identified three key objectives for the CCCI in the Asia-Pacific region:

1. To build the capacities of at least 50 cities in at least 15 countries to prepare and implement comprehensive climate change strategies and action plans.
2. To integrate good climate responsive urban development practices into national policies, strategies and legislative reforms.
3. To establish a CCCI regional partners' advocacy, knowledge management, capacity building and networking platform.

Pakse is the first city in Lao PDR where CCCI is active.

[1] World Health Organization, World Health Observatory, http://www.who.int/gho/urban_health/situation_trends/urban_population_growth_text/en/ , (accessed 15 Dec. 2013).

02

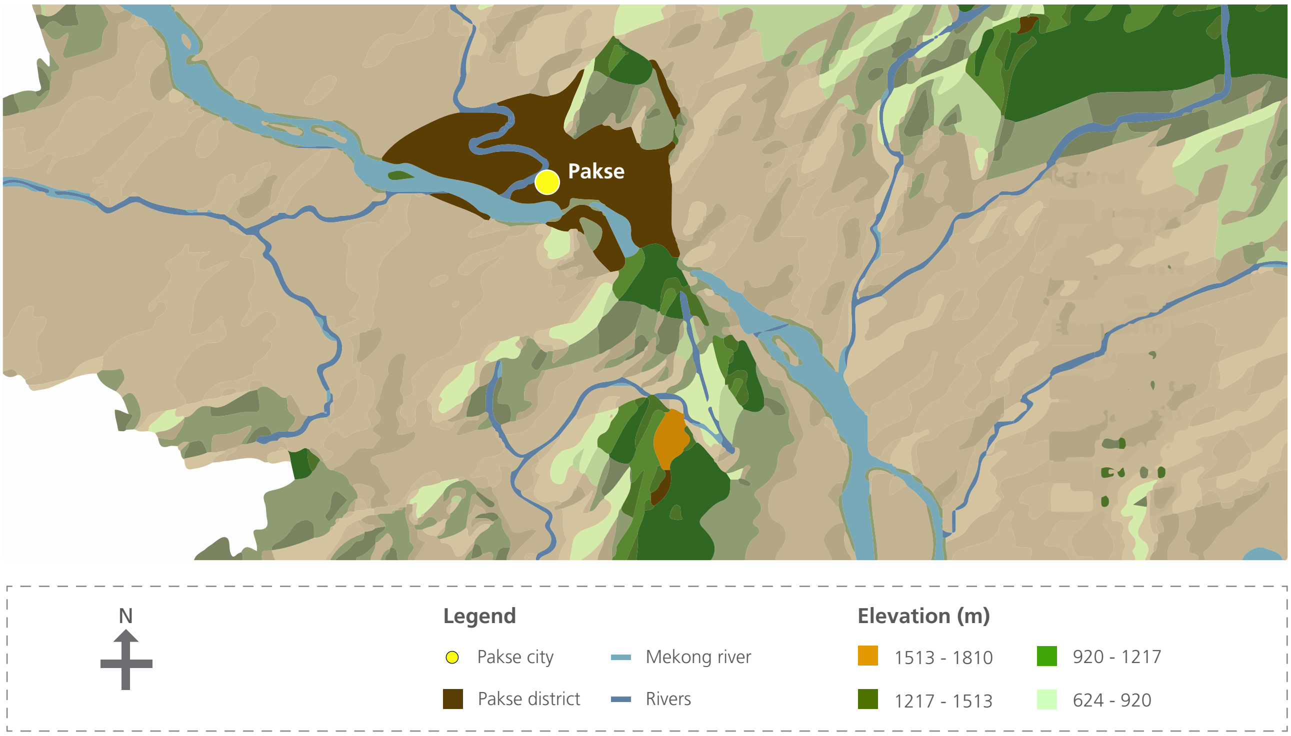
Overview of the City

2.1 Pakse: Overview

Pakse is located at 15 11 N, 105 78 E and has a tropical climate affected by the southeast monsoon winds. The rainy season in Pakse lasts from May to September, and the dry season lasts from October to April. Approximately 85 per cent of the total annual rainfall is observed during the rainy season, with only 15 per cent of the annual rainfall observed during the dry season. The hottest time of year in Pakse is the month of April with an average temperature of approximately 30°C. The coldest time of year is in December when it is on average approximately 24°C. However, minimum temperatures are observed in January at around 18°C.

The city of Pakse is located on a plain area approximately 102 metres above Mean Sea Level (MSL) and surrounded by high peaks adjacent to a large mountain. The map in figure 1 below illustrates the surrounding geography near Pakse, including the main Mekong River and other tributaries. This report will focus primarily on issues of flooding and the interactions between the hydrology of the two rivers and the town itself. The Mekong is over one kilometre wide as it passes through Pakse, flowing broadly from north-west to south. There is very little development on the west bank of the Mekong and the land is predominantly used for agricultural purposes.

Figure 1: Geographical map of Pakse and surrounding area.



Source: UN-Habitat

The Champasak Provincial Department of Public Works states that the flood danger level is around 12 metres and that at its peak the river is flowing at 28,000 cubic metre per second (CUMECS).

2.2 Economy

The province of Champasak had a gross domestic product (GDP) growth rate of 10.6 per cent in 2012 and has been growing on average by 9.8 per cent per year since 2006.[2] The provincial economy is dominated by the agriculture, services, and tourism sectors. Figure 2. shows annual GDP growth rates in Champasak province from 2006–2012.

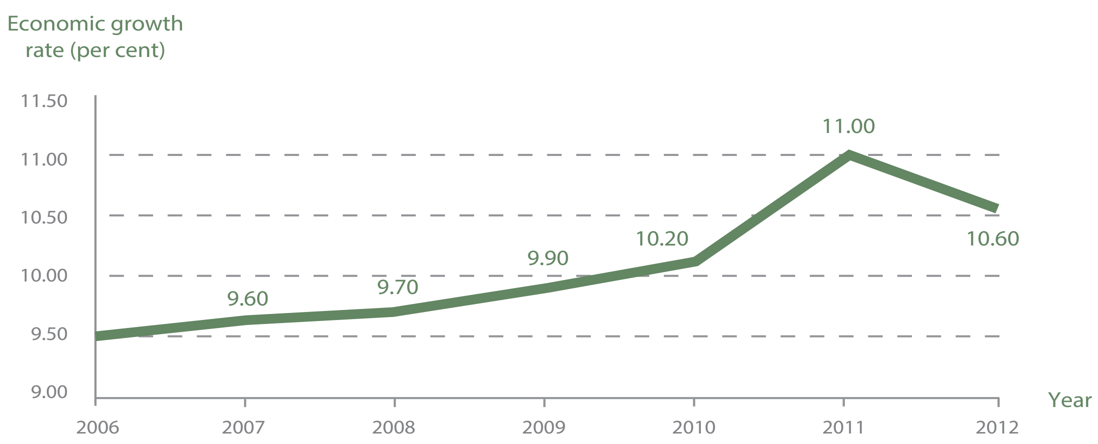
The average income per capita in the province rose from USD 1,034 from 2010–2011 to USD 1,428 from 2011–2012 and reflects both the economic dynamism of Champasak Province and the improvement of the socio-economic living conditions of the population. With a poverty rate of 2.36 per cent, a total of 2,584 poor families (2012), Champasak Province continues to work to reduce poverty and to improve people's livelihoods in the rural areas.[3] Table 1 below displays key economic indicators for Champasak Province.

The economy is largely driven by the industrial and services sectors, which combined accounted for 60 per cent of total economic output in 2010. Pakse city in particular has a diversified economy built around the coffee industry, trade and tourism. Though the main coffee production area is due east of Pakse, in Paksong, the most important processing investments and processing facilities are on the eastern fringes of Pakse. The United States Department of Agriculture estimated that Lao People's Democratic Republic would produce 575,000 60kg bags of coffee in 2013.[4] Development of the tourism industry has stimulated local investment in facilities and has generated local employment. Since 2005, tourist numbers in the province have grown by an average of 20 per cent per year.[5]

2.3 Gender

Gender equality is one of the top development issues in the Lao People's Democratic Republic. The Gender-related Development Index (GDI) rank for Lao People's Democratic Republic was 125 of 174 countries. The rank difference between the Human Development Index (HDI) and GDI is +11. This means that substantial gender disparities still prevail at the national level. In terms of national government representation, women currently hold 11.6 per cent of the posts.

Figure 2: GDP growth rates for Champasak Province, 2006–2012.



Source: Compiled by UN-Habitat from various sources indicated in the references

[2] Department of Planning and Investment, Investment Opportunities in Champasak Province, Champasak 2012.

[3] Investment opportunities in Laos, 2013, http://provincedechampassak.free.fr/champasakprovincedechampassak/pdf/pdfeng/investmentbrochureinchampasakprovince.pdf accessed (15 Dec. 2013).

[4] USDA, Green coffee robusta production by year, (http://www.indexmundi.com/agriculture/?country=la&commodity=green-coffee&graph=robusta-production) (accessed 15 Dec. 2013)

[5] Committee for Planning and Development, Sixth National Socio-Economic Development Plan (2006-2010), Lao People's Democratic Republic

Table 1: Economic indicators of Champasak province.

Description	Data year 2012
Annual GDP growth	10.6 %
GDP	USD 989.4 m
Export volume	USD 97.1 m
Import volume	USD 136.57 m
Average income per capita/year	USD 1 428
Inflation rate	3.8 %
Economic sectors	35 % Agriculture 31 % Industry 34 % Services

Source: UN-Habitat

2.4 Governance

The Urban Development Agency (UDA) is the executive agency of the Provincial Government of Pakse, responsible for developing and implementing plans and managing the city, including organising solid waste management, environmental management and flood protections. The national government has the task of building the infrastructure necessary to cope with the growing urban populations across Lao People's Democratic Republic.

Floods in Pakse
Photo @ UN-Habitat

Floods in Pakse
Photo @ UN-Habitat

Floods in Pakse
Photo @ UN-Habitat

03

City-Wide Vulnerability - Scoping Exposure, Sensitivity and Adaptive Capacity

3.1 Assessment Framework

The climate change vulnerability of Pakse can be analysed by three main pillars: exposure, sensitivity and adaptive capacity to change. The following Figure 3 illustrates the relationships and interactions between the pillars.

Figure 3: Pakse vulnerability assessment framework.

Source: UN-Habitat

3.2 Climate Change Exposure

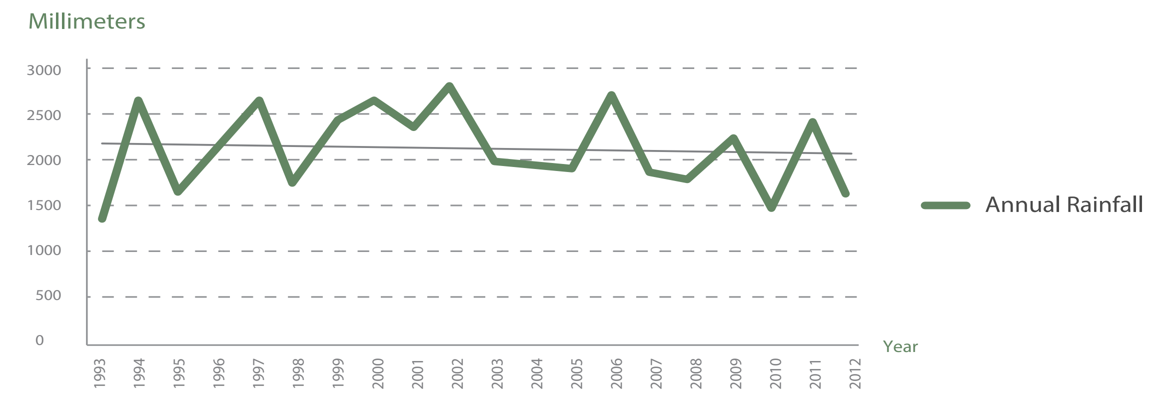
Exposure is defined as what is at risk from climate change (e.g. population, resources, property) and the change in the climate itself (e.g. sea level rise, temperature, precipitation, extreme events, etc.). A key theme in Pakse is that climate change is intensifying the seasonal changes and weather conditions. We can see this with the dry seasons getting drier, the wet seasons getting wetter and the rainy days are becoming more intense, and April (the hottest month) is estimated to get even hotter.

3.2.1 Rainfall Trends

There has been little observed change in rainfall recorded throughout the last twenty years. The mean annual rainfall of 2,127 millimetres has a fairly high standard deviation of 433 millimetres (20.35 per cent) which indicates that rainfall varies fairly significantly around the annual average[6]. The highest annual rainfall recorded over the twenty-year period was 2,793.9 millimetres in 2002, while the lowest was 1,371.9 millimetres in 1993, see Figure 4 that illustrates that overall there has been a slight downward trend in the rainfall.

[6] Only 60 per cent of years fell within one standard deviation of the mean. If 68 per cent is the expected value for a normal distribution, we can surmise that the annual average rainfall is too 'random' to be normally distributed. In layman's terms– Pakse's rainfall is inconsistent.

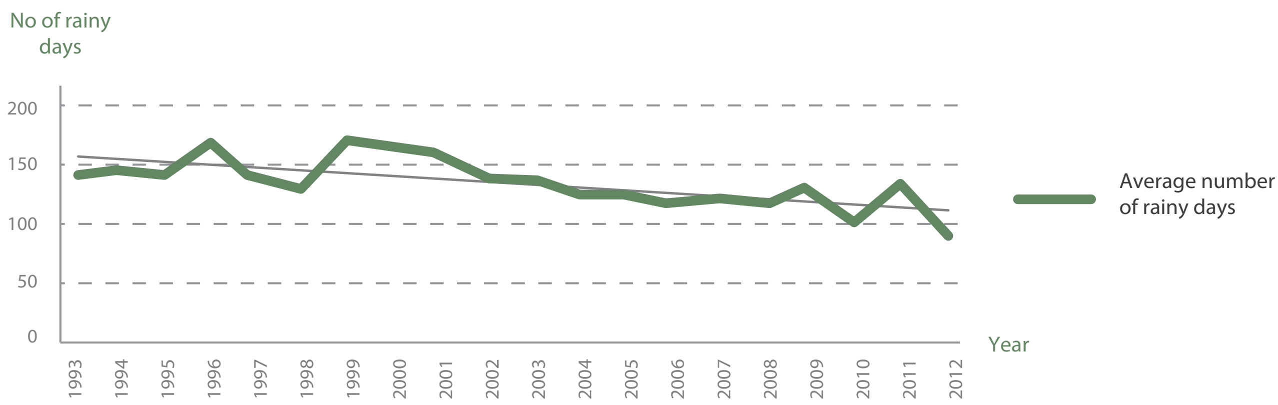
Figure 4: Annual rainfall in Pakse.



Source: UN-Habitat

However, this downward trend represents a less than ten per cent decline in rainfall, over a twenty year period. Over a twenty year period this is not statistically significant. Data on the number of rainy days over the same period can be seen in Figure 5.

Figure 5: Number of rainy days per year in Pakse.



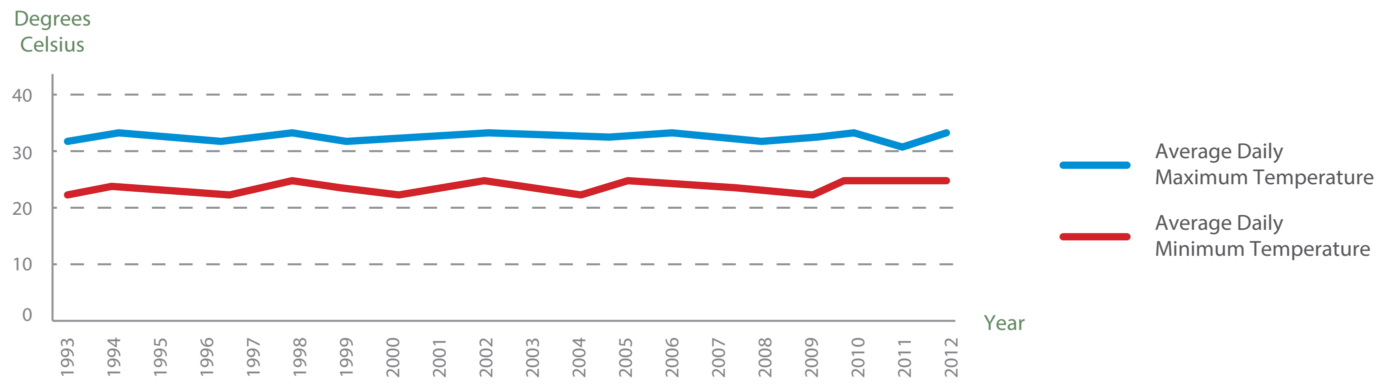
Source: UN-Habitat

It shows the number of rainy days per year has declined over a twenty-year period: from an average of 160 days in 1993 to around 115 presently. Indeed, 2012 was the only year in the dataset which recorded less than 100 rainy days. The mean average number of rainy days over the period was 135.4 per year, with a standard deviation of 14 per cent from the mean. The pronounced downward trend and lower standard deviation (than the standard deviation of overall annual rainfall) suggests that the number of rainy days experienced in Pakse is declining more quickly, significantly and consistently than overall rainfall. This, in turn, would suggest that rainfall is concentrated over fewer, heavier bursts in the city, which has potentially serious consequences on local flooding impacts. This will be further explored in the sensitivity section.

3.2.2 Temperature Trends

Temperatures recorded in Pakse were very consistent over recent years. The maximum annual mean temperature recorded was between 30.8°C and 33.1°C and the minimum annual mean temperature was between 22.6°C and 24.4°C. See Figure 6, this minimal variation in average temperatures, a standard deviation of 1.7 per cent in maximum temperatures and 2.1 per cent in minimum temperatures suggests very consistent temperatures over the twenty-year period.

Figure 6: Annual mean maximum and minimum temperatures in Pakse.



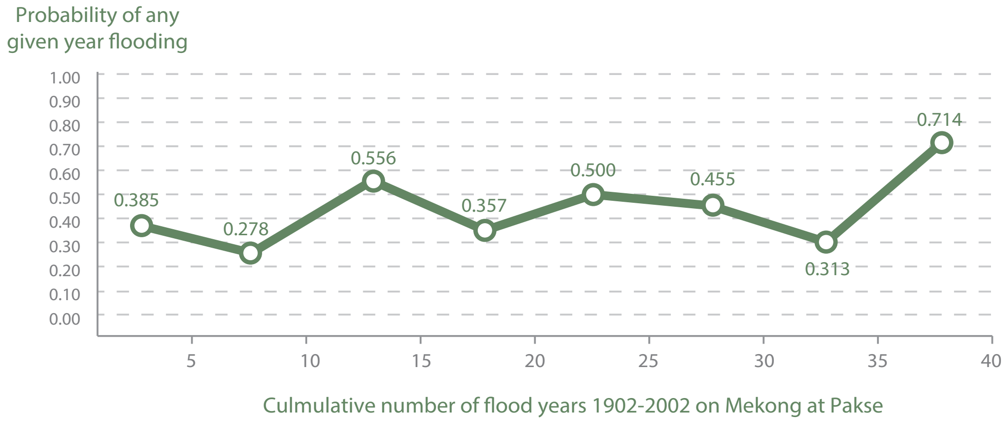
Source: UN-Habitat

The average duration of sunshine has also been relatively consistent over the twenty year period, showing no discernable upward or downward trend and a fairly insignificant deviation from the mean. The temperature data indicates that if there are climate change impacts in Pakse, they have not taken the form of changes in temperature or cloud presence.

3.2.3 Flooding

Between 1902 and 2002, the Mekong River at Pakse reached or surpassed the 12 metre flood danger level a total of 40 times. In any given year there was a 0.4 risk of flooding or 40 per cent, see Figure 7 below. It is important to note that flooding is an intrinsic part of river systems and an entirely natural process, with the nutrient rich sediments helpfully fertilising nearby fields.

Figure 7: Observed changes in flood levels in Pakse (1902 to 2002).



Source: UN-Habitat

The observed frequency of flooding has varied widely. There appears to be a range of values 0.278 to 0.556, until the last 5 flood years (0.714). This indicates that, based on observed river levels, the probability of flooding in any given year has increased in recent years, as floods occurred more frequently towards the end of the twentieth century than they did at the beginning.

Flooding is a significant problem for Pakse and dominates environmental discussions in the city. The Mekong River is one of the world's largest waterways with flows of ca. 30,000 CUMECS (reported near Pakse). In the dry season flows are still reported regularly at around 8,000 CUMECS. In comparison the Xe Don River's maximum flow is around 174 CUMECS at the peak of the rainy season.

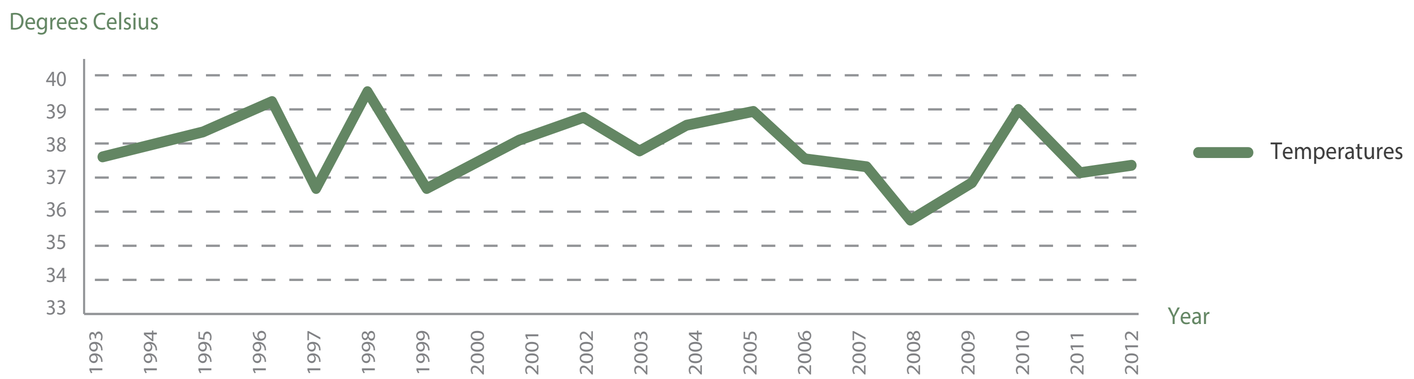
The hydrological interaction between the Mekong River and its tributaries remains fundamentally problematic and changeable. The hydraulic pressure exerted by the river is commonly seen to be in excess of the hydraulic pressure exerted by the tributaries flowing into it. Thus, this is commonly noted in terms of intrusive flow from the Mekong into the tributary in question in the rainy season. However, during the dry season the flow is led from the tributary to the Mekong as a natural flow. In Pakse, when the flow from the Xe Don River is at the lower level than the Mekong then the Mekong water will flow into the Xe Don River and effectively create a hydrological dam that impacts the whole Xe Don River basin.

The Xe Don—Mekong river interchange is only one part of the flooding issue in Pakse. The Mekong can, and does, burst its banks and flood the surrounding areas. There is a further challenge in that water trying to get to the river from nearby mountains can cause flash-floods. High capacity storm drains might help but will be of limited success if the volumes of water are very high. How to manage where this water goes is difficult, because if the mountain water is diverted into the Mekong above the city, it will have to deal with even higher Mekong River levels. If the water is instead diverted to below the city then it puts communities downriver of Pakse at greater flood risk.

3.2.4 Drought and Heat Stress

While the temperatures have been fairly consistent in Pakse, it is also worth considering changes in extreme temperatures. It is feasible that extremes of heat could occur more frequently as a result of climate change. In Lao People's Democratic Republic, it has been suggested that the number of 'hot' days – defined as where the maximum temperature recorded for that day is more than ten per cent above the average for that month – are predicted to significantly rise (under a moderate emissions scenario). In order to perform a localised analysis in Pakse, average temperatures trends for the three hottest months of the year – March, April and May were analysed, see Figure 8.

Figure 8: Trends in extreme temperatures for three month in Pakse (March, April and May).



Source: UN-Habitat

3.2.5 Rainfall and Temperature Projections for Pakse

In order to make projections about possible future climate changes impacts in Pakse, we have to predict what we expect to see in terms of emissions agreements and economic growth. The assessment team has chosen two emissions scenarios models for Pakse, namely B2AIM and P50.

The P50 scenario: A baseline scenario in which the government and policy makers do not implement any policy changes. For example, none of the international climate change talks are successful. However the P50 scenario does assume that more efficient technologies will be adopted which use less fuel and produce less greenhouse gas emissions.

The B2AIM scenario: The B2AIM scenario assumes that intergovernmental agreements on reducing greenhouse gases will emerge that slows the emissions growth rate by 2100 and that local policies will help mitigate GHG emissions.

Both the P50 and B2AIM scenarios are similar scientifically as they apply the same sensitivity, which is that with a doubling of the carbon dioxide (CO^2) level in the world, there will be a commensurate 3°C increase in temperature on a global scale. The two models both assume no stabilisation of global GHG emissions to 2100, as it is still unclear as to if, and at what level, stabilisation would occur. By 2100 it is forecast that non-CO2 greenhouse gases will have caused an extra 1°C of warming globally.

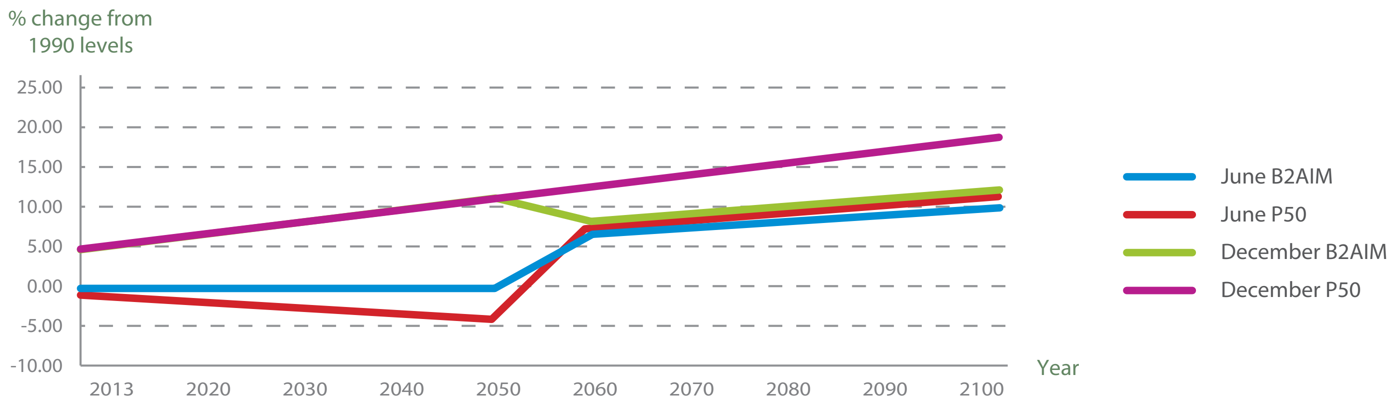
The key differences between the two scenarios is that the P50 scenario assumes that government policies that reduce GHG emission growth rates fail to emerge by 2100. The B2AIM scenario alternatively assumes that governments will adopt a number of policy interventions. By comparing the two scenarios it can be analysed much policy makes a difference to climate change at Pakse.

3.2.6 Forecast Precipitation Changes

Both models predict that by 2050 the dry season will be drier, the wet season wetter and the differences between the two seasons will be more marked. Also importantly, both models show increasing rainfall in October, November and December as the rainy season lengthens. The rice harvest in Lao People's Democratic Republic typically takes place during these three moths and the coffee harvest usually takes place from November to January.

Increases in rainfall have already been observed and the increase in rainfall in December appears to be very strong indeed, see Figure 9.

Figure 9: Estimated percentage of change in precipitation in Pakse from 2013 to 2100.



Source: UN-Habitat

3.2.7 Forecast Changes in Atmospheric Pressure

The atmospheric pressure over southern Laos is predicted to rise in the coming years and are generally associated with more clear sunny weather and less thunderstorms. The primary impact of the increase in atmospheric pressure will be more stable weather.

It is important to note that there is a prediction of increased atmospheric pressure just above Lao People's Democratic Republic of a magnitude greater than the increase with the atmospheric pressure over southern Yunnan province in China, forecast to increase by five Hectopascals (hPa). This is of concern because high pressure systems play a key role in determining the track of low-pressure systems such as typhoons. Therefore, it appears at this early stage that the impact of increased atmospheric pressure in southern China will potentially have a greater impact on the weather and climate of Pakse, than the increases in atmospheric pressure over Pakse itself.

3.3 Climate Change Sensitivity

Sensitivity is the degree to which a system is affected by the biophysical impact of climate change. In particular it takes into consideration the socio-economic context of the system being assessed.

3.3.1 Socio-economic Impacts

Pakse has a diversified economy built around the coffee industry, trade and tourism.

Flooding has been identified as the most pressing climate-related threat to Pakse and can impact numerous local trade-related economic activities. At the most basic level, flooding impacts local family-run restaurants, shops and grocery stores by destroying items for sale, impeding customer access and through the indirect cost of repairs. Over short-term flood events (3-5 days) the impact on trade is at best manageable. The local population has built-up certain resilience to the economic impacts of this type of flooding (excepting the costs of repairs). It is long-term flood events that have the worst effects, such as in 2011 when the floodwaters reportedly reached 2.2 metres in height and lasted three months. There is no evidence at this stage to suggest other climate-related changes beyond flooding will have an impact on local trade in Pakse.

The current thinking about tropical agriculture and climate change is that there will be a positive impact on yields and agricultural productivity within 2°C increase in temperature. The current forecast is that Pakse will see monthly temperatures rise on average by 0.68/0.69°C by 2020 and it is forecast that average monthly temperatures will increase by 1.37°C by 2050. Taken in isolation, it could therefore be considered that agriculture will be positively affected in the region within this time period.

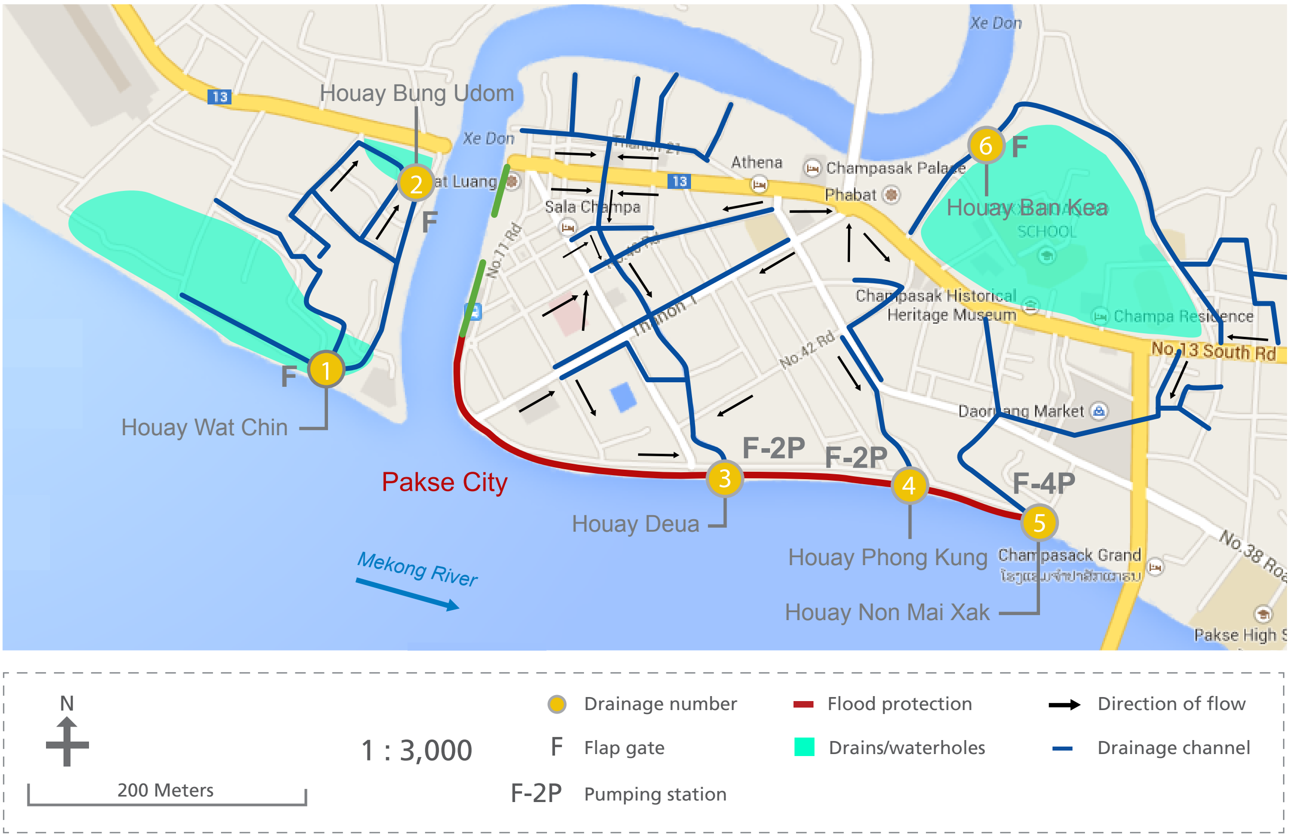
The main cash crop is coffee, which is grown on the nearby Bolovens Plateau where both Robusta and Arabica coffees are widely planted. The Bolovens Plateau covers an area of around 500 km2 with an elevation of 600m-1300m, and has characteristic red volcanic soils. For Arabica coffee to meet international quality standards, it needs to be grown above 1000m elevation, for the coffee cherries to ripen slowly. The slow ripening gives the coffee its distinctive taste.[7] Climate change poses significant challenges for the coffee sector. The low-elevation Arabica coffee widely planted in countries such as Viet Nam are likely to be much more affected by rising temperatures than the high elevation Lao Arabica because the low-elevation coffee will ripen too fast and be poor quality.

3.3.2 Infrastructure and Housing

Between 1998 and 2002 Pakse was part of the Secondary Towns Urban Development Project (STUDP), funded by an Asian Development Bank loan, which, inter alia, aimed to provide flood protection infrastructure, drainage and develop solid waste management capacity. The flood protection component of the project worked to build flood gates and embankments along the Mekong River, as well as a number of water drainage channels and culverts, and two catchment areas to act as overflows, during peak water levels.

[7] UN FAO, Arabica Coffee Manual for Lao PDR, 2005, http://www.fao.org/documents/en/detail/194344 (accessed 15 Dec. 2013)

Figure 10: Flood protection infrastructure map of Pakse.



Source: Google map redesigned

The red line is a man-made embankment which provides protection to the homes and businesses which are located behind it. The embankment is designed to prevent the water from flowing over the top. During the mega-flood in 2011 only ten centimetres of flood water were recorded in areas protected by the embankment, compared to up to two and a half metres in unprotected areas.

The green line on the map is an area of restored ecosystems that provide protection on the east bank of the Xe Don River. The embankments are supported by a network of six mechanical flood gates, which are activated automatically when there is sufficient water pushing against them. During consultations with the government it was expressed several times that there is currently no pumping station, or other method of manually shifting water between the rivers, flood gates, and catchment areas. This means that the flood gates are entirely dependent on the hydrology of the river and in-built mechanisms and do not have a back-up system.

Another issue is the lack of maintenance of the flood infrastructure, especially the catchment areas. Housing and other infrastructure, such as expanded roads have encroached on the catchment areas, reducing their capacity to cope with increasing amounts of run-off and rainfall. In addition, the lack of solid waste services means that, inevitably, waste ends up in the river. This means that the flow of water to and from the catchment areas is polluted and impeded and overall effectiveness reduced.

3.3.3 Solid Waste Management in Pakse

The Urban Development Authority (UDA) is responsible for planning and environmental management in Pakse, which includes solid waste management. Around 35 per cent of the households in Pakse have regular solid waste collection services, and the service is available to all or parts of 28 of the 42 villages that makeup Pakse. The price of the service is between 15,000 and 25,000 Kip per month, depending on how much is disposed of and is collected twice per week. The collected waste is then transported to a landfill site that is located 17 km north of the city at Ban Yong, Xanasomboun District. This landfill site, managed by the UDA in Pakse, covers an area of 12.5 hectares and is on higher ground than the city to minimise flood risks. The vehicles provided to compact the waste and manage the site properly are currently unserviceable, and according to local officials waste is overflowing the site.

As part of the proposed Asian Development Bank (ADB) Environmental Improvement Project, it is proposed to "rehabilitate the entire landfill site in Ban Yong, Xanasomboun District, 17 km north of the Pakse and upgrade the existing dump site to controlled landfill standards, meeting appropriate environmental standards."[8]

The landfill site will necessarily need to be expanded as solid waste increases.

3.3.4 Public Health

Infrastructure problems do impact public health, not least because stagnant water encourages mosquitoes to breed. Malaria appears to be under-control in Lao People's Democratic Republic, but Dengue Fever remains a very serious problem. Dengue Fever is a viral disease spread by mosquito vectors, and it is forecast that a number of vector-borne viral diseases will emerge in a similar way to Dengue Fever. It is important to note that almost all viruses found in the country are vector-borne viruses, which means they are spread by an intermediary such as mosquitoes.

Drastic weather changes affect epidemic diseases directly and indirectly. Changes in temperature and precipitation among others have facilitated disease emergence.[9] The seasonality of infectious diseases is more worrying in the summer in tropical areas when the main factors are optimum for a quick outbreak. For bacterial diseases, most of them grow preferentially above 15°C. The main group is Vibrios. They are responsible of a wide range of infections, from cholera to gastroenteritis-like symptons. The path of infection is quite varied. It can be spread from person to person or by small infectious organisms (vector-borne) such as mosquitos, as well as in water and soils. Direct contact between people is mainly due to crowded places which spread the agent quickly. Extreme changes in water levels or temperatures increase vector populations with timing and niche creations. Human exposure to waterborne infections increases by contact with polluted drinking water, floods or food.

According to the World Health Organization, floods can potentially increase the transmission of the following communicable diseases:

- Water borne diseases: typhoid fever, cholera, leptospirosis and hepatitis A.
- Vector borne diseases: malaria, dengue, dengue haemorrhagic fever, yellow fever and west nile fever.

It is estimated that about 50 per cent of waterborne outbreaks, globally occur as a consequence of heavy rainfall events. The risk of diarrhea is low unless there is a significant movement of people. The floods can cause river water pollution from the sewage treatment plant which can lead to gastroenteritis and cholera in the worst cases. Leptospirosis, a zoonotic bacterial disease, is an epidemic-prone infection transmitted directly from contaminated water. Transmission occurs with direct contact with the skin or mocous membranes with water, vegetation or mud contaminated with rodent urine. Flooding spreads the organism due to rodent proliferation.

The case of Pakse is a clear example of disease being spread after severe flooding occurance. Flooding for three months with high temperatures allows the high growing rate of vectors which propague vector-borne diseases. People are kept in the same room for long periods, isolated by the sorrouding and stagnant water. These conditions create the optimal conditions for parasites to spread. In 2013, floods affected a large number of people as well as livestock. Runoff of manure into watersheds caused an increase in micro-organism proliferation which may have affected the health of human beings and animals.

3.3.5 Climate Change Drivers and Biophysical Effects Relevant to Pakse

Four key drivers and biophysical effects relevant to Pakse were identified, namely:

1. Increased temperature;
2. Fewer rainy days but more rain per rainy day;
3. Annual flooding in vulnerable parts of Pakse; and
4. More "10 year floods."

Likewise, we also looked at the issue of the rainy season finishing later, but again this is changing slowly.

[8] ADB, Pakse Urban Environmental Improvement Project- Project No. 43316-022 April 2012- Annex G: http://www.adb.org/projects/documents/pakse-urban-environmental-improvement-project-draft-environmental-management-plan (accessed 15 Dec. 2013)

[9] J.T. Hoverman, Does Climate Change increase the risk of disease? Analysing published literature to detect climate-disease interactions, 2013.

Table 2: Climate change drivers/biophysical effects relevant to Pakse

Change	Primary impact	Secondary impact	Tertiary impact
Increased temperature	Plants grow more.	Higher yields.	Increased farmer income.
	More evaporation.	More water stress.	Increased mortality from viral diseases due to physiological stress.
Fewer rainy days but more rain per rainy day	Increased amount of water into drainage system on wet days.	Pressure on existing drainage system.	More flash floods. More repairs needed to existing system. Investment needed to resize the drainage system.
	Greater range between wet and dry days.	Foundations of buildings and infrastructure at risk of cracking.	More expensive structural assessments needed and increased demand for capacity in this sector.
Annual flooding in vulnerable parts of Pakse	Streets are submerged for typically 3-5 days.	Access issues during the flood, cleaning up after the flood.	Reduced incomes due to inability to access market.
	Electricity is turned off when inundated.	Lights and fridges not functioning.	Disruption of family activities, homework, and food storage.
	Housing sanitation issues.	Septic tank overflows. Toilet backflow possible. Solid waste accumulation.	Septic tank repair and drainage costs. Unpleasant smell around house. Without access to solid waste disposal, during flood times the solid waste either accumulates in the house or is dumped into the flood waters themselves, further polluting the flood waters.

More "10 year floods"	Areas of Pakse flooded out with 2.5m deep floodwater that remained for three months in 2011 floods.	Significant infrastructure damage to buildings, roads, local water and electricity infrastructure, and to local shops and businesses.	Expensive structural repairs and rebuilding.
		Houses unliveable as floodwater reached second floor, travel only possible by boat to visit their homes.	Necessary, but hugely disruptive relocation of affected families to relatives outside Pakse for floodwater duration.
		Damage to sanitation systems in affected houses and septic tank overflows.	Repairs to sanitation systems more costly after long inundations. Survey of septic tank integrity required once tank emptied. Extensive community clean up and sanitisation from septic overflows.

Source: UN-Habitat

3.3.6 Impacts on People

Some of the impacts of climate change on people in Pakse will be positive at least until 2050 according to the climate modelling used in this assessment. However, the frequently occurring floods in Pakse remain a great challenge for the residents affected.

Table 3: Scale of the impacts on people

Change	Primary impact	Secondary impact	Tertiary impact
Increased temperature	Vegetables and other crops will grow faster in the wet season.	Higher yields in volume and weight of crops, especially in irrigated dry-season cropping systems.	Higher economic income for farmers able to exploit the rising temperatures beneficially such as out of season cropping.
Fewer rainy days but more rain per rainy day	Increased flash flooding.	Risk of more possessions destroyed by floods.	Extra financial burden on community.
Annual flooding in vulnerable parts of Pakse	Floodwater in the houses.	Disruption and damage by dirty water including septic tank overflows.	Costly and disruptive clean-up after flood gone and where necessary sanitisation required from septic tank overflows.
More "10 year floods"	Areas of Pakse flooded out with 2.5m deep floodwater that remained for 3 months during the 2011 floods.	Significant infrastructure damage to buildings, roads, and local water and electricity infrastructure, and to local shops and businesses.	Expensive structural repairs and rebuilding.

Source: UN-Habitat

3.3.7 Impacts on Places

The forecast climate changes pose a number of challenges, in terms of successfully adapting and rebuilding the necessary infrastructure to cope with the forecast changes.

Table 4: Scale of impacts on places.

Change	Primary impact	Secondary impact	Tertiary impact
Increased temperature	Hotter and drier especially towards end of dry season.	Likely higher per person drinking water demand.	Water scarcity through shortage of supply.
Fewer rainy days but more rain per rainy day	Much more water into existing drainage system.	Risk of drainage system overwhelmed.	Damage to local infrastructure, and local livelihoods.
Annual Flooding in vulnerable parts of Pakse	Inadequate current flood management approaches.	Same areas routinely flooding at least once per year.	Impact on local health and livelihoods.
More "10 year floods"	The 2011 Pakse floods inundated areas with water for three months, typically at 2.5m depth.	Significant damage to buildings in affected areas.	Lengthy and expensive re-building once floods eventually left affected areas.

Source: UN-Habitat

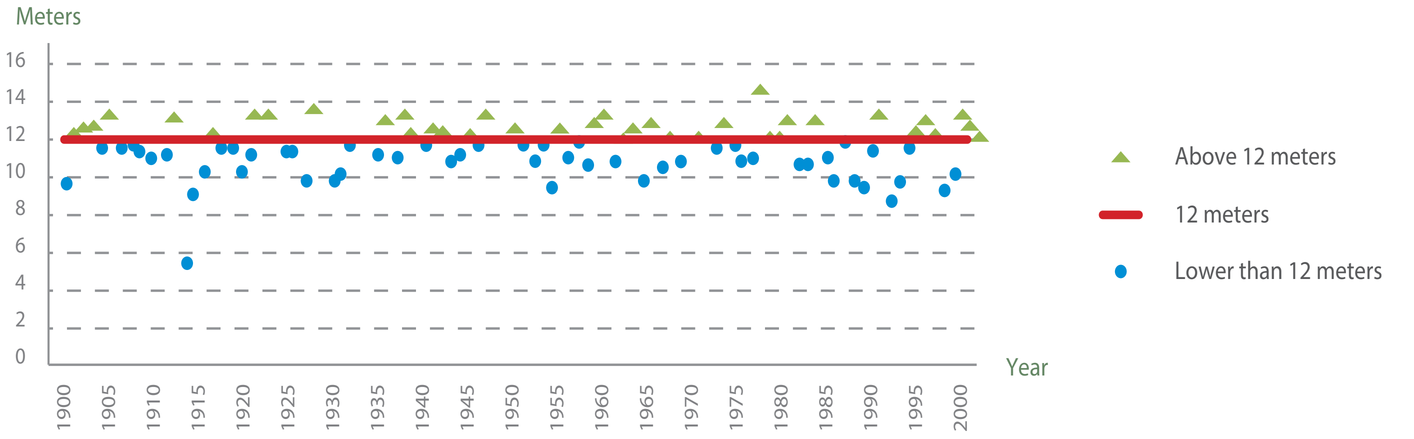
The key theme reflected in this section has been that climate change is intensifying the seasonal changes and weather conditions, seen with the dry seasons getting drier, the wet seasons getting wetter and the rainy days becoming more intense, and April (the hottest month) getting even hotter. The core secondary theme reflected in this section is that coping with climate change is going to require significant resources and support.

3.3.8 Triggers and Thresholds

The dominant issue that Pakse faces is flooding and flood levels. The following chart shows the maximum height recorded annually at the Mekong River in Pakse between 1902 and 2002. The red line is the 12m level which is the identified flood level.

The chart clearly shows that relatively modest increases in the flood level would result in notably fewer floods at Pakse. Between 1902 and 2002 the Mekong exceeded the 12m flood level 40 times. However if the flood level had been 14m and not 12m, there would have been only one flood year, namely in 1978 when the peak height was measured at 14.63m.

Figure 11: Mekong River maximum levels for 100 years (1902-2002).



Source: UN-Habitat

3.4 Adaptive Capacity

Adaptive capacity in the context of climate change refers to:

> *The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. The IPCC Third Assessment Report outlines that it is a function of wealth, technology, institutions, information, infrastructure, social capital.*[10]

Champasak Province is the hub for economic activity in southern Lao People's Democratic Republic, fuelled by an expansion of the agriculture and service sectors. Infrastructure development in both urban and rural areas is one of the core elements of the poverty alleviation strategy. Consequently, Pakse, the provincial capital, is the most important and developed city and is experiencing an unprecedented construction boom with growth in domestic and foreign direct investment due to the proximity to Thailand, Cambodia and Viet Nam.

3.4.1 Institutional

Institutional adaptive capacity refers to the ability of institutions that provide governance structures and infrastructure services to adapt. For example, institutional adaptive capacity can refer to the ability of the government to provide emergency services and repairs, communication services, weather warnings, as well as industry and social safety nets. Two key aspects of institutional adaptive capacity is the commitment to build durable infrastructure and the ability to mobilise services quickly and efficiently when needed.

3.4.2 Community (collective)

Community or collective adaptive capacity refers to the ability of a group to adapt together. For example, community adaptive capacity can refer to people's ability to access goods and services such as clean water, electricity, waste collection, building materials, hospitals, food and finance. Examples of collectives include villages, districts, religious groups, etc.

[10] Cities and climate change initiative discussion paper, no.1 participatory climate change assessments a toolkit based on the experience of Sorsogon City, Philippines 2010.

3.4.3 Autonomous

Autonomous adaptive capacity refers to the ability of people, organisations and environments to adapt separately and independent of external influences. For example, in reference to people, autonomous adaptive capacity includes the ability of people affected by climate change to switch income sources, buying behaviours and dwellings. Data for determinants of adaptive capacity in Pakse are listed against three different response types in Table 4.

The IPCC Third Assessment report lists six determinants of adaptive capacity: wealth (which includes economic factors such as assets), technology, information, infrastructure, institutions (including governance), and social capital.

Table 5: Adaptive capacity determinants.

Determinant	Institutional/city	Community	Autonomous
Wealth	National percentage above the poverty line USD 1.25 (PPP): 66.2% (2008).	Nationally between 2009 and 2013. Number of active microfinance borrowers: -11.1%. Microfinance assets have increased by 41.9% during this time but liabilities have increased by 60.9%.	Ability to switch livelihoods/ number of income sources.
Technology	Weather radar/storm warning technology, broadband penetration. Department of Meteorology and Hydrology: 245 staff, including 14 weather forecasters and 15 staff with degrees (1 PhD, 9 MSc, 5 BA degree). 1 main weather radar at Wattay Airport, Vientiane (2010).[11] National internet users per hundred people 9 (2011).[12] National fixed broadband internet per 100 people: 0.6634 (2011). Mobile telephone subscriptions per 100 people: 87.16 (2011).		Kubota Laos, the distributor for all of the Kubota tractors, implements, and engines is targeting. 2 billion Baht (USD 62 million) sales in Laos by 2015[13].

[11] UNSDIR Country Assessment www.unisdr.org/files/33988_countryassessmentreportlaopdr.pdf (accessed 15 Dec. 2013).
[12] World Bank Lao PDR data
[13] Kubota dominates the small farm tractor market in USA, Europe, SE Asia, and Japan and can therefore be used as a proxy measurement of farm investment.

Institutions	National policy implementation. City level policies/ initiatives expected to focus on meeting the Millennium Development Goals (MDG) for 2015 and subsequently to meet the national government objective of leaving Least Developed Country (LDC) status by 2020. Basic services – solid waste, sewerage, etc. In Pakse 35% of households had access to solid waste collection services in 2013.[14] Nationally 63% of population have access to improved sanitation facilities (2010).[15]		Impact on local health and livelihoods.
Information	Ministry of Information, Culture and Tourism. Ministry of Post, Telecom and Communication. KPL – Lao News Agency.	Radio:49 radio transmitters (2012). TV: 34 TV transmission places (2012).[16]	Number who use radio/TVs, read newspapers, etc. 9.1 million newspapers and 2.7 million magazines were produced in 2011.
Infrastructure (and housing)	National per cent of roads paved: 13.7% (2009).	National access to improved water source: 67% (2010). Comprising of : rural people access to improved water source: 62% (2010).[17] Urban people access to improved water source: 77% (2010). National access to electricity: 71% (2010).	Affordable building materials easily available, including low-priced power tools; such as circular saws.

[14] Field visit to UDA-Pakse on 9 October 2013
[15] World Bank Lao PDR data
[16] Lao Statistical Yearbook-2012, Lao Statistics Bureau, Ministry of Planning and Investment.
[17] World Bank Lao PDR data

Social capital	Social safety nets. The city occupies 140 km^2 approx. Less than 1% of the province. Strong economic ties with the neighbouring countries. Construction boom. International transport by road. There is a museum and a provincial Tourism Office. Trade area at the Lao. Nippon friendship bridge contributes to economic growth for the region. A large duty-free shopping area at Vangtao Chongmek border is under construction.	Nationally more than 4,000 Buddhist temples. Lao disabled women centre in Vientiane. Handicraft association.	Affordable building materials easily available, including low-priced power tools; such as circular saws.
Gender	Percentage of national population women: 50.04%. Nationally 5% of Lao households are female-headed.[18]	Percentage of Champasak Province population women: 50.31%.	

Source: UN-Habitat

Family in Pakse relocating goods to safer grounds during the floods.
Photo @ UN-Habitat

Floods in Pakse disturbing daily life of the community.
Photo @ UN-Habitat

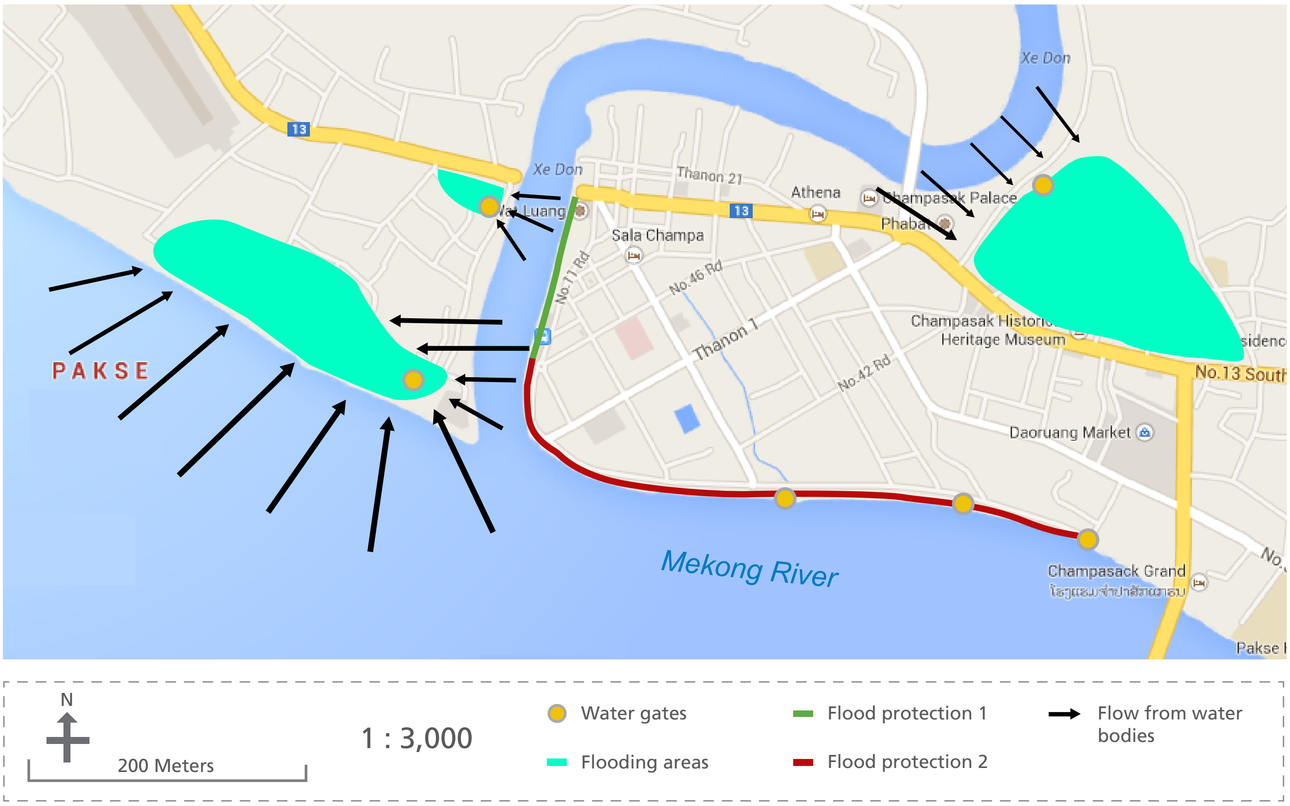
[18] UN FAO, The FAO Gender and Agricultural Statistics Framework, 2012, http://www.fao.org/fileadmin/templates/rap/files/meetings/2012/121113_the-fao-gender.pdf (accessed15 Dec 2013).

04

Vulnerable People, Places and Sectors

The feedback obtained from government officials and residents was that flooding is the biggest issue for Pakse and its future development. Areas currently at flood risk are found close to the Mekong River and Xe Don River. These are the hotspot areas for Pakse in respect to climate change. The most susceptible areas to flooding are shown on the map in Figure 12.

Figure 12: Flooding hotspots in Pakse.

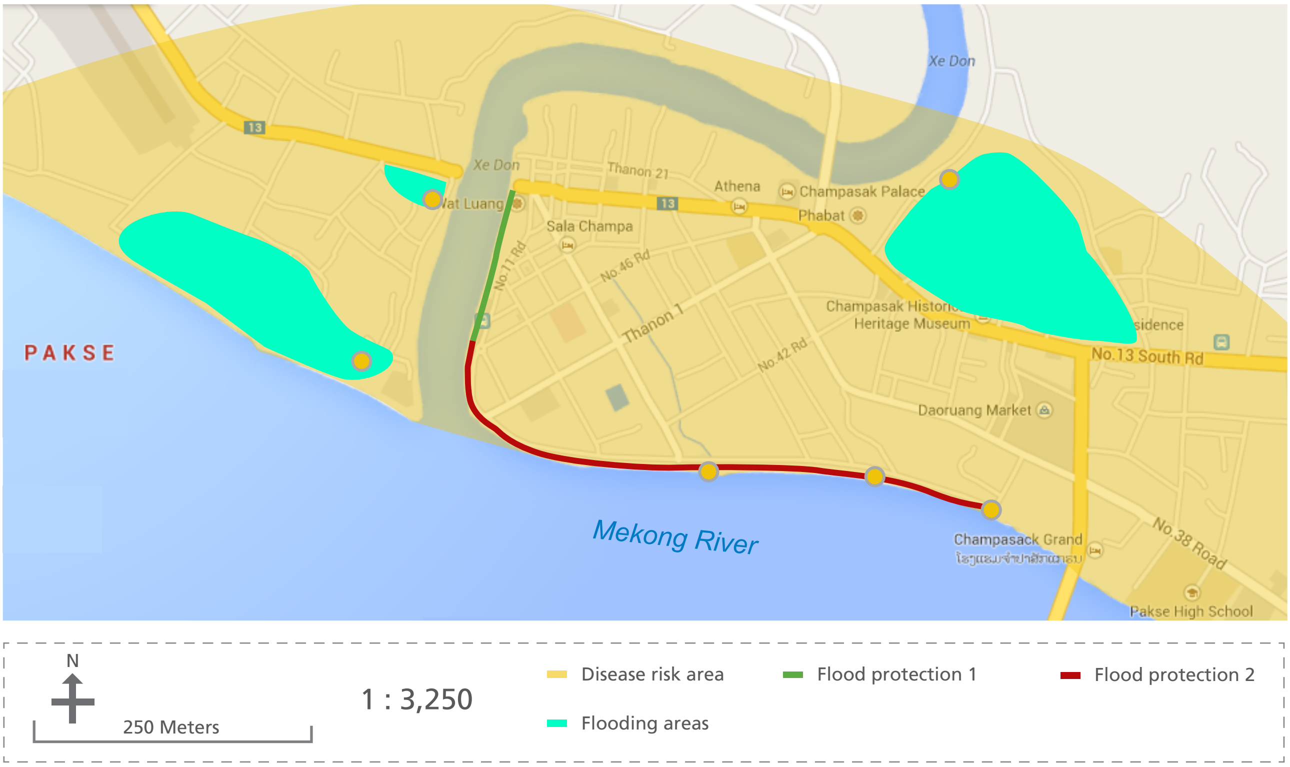


Source: Google map redesigned

The most susceptible areas to flooding are indicated. The banks of the Xe Don River are not only affected by increased flows but also by the flooding of the Mekong River. As the overpowering hydrological effect of the Mekong flow pushes water up into the Xe Don River channel it combines the water volumes to breach the banks, most commonly at the points indicated.

Figure 13. shows the areas most susceptible to the spread of flood-related diseases (the light yellow shaded area). Flooding increases the spread of diseases and infections (mainly bacterial). The susceptibility of these areas takes into consideration the population numbers, flooding events, drainage as well as the opinions of local residents.

Figure 13: Flood-related disease risk areas.

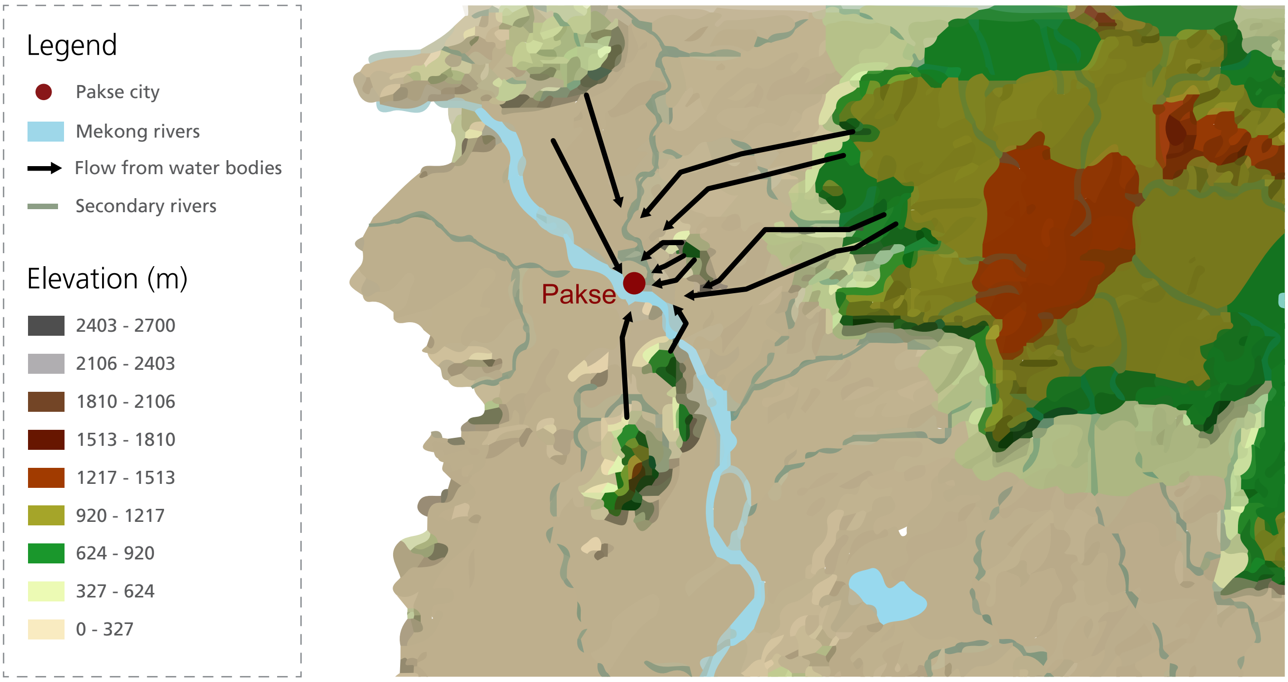


Source: Google map redesigned

Figure 14. shows water flow during flash flood events resulting from heavy rain on the mountainous areas surrounding Pakse. The arrows represent the water flow during very intense rainfalls through the steepest sloped gorges. Pakse is located in the middle of two hilly areas (north and south) with the biggest flash flooding influence coming from a mountainous area northeast of the city that result in flash flooding during the rainy season in Pakse city. The Phou Xieng Tong nationally protected area (NPA) is located north of the city and crosses over into Salavan Province while east of Pakse is the Dong Houa Sow national biodiversity conservation area (NBCA). Both have an important role in retaining water from heavy rainfall events. This reduces the magnitude of flash flooding and such areas should be seen as an intrinsic part of the hydrology of Pakse.

Flash flood resulting from heavy rain on the mountainous areas.
Photo @ UN-Habitat

Figure14: Flash flooding direction of flow.



Source: UN-Habitat

Flash flooding in Pakse
Photo @ UN-Habitat

05

Identifying Key Adaptation Options

There are a wide range of possible adaptation options available such as:

1) Hard engineering
   - Flood walls.
   - Flood gates.
   - Pumping systems.
   - Storm drain systems.
   - Storm water storage systems.
   - Channelling rivers and streams.

2) Relocation inside city
   - Moving residents away from high risk zones.
   - Moving entire communities to safer locations.
   - Key infrastructure moved to lower risk locations.

3) Improved resilience measures
   - Flood proofing houses in vulnerable areas.
   - Zero flood overflow septic tank systems.
   - Upgraded building standards.
   - Mobile phone networks improved coverage over flooded areas.

4) Flood management system improvements
   - Government departments have flood roles clarified.
   - Management centre for serious events established.

5) Enhanced flood and typhoon warning systems
   - Better modelling and forecasting.
   - Flood protection measures deployed ahead of peak flood risk time.
   - More accurate basin modelling.
   - More time to move people away from typhoon risk zones.

6) Improved public health measures
   - Chickens, ducks, pigs and other livestock moved out of the city.
   - Enhanced vaccination programmes for humans and animals in advance of season changes.

5.1 City adaptations options

With so many available adaptation options, it can be an uneasy task for stakeholders to know what approaches are appropriate and helpful from their perspective. Therefore, three individual scenarios for stakeholder consultations were advised.

5.1.1 Proposed Adaptation Strategies for Further Consultations

Identified are three strategies for adapting to the vulnerabilities addressed, for further consultation with key stakeholders to better understand stakeholder preferences for adaptation.

Strategy 1: Autonomous adaptation only

When talking with flood affected residents it is very clear how well they have coped with the frequent floods. None of the residents mentioned any desire to move away from the area because of flooding. There are many small adaptation measures such as a family that had a flat bottomed canoe tied to the side of their house for use in floods. The communities affected by serious flooding clearly showed strong levels of resilience and were impressive in coping with the regular floods extremely well. However, the key change they wanted locally was a functioning pumping system to reduce the severity and duration of floods. Though the current drainage system in Pakse does need upgrading, this would be the case irrespective of any climate change issues, or floods. Furthermore, Pakse continues to grow strongly economically, and it is hard to identify any discernible impacts of the regular flood on the economic growth of the city.[19]

[19] Strategy 1 is intentionally meant to represent in scientific terms "the control", strategy 2 is "the soft engineering option", and strategy 3 is the "hard engineering option."

Strategy 2: Managed flooding

With some simple terrain mapping it is possible to identify areas that would be affected by severe and infrequent floods. This approach would try to re-zone the city, focus flood management efforts on high-risk areas and, if hazards become extreme, re-locate people away from flood-prone to much lower risk areas.. Also, enhance local government and community capacity to improve local services such as solid waste collection.

Floods in Pakse
Photo @ UN-Habitat

Strategy 3: Engineering-focused approach

This strategy is based around the concept that the acceptable flooding frequency in Pakse is one time per hundred years, and what would need to be changed in Pakse to achieve this. This particular approach especially focuses on hard-engineering options such as walls to keep the floods out, and flood gates and electric pumps to get rid of any flood waters that come inside the city. This strategy also involves intentionally flooding designated areas north of the city to further reduce the risk of flooding in Pakse.

Floods in Pakse
Photo @ UN-Habitat

06

Recommendations and Conclusions

Based on the findings of this vulnerability assessment, it is clear that both actions to build resilience and mitigate the causes of climate change are necessary. In Pakse, at both the community and local government level, there is limited knowledge about the causes and effects of climate change, and the actions needed to build resilience to its impacts. However, there is institutional readiness to respond to the effects of climate change, by planning for its impacts, mitigating its causes and implementing actions that will achieve this.

Strengthening physical infrastructure – especially to cope with flooding from the Mekong River – is a key area of adaptation, as communities, especially those not protected by flood gates, remain highly vulnerable to flooding. To complement this, Pakse's urban expansion needs to be planned in such as way that new settlements – including settlements that house the urban poor – are situated in areas that are not prone to flooding, while existing settlements will become less vulnerable if infrastructural improvements are also accompanied by effective maintenance and management.

Meanwhile urban basic services are especially challenging. In particular, solid waste management remains an issue in Pakse. Inefffective waste management allows solid waste to clog drains and waterwars, exacerbating climate related causes of flooding. Meanwhile, poor disposal results in high methane emissions. Addressing such services is a critical area. In terms of water supply, it is estimated that 77 per cent of the population has access to improved water sources – climate resilience will be enhanced as this statistic moves towards 100 per cent of households with year-round water supply.

Public health is also a key challenge. Pakse faces year-round climate change related health impacts, such as water and vector borne diseases and respiratory problems. Health impacts are especially severe after times of flooding, as was shown during the community consultations that took place as part of this vulnerability assessment.

In governance terms, while there are many actions, outlined in this report, that can be taken locally, the connection between local and national government should remain strong. One of Pakse's main sources of vulnerability is the Mekong River. There needs to be effective coordination to ensure that, for example, riparian ecosystems are protected and enhanced, which will help minimize flood waters. Management of the river takes place throughout the whole country.
This report groups the proposed priority actions into six categories:

- Hard engineering
- Relocation inside the city
- Improved resilience measures
- Flood management system improvements
- Enhanced flood and typhoon warning systems
- Improved public health measures

These categories of actions are not mutually exclusive - they can complement one another. Indeed, in order to move towards resilience, deciding the correct actions should be seen as part of a broader planning cycle, where the Pakse's values and objectives are identified, adaptation and mitigation options are further long listed and defined, actions are shortlisted and prioritized, implemented, monitored and then the process is repeated.

Building resilience is a process; a process that takes a long time, and requires the engagement of a broad range of stakeholders. Resilience can not be built through a one off action or a series of actions, but through an ongoing process of mainstreaming actions into all areas of planning for and managing Pakse's development.

UN-Habitat's Cities and Climate Change Initiative promotes enhanced climate change mitigation and adaptation in developing country cities. This document is an initial output of the Cities and Climate Change Initiative activities in Pakse, Lao People's Democratic Republic. This abridged report is based on the report titled: "Pakse, People's Democratic Republic – Climate Change Vulnerability Assessment".

Starting with a brief background of the city, this report addresses Pakse's climate change situation from a comprehensive vulnerability perspective that focuses on exposure to climate change hazards, socio-economic sensitivities and the adaptive capacities of the city and its stakeholders. Based on this analysis the report identifies vulnerable people, places and sectors and provides preliminary climate change adaptation options.

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