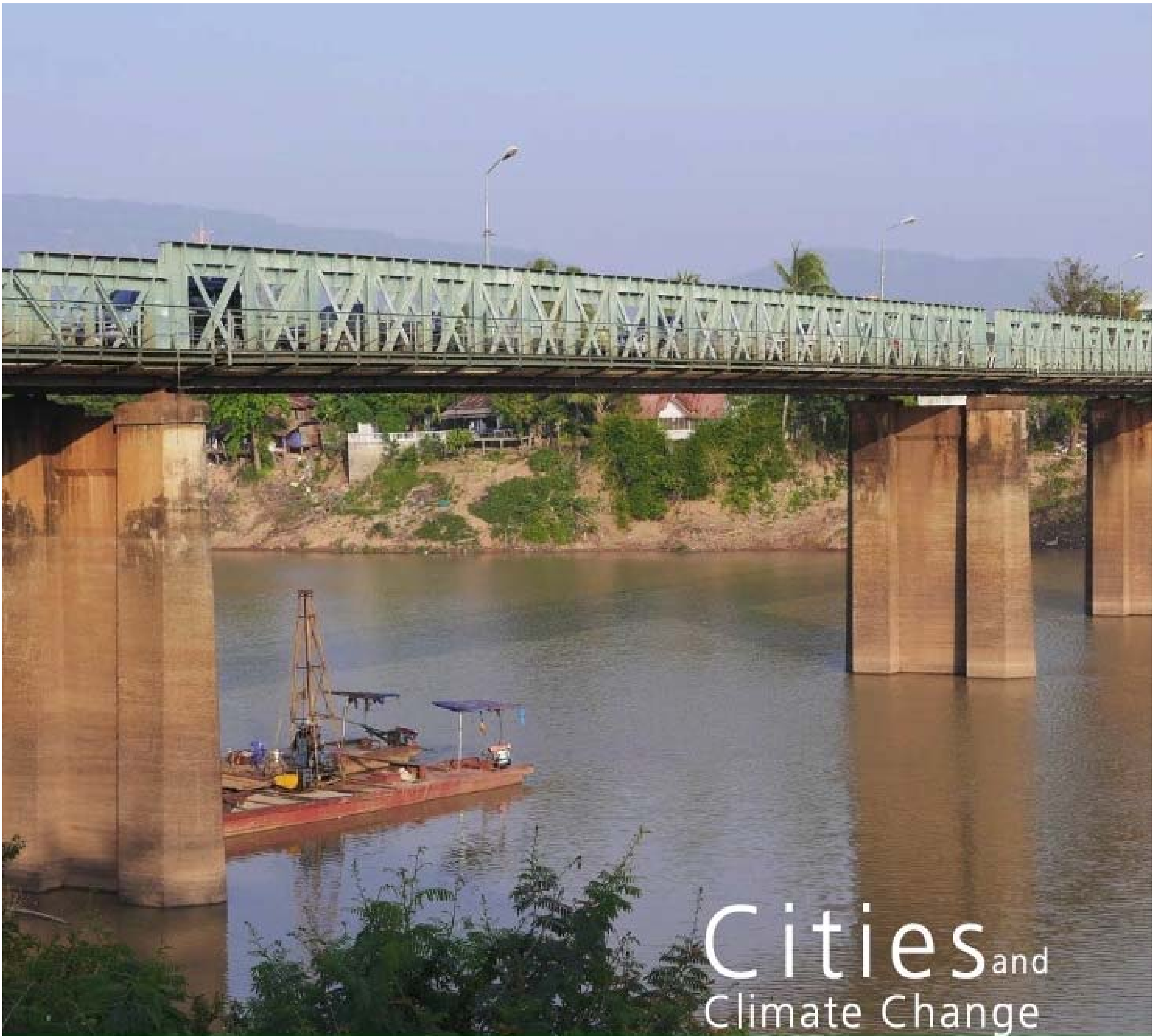

Cities and Climate Change Initiative

Pakse
Lao People's
Democratic Republic

Climate Change
Vulnerability Assessment

UN-HABITAT
FOR A BETTER URBAN FUTURE

Cities and Climate Change Initiative

Pakse, Lao People's Democratic Republic

Climate Change Vulnerability Assessment

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

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LIST OF ABBREVIATIONS

ADB	Asian Development Bank
^{o}C	Degrees Celsius
CCCI	Cities and Climate Change Initiative
CUMECS	Cubic meters (m^3) per second
DPI	Department of Planning and Investment
Mm	Millimetres
PDR	People's Democratic Republic
UDA	Urban Development Agency
UN	United Nations
USDA	United States Department of Agriculture
WHO	World Health Organisation

1 INTRODUCTION TO CITIES AND CLIMATE CHANGE INITIATIVE (CCCI)

1.1 Cities and Climate Change and UN-Habitat's CCCI Programme

Urban areas around the world continue to grow in population and in 2008 the landmark figure of more than 50% of the world population living in urban areas was passed.[1] According to the United Nations (UN) Department of Social and Economic Affairs, from now to 2050 "Virtually all of the expected growth in the world population will be concentrated in the urban areas of the less developed regions."[2]

At the same time as this demographic shift towards increasing urban populations in the developing world, the rate of global Climate Change has been very rapid indeed. On July 3, 2013, the World Meteorological Organisation declared:

> *The world experienced unprecedented high-impact climate extremes during the 2001-2010 decade, which was the warmest since the start of modern measurements in 1850 and continued an extended period of accelerating global warming. More national temperature records were reported broken than in any previous decade.*[3]

It is into this context of rapidly growing cities in the developing world, and accelerating global warming, that UN-Habitat has established the "Cities and Climate Change Initiative" (CCCI).

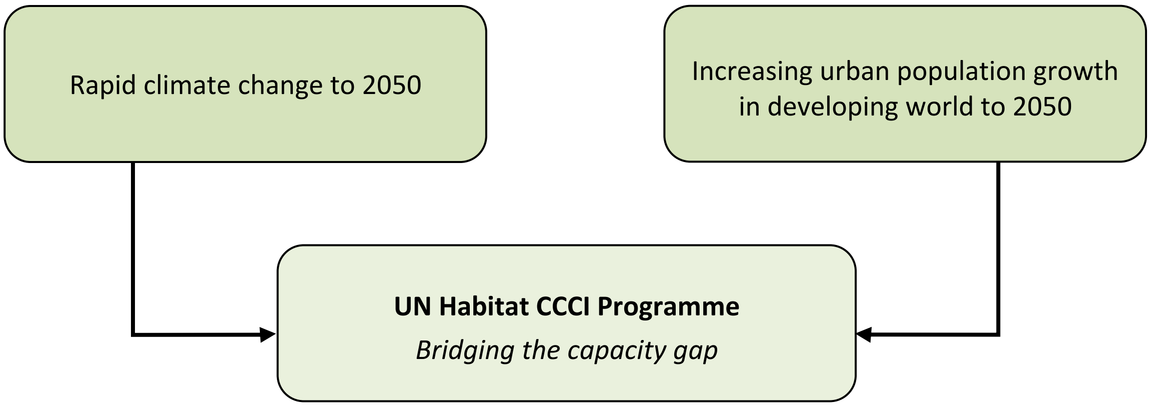

Figure 1: Underlying factors and needs addressed by the CCCI programme

With respect to the Asia-Pacific region, the "UN-Habitat Asia-Pacific Strategy 2011-2015" has identified three key objectives for the CCCI programme:

1) To build the capacities of at least 50 cities in at least 15 countries in preparing and implementing comprehensive climate change strategies and action plans

2) To integrate good climate responsive urban development practices into national policies, strategies and legislative reforms

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[1] http://www.who.int/gho/urban_health/situation_trends/urban_population_growth_text/en/
[2] United Nations Department of Economic and Social Affairs/Population Division 3. *World Urbanization Prospects: The 2011 Revision Downloaded: http://esa.un.org/unup/pdf/WUP2011_Highlights.pdf*
[3] http://www.unep.org/newscentre/default.aspx?DocumentID=2723&ArticleID=9561

3) To establish the CCCI Regional Partners' Advocacy, knowledge management, capacity building and networking platform

1.2 Site selection, city consultation and forming a committee process

In order to meet these objectives – and especially objectives 1 and 2– the CCCI has developed the following process model:

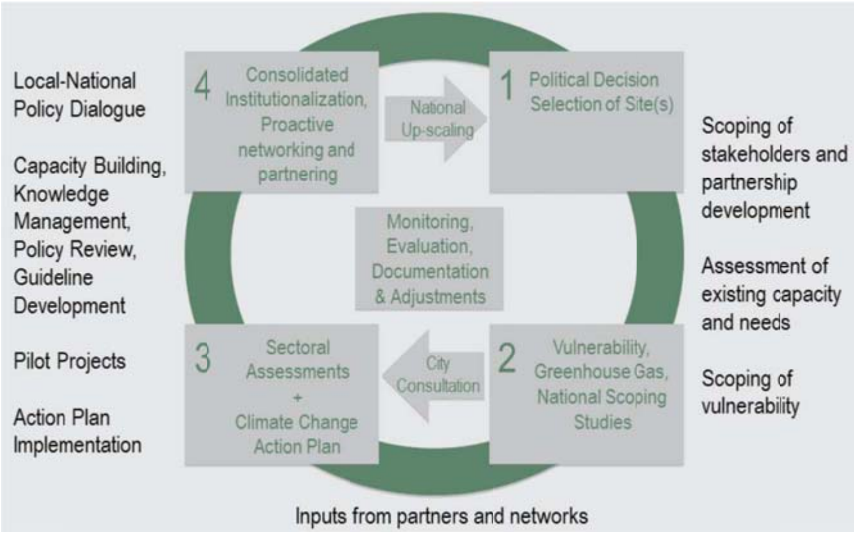

Figure 2: Process for CCCI Programme Implementation

The process flow shown in Figure 2 has been used, within the scope of this study, to provide not only a sequential order of research activities, but also a clear link towards nationally scaling up CCCI in Lao PDR going forward.

The selection of Pakse was made after considerable discussions with stakeholders and an evaluation of the potential to develop healthy partnerships with significant agencies in Pakse.

Pakse is the second biggest town, by population, in Lao PDR, and the provincial capital of Champasak Province. Furthermore, having there once been a Champasak Kingdom, local officials appeared keen to suggest that Pakse is also the "Capital of Southern Lao PDR".[4]

[4] The formal capital of Champasak Kingdom was the town of WatPhu; about 20km south of Pakse and Pakse was actually never the capital of the Champasak Kingdom.

2 BACKGROUND TO THE CITY OF PAKSE

2.1 Geography of Pakse

Figure 3: Localisation map of Pakse district (dark brown) in Champasak province (light brown) in Lao PDR (green)

The City of Pakse is at the confluence of the Mekong and the Xe Don rivers in Southern Lao PDR. It is one of 10 districts within the province of Champasak. Pakse district has 42 villages with 12,580 households with a population of 77,331. Annual population growth is currently strong and the Asian Development Bank (ADB) expects Pakse to have a population of 125,000 by 2018. This represents over 7% population growth per year[5].Pakse is exactly located at 15 11 N, 105 78 E, (see Figure 3).

Pakse has a geographically significant location. It is just 40km from the border with Thailand, 130km from the major Thai town of Ubon Ratchathani and 150km from the Cambodian border. There are regular buses to Hue and Danang in Vietnam, with the journeys taking around 12 hours. Pakse also has the third busiest airport in Lao PDR, after Vientiane and Luang Prabang, with direct services to Bangkok, Siem Reap, Ho Chi Minh, Vientiane, Savannakhet and Luang Prabang.

Much of this report will focus on flooding and the interaction between the hydrology of the two rivers and the town itself. The Mekong, which is over one kilometre wide as it passes through Pakse, flows broadly from north-west to south-east through the town; while the Xe Don river flows north-south. Therefore, we describe the areas affected as the north-east bank and the south-east bank of the Mekong, and the west and east bank of the Xe Don. There is very little development on the west bank of the Mekong and the land in this area is still primarily used for agricultural purposes.

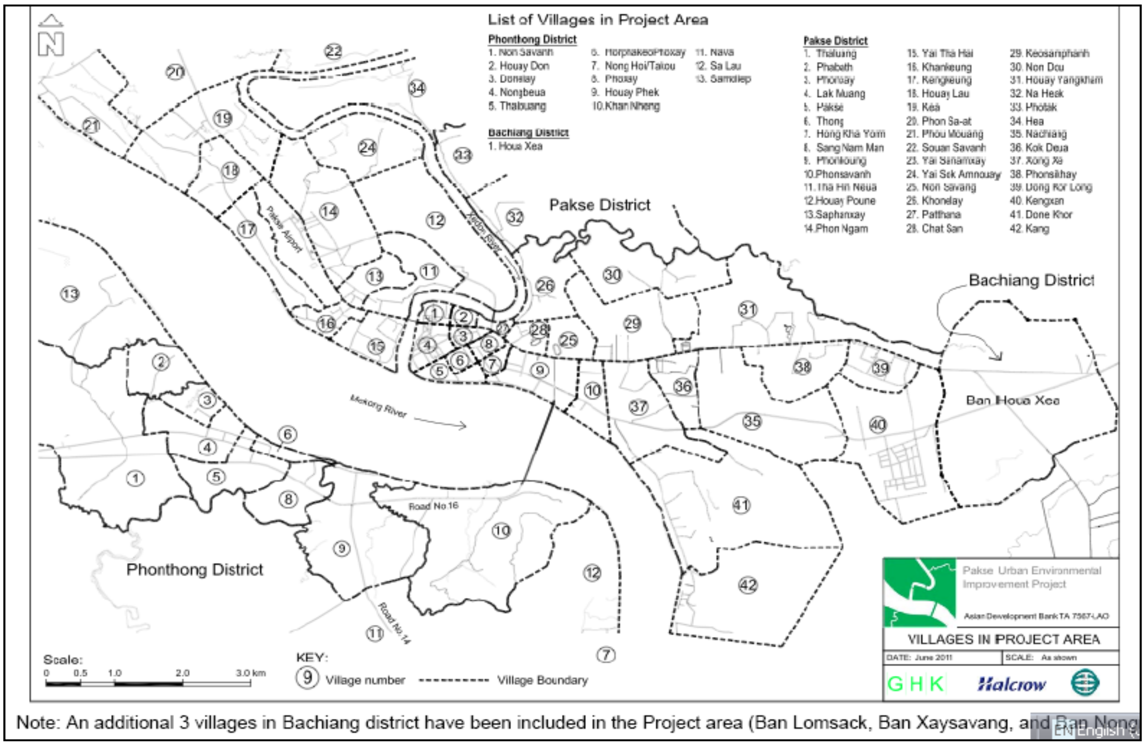

Figure 4: List of villages in project areas

[5]Though 7% is rapid growth, it is generally in line with the economic growth rates in the past 5 years according to the ADB Laos Factsheet downloaded on 26/08/13.

2.1.1 Elevation and geology of Pakse

The city of Pakse is located on a plain area surrounded by high peaks where on the nearby a large mountain is settled. The elevation of the city is 102 metres above Mean Sea Level (MSL).

Below, a 3D map can be seen with the surroundings of Pakse, the main river (Mekong) and other tributaries as well as the elevation (Figure 5).

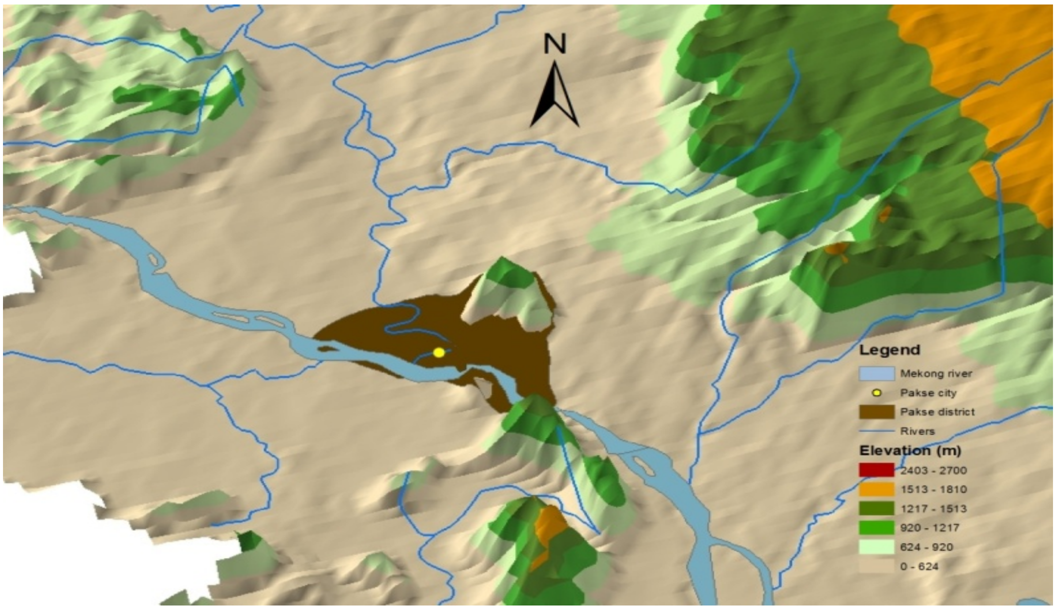

Figure 5: Elevation map of Pakse surroundings with main natural landscapes

The Mekong River generally sits on top of a layer of hard sandstone rock. In areas immediately surrounding the Mekong River there is a layer of soft rock, sandy clays and silts that sit above this hard layer. This is the geological formation on top of which Pakse sits, and this soft material is typically 12-15m deep at Pakse.

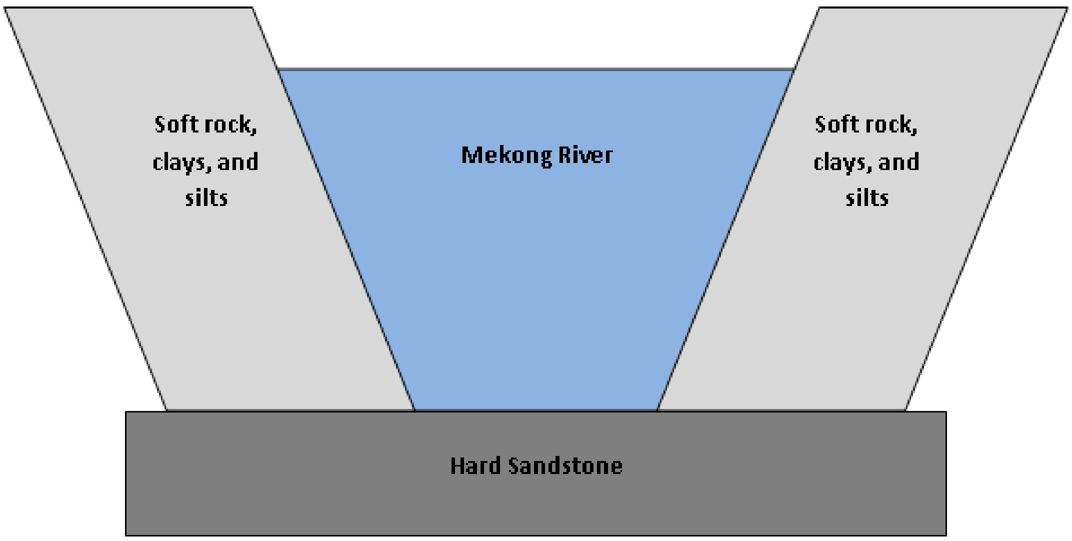

Figure 6: Schematic Mekong geology at Pakse

2.1.2 Hydrology

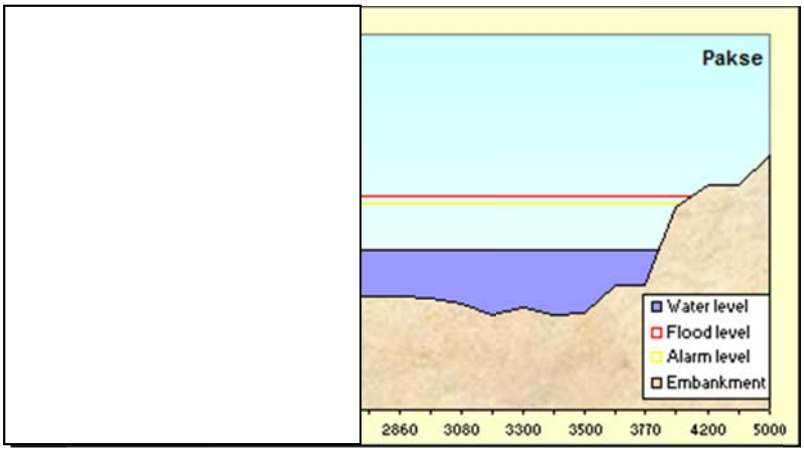

Figure 7: Pakse flood alert level

In terms of hydrology (Pakse means mouth of the river Xe) the interchange between the Xe Don River and the Mekong River gives the city its distinctive layout. The Champasak Provincial Department of Public Works considers a depth of over 12 metres to be 'danger' level. When the Mekong is at its danger level of 12metres, the peak flow is consistently measured at around 28,000 CUMECS. A CUMEC is a cubic metre per second, and as one CUMEC weighs around 1 tonne, every second 28,000 tonnes of water and sediment pass through Pakse at flood peak.

2.2 Weather and climate of Pakse

The weather and climate of Pakse is tropical and is affected by the South East Monsoon. Pakse has one rainy season from May to September, and one dry season from October to April. Approximately 85% of the total annual rainfall is observed during the rainy season, with only 15% of the annual rainfall observed during the dry season.

The hottest time of year in Pakse is in April when it is on average approximately 30C. Maximum temperatures are observed this time of year at approximately 35C. The coldest time of year in Pakse is in December when it is on average approximately 24C. However, minimum temperatures are observed in January at around 18C.

Below is a climate graph for Pakse showing both the average temperatures throughout the year in degrees Celsius and also the average total rainfall in millimetres.[6]

6World Climates, 'Pakse Climate' <http://www.world-climates.com/city-climate-pakse-laos-asia/> (at 25 October 2013)

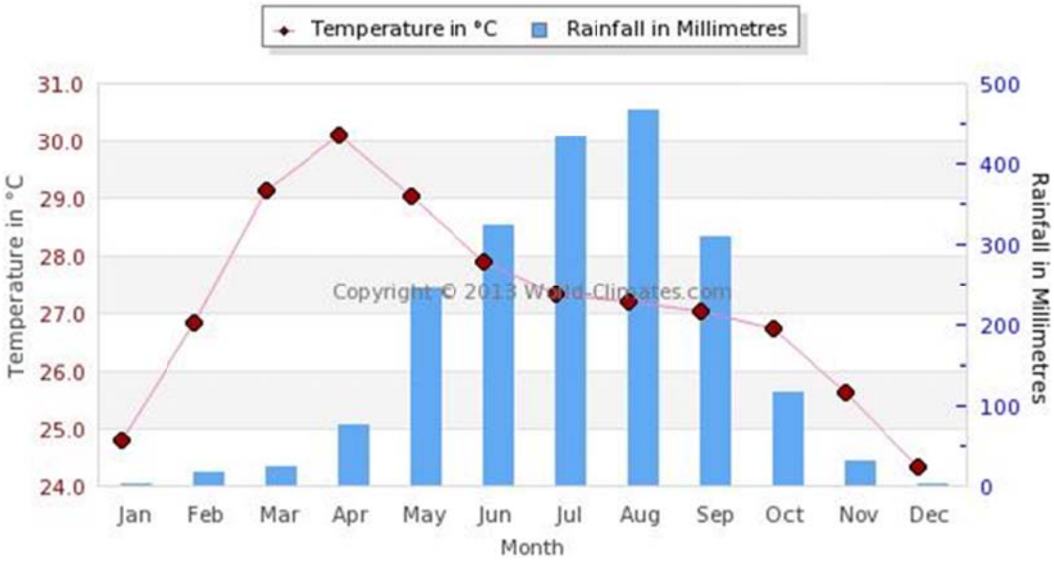

Figure 8: Monthly average temperature (C) and rainfall (mm) in Pakse, Lao PDR

2.3 Socio-economic status of Pakse

The province of Champasak is one of the most dynamic provinces in the country with a GDP growth rate of 10.6% in 2012[7], with Pakse city being the capital of the province. Since 2006, the urban area of the province of Champasak has seen a GDP growth averaging 9.8% per year.

Champasak is the economic centre of the region southern Lao PDR, with Champasak accounting for 57% of the GDP of the southern region[8] (which comprises of Champasak, Salavan, Sekong, and Attapeu Provinces).

The economy of the province is dominated by three key sectors of equal size that are Agriculture, Services, and Tourism.

The government of Champasak province expects to attract outside investment; to date, Champasak has approved a total of 316 projects at a value of 8,628 trillion KIP (US$ 1.070 bn.). Between 2007 and 2012 the number of private companies registered officially in this province has increased by 54%.

The average income per capita rose from 1,034 USD (year 2010-2011) to 1,428 USD (year 2011-2012), which 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% with a total of 2,584 poor families (2012), Champasak province in particular is told to work hardly to reduce poverty and to improve the livelihoods in the rural areas[9].

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7 Investment Opportunities in Laos-Champasak Province, Department of Planning and Investment, Champasak 2012. 4th Edition

8http://www.ide.go.jp/English/Publish/Download/Brc/pdf/08_chapter2.pdf

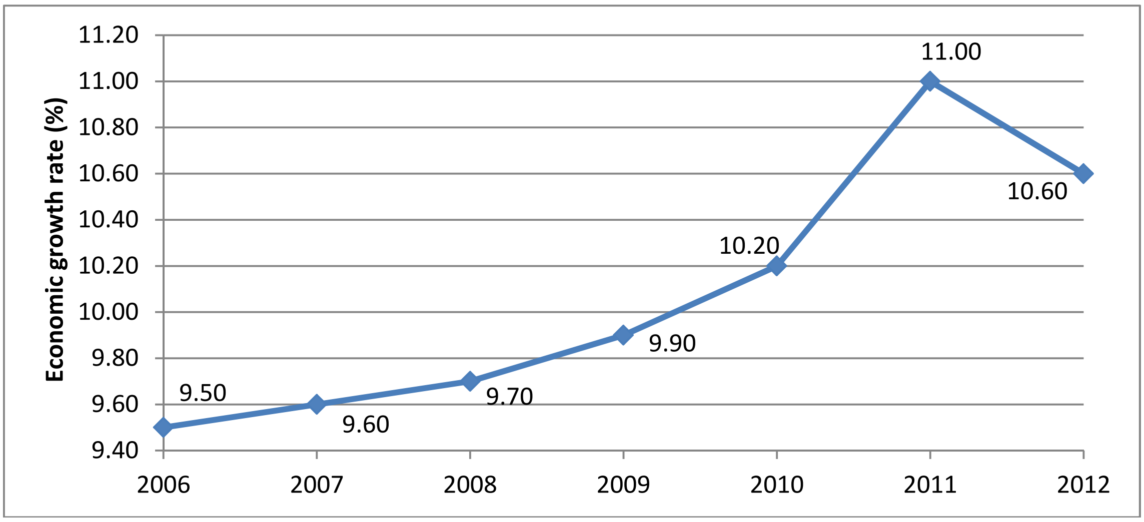

Figure 9: GDP growth rate of Champasak province

Table 1: Economic figures of Champasak province

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

Source: DPI Champasak, 2012.

Pakse city in particular has a diversified economy built around the coffee industry, trade and tourism. This has been driven largely by industry and services, which accounted for 60% of total economic output in 2010.

Revenue from tourism, banking, transport and construction is also increasing. Pakse's proximity to a worldwide UNESCO protected cultural and heritage site, namely Wat Phu pre-Khmer Empire temple, make it a significant tourist destination in Lao PDR. Tourism

9http://provincedechampassak.free.fr/champasakprovincedechampassak/pdf/pdfeng/investmentbrochureinchampasakprovince.pdf development 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 year[10].

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 US Department of Agriculture (USDA) estimates that Lao PDR will produce 575,000 60kg bags of coffee in 2013. It is estimated that the crop of 2013 will be upwards of four times as large as it was 20 years ago[11]. The largest coffee processor in Lao PDR is Dao-Heung group, which continues to make substantial investment into their Pakse facilities, including the recent commissioning of their instant coffee factory in Pakse. Dao-Heung group is a Lao company which was established by a national investor in 1991, and now operates as a diversified conglomerate within LaoPDR.

Pakse's substantial economic growth has been a driver of in-migration into almost all Lao cities including Pakse. Minorities in Southern Lao PDR, and in Pakse itself, appear to be treated no differently than anywhere else in Lao PDR and they are respected as part of the diverse culture of the country. The main ethnicities of the province is composed of Lao mainly, but also Chieng, Inthi, Kaseng, Katang, Kate, Katu, Kien, Lavai, Laven, Nge, Nyaheun, Oung, Salao, Suay, Tahang and Tahoy.[12.]

Considering the Gender issue and due to that no specific information was found to possibly describe the associated situation in Pake, Gender is one of the top development country issue nationwide in the Lao PDR. Dr Leena M Kirjavainen has researched this extensively and explains that "Human Development Index (HDI) rank of Lao PDR in 1995 was 136 out of 174 nations, indicating a low life expectancy at birth, low educational attainment and standard of living. The Gender-related Development Index (GDI) rank for Lao PDR was 125 of 174 countries. The rank difference between the HDI and GDI is +11. This means that although Lao PDR has succeeded in building basic human capacities of both women and men, substantial gender disparities prevail at national level.[13]Demographically, the men: women ratio is quite close to 0.96:1, which corresponds with the general gender in Lao PDR. Regarding education, Lao women have lower literacy rates than Lao men (59.1% against 81.7%). However, the averages are becoming higher for both genders[14], especially in urban areas.

In terms of government representation, there is still much progress to be made. The National government consists of 43 positions, of which 5 are currently held by women[15], amounting to women currently holding 11.6% of the posts. Of particular note is Ms Pany Yahortou, who is the current President of the National Assembly.

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[10] Sixth National Socio-Economic Development Plan (2006-2010) Committee for Planning and Development, Lao PDR.
[11]USDA (http://www.indexmundi.com/agriculture/?country=la&commodity=green-coffee&graph=robusta-production)
[12]GMS sustainable tourism development project in Lao PDR. Lao National Tourism Administration (LNTA)
[13] http://www.mekonginfo.org/assets/midocs/0003171-society-gender-issues-lao-pdr.pdf
[14] National Growth and Poverty eradication (NPGES)
[15] http://www.laos-guide-999.com/laos-government.html

In terms of the Central Committee of the Lao People's Revolutionary Party, the 9th Congress (2011-2016), 61 members were elected. Of these 61 members, 4 were women, with women occupying 6.56% of the posts. Of particular note Ms Pany Yahortou who is both in the Central Committee and was also appointed to the Politburo.

Though progress has been made in increasing Women representation in the Government and Revolutionary Party Leadership, there is clearly a long way to go in terms in terms of increasing female representation. Clearly there is a long way to go in terms of higher female representation rates. It is also of note and concern of the substantial difference in female participation rates in the Government leadership and the Central Committee of the party, namely 11.6% versus 6.56% of posts held by women.

2.4 Governance system

Irrespective of whether someone in Lao PDR is living in a rural or urban area, the same governance structures apply.

The smallest unit is a village or "Ban" and often the name of the village is the name of the local "Wat" (Buddhist temple). Each Ban has a village head, usually called a Nayban. The Nayban is responsible for very local actions, such as recording population changes and communicating the village needs to the district leaders. The Nayban's role is not a full-time job and the length of time that a particular person will do the Nayban role varies widely.

Every Ban is in a district, called a "Muang". At the district level, there are government officials specifically representing particular agencies, such as the Ministry of Energy and Mines (MEM) and the Ministry of Agriculture and Forestry (MAF). The district authorities have the role of overseeing the villages and village authorities.

The district, Muang, is managed by the Provincial Authorities, the "Kweng". The Kweng has quite a hands-on management role with respect to its districts, including being able to move staff between the district and province authorities. Province authorities are also heavily involved in economic planning and investment in their provinces. The national government works closely with the provinces, especially the larger programs and projects. It is a decentralised system but not a federal system.

In some provinces in Lao PDR, the Provincial Authorities establish an Urban Development Agency (UDA) as an executive agency of the Provincial Government to oversee the urban centres and their development. The field mission met with the UDA in Pakse, and they explained that the role of the UDA in Pakse is to plan and manage the city, including solid waste management, environmental management and flood protection.

The Lao Government has the task of putting in infrastructure necessary to cope with the growing urban populations across Lao PDR. This needs to be done in an equitable and fair manner, especially with respect to lands that are directly and indirectly affected by infrastructure developments.

3 CITY-WIDE VULNERABILITY

3.1 Assessment framework

The vulnerability of Pakse depends mainly of three pillars: Exposure to an intense change, Sensitivity and the Adaptive capacity to that change. The Figure 10 below shows their relationship.

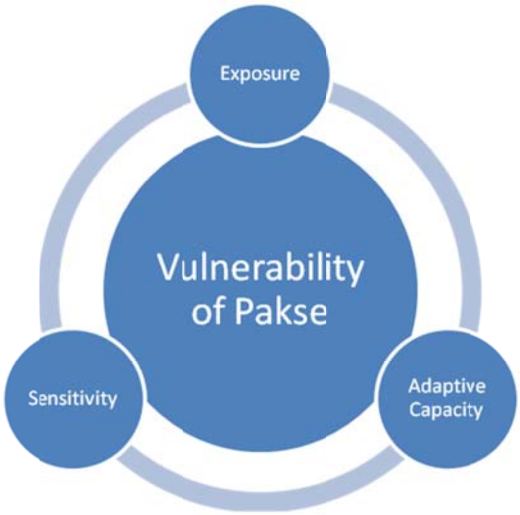

Figure 10: Vulnerability of Pakse assessment framework

3.2 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).

The key theme that is very noticeable in this data is that Climate Change is intensifying the seasonal changes and weather conditions in Pakse. We 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 due to get even hotter.

3.2.1 Rainfall –Observed/Historical trend

Using the data available to the assessment team, there is little observed change in rainfall recorded throughout the last twenty years. The mean annual rainfall of 2,127millimetres has a fairly high standard deviation of 433 millimetres –20.35% –which indicates that rainfall varies fairly significantly around the annual average[16]. Indeed, 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.

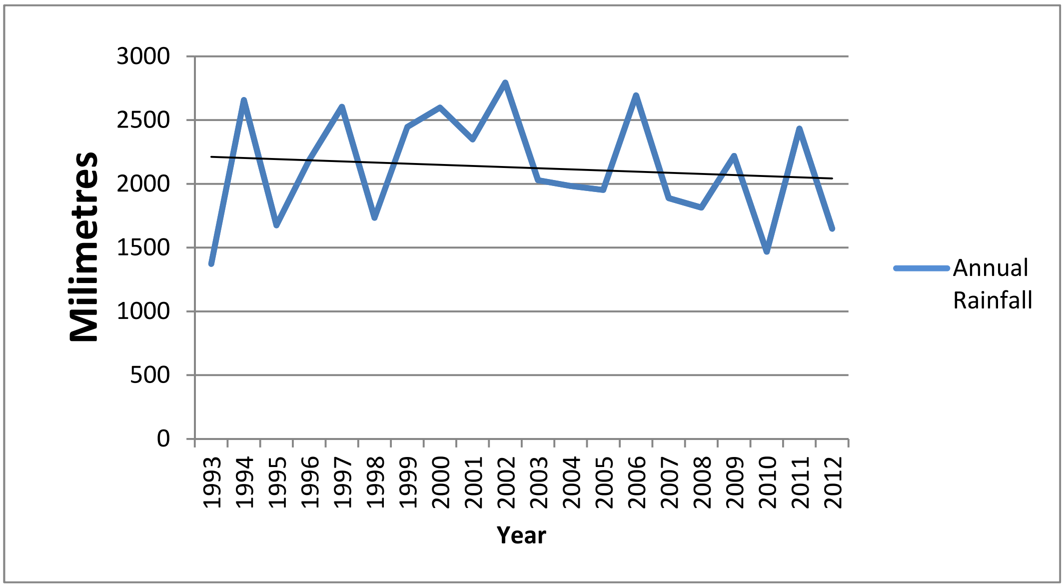

Figure 11: Annual rainfall in Pakse

The graph shows that overall there has been a slight downward trend in the rainfall experienced. However, this downward trend represents a less than 10% decline in rainfall, and it could be argued that, over a twenty year period, this is not statistically significant. The team was able to acquire data on the number of rainy days over the same period:

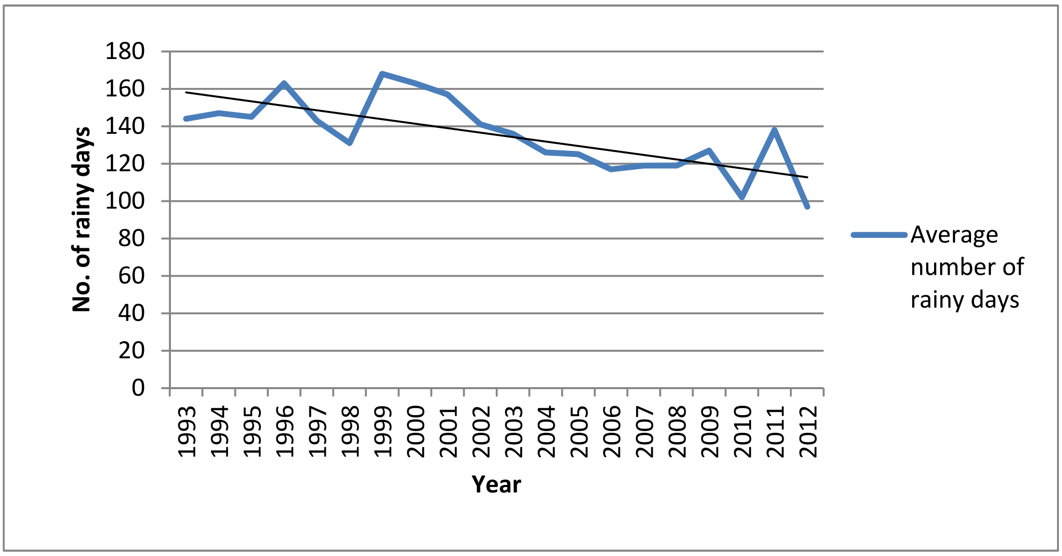

Figure 12: Number of rainy days per year in Pakse

[16]Only 60% of years fell within one standard deviation of the mean. If 68% 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.

As 12 shows, the number of rainy days per year has declined over the twenty-year period: from an average of 160 days in 1993 to around 115 presently. Indeed, 2012 was the only year in the data set which recorded less than 100 rainy days.

However, Figure 13 below shows how the amount of rain per rainy day has noticeable increased.

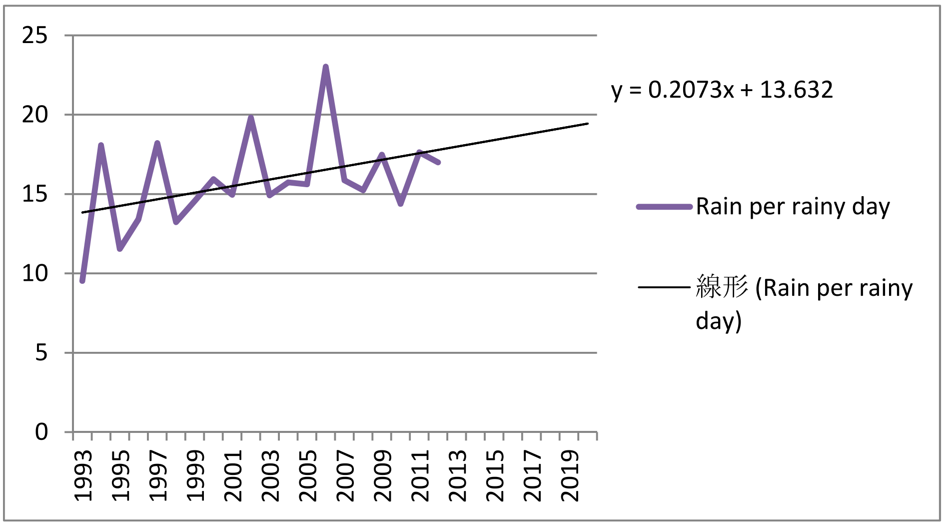

Figure 13: Rain per rainy days from 1993 to 2012

The mean average number of rainy days over the period was 135.4 per year, with a standard deviation of 14% 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 being experienced by 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 observed/ historical trend

Temperatures recorded in the dataset were very consistent. The maximum annual mean temperature recorded was between 30.8Cand 33.1Cand the minimum annual mean temperature was between 22.6Cand 24.4C. This minimal variation in average temperatures a standard deviation of 1.7% in maximum temperatures and 2.1% in minimum temperatures– suggests very consistent temperature over the twenty-year period.

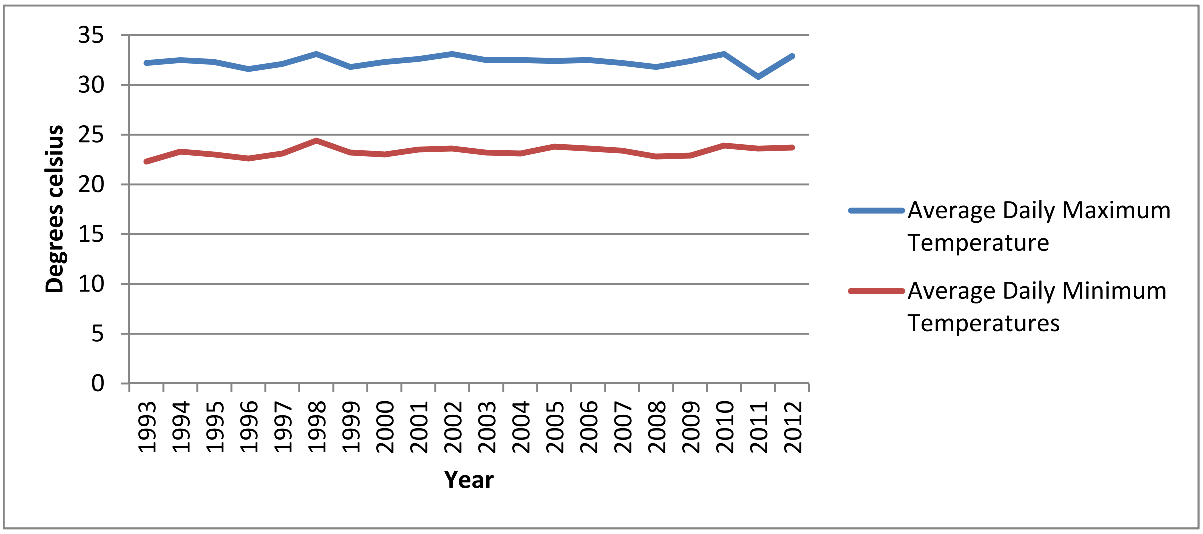

Figure 14: Annual mean maximum and minimum temperature

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. This temperature data would tend to show that if there are climate change impacts in Pakse, they have not taken the form of changes in temperature or cloud presence.

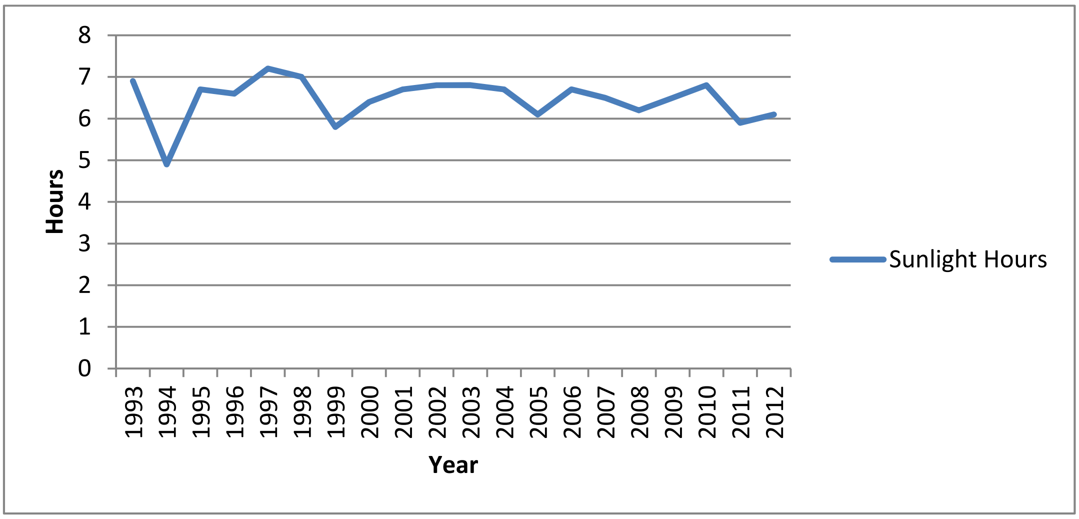

Figure 15: Average duration of sunlight hours

3.2.3 Storms/high winds observed/ historical trend

Pakse, and Southern Lao PDR more generally, are on the typical track for typhoons and tropical storms that cross the South China Sea and typically peak between August and October.

There is not much data about thunderstorms in Pakse city. A few records are collected and an increase of number of days of thunderstorms can be appreciated in the graph below between two year ranges. As an average, in the period comprised between 1964 and 1966 there were 38 days on which a thunderstorm occurred while comparing it with more recent years (from 2008 to 2010) the average of days with thunderstorms is up to 57.

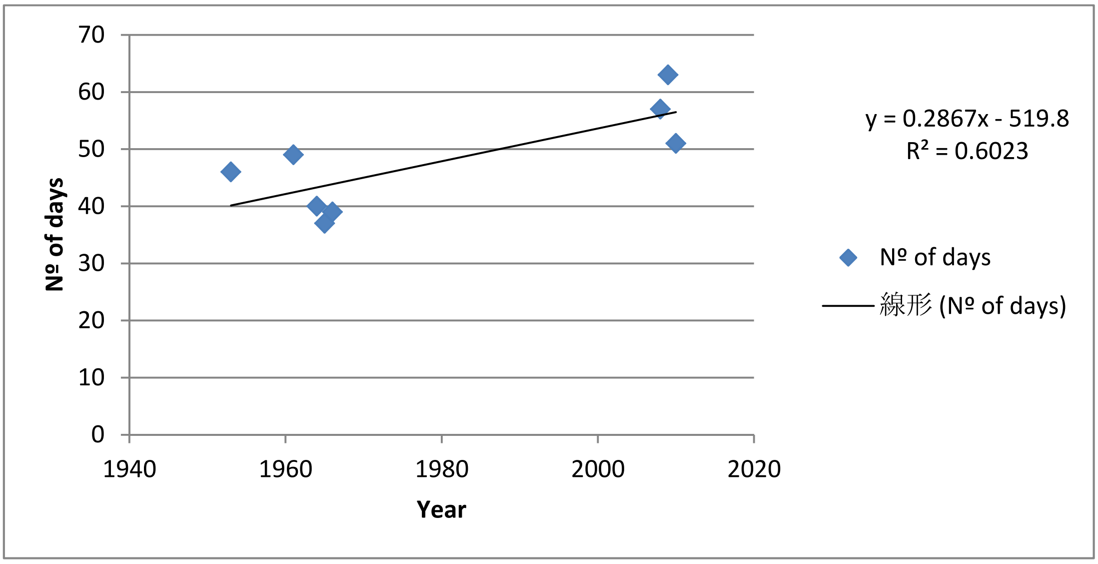

Figure 16: Historical data of the thunderstorm days in Pakse

Given the frequency and magnitude of storms that pass over or near Pakse, the observed maximum wind speeds are generally low.

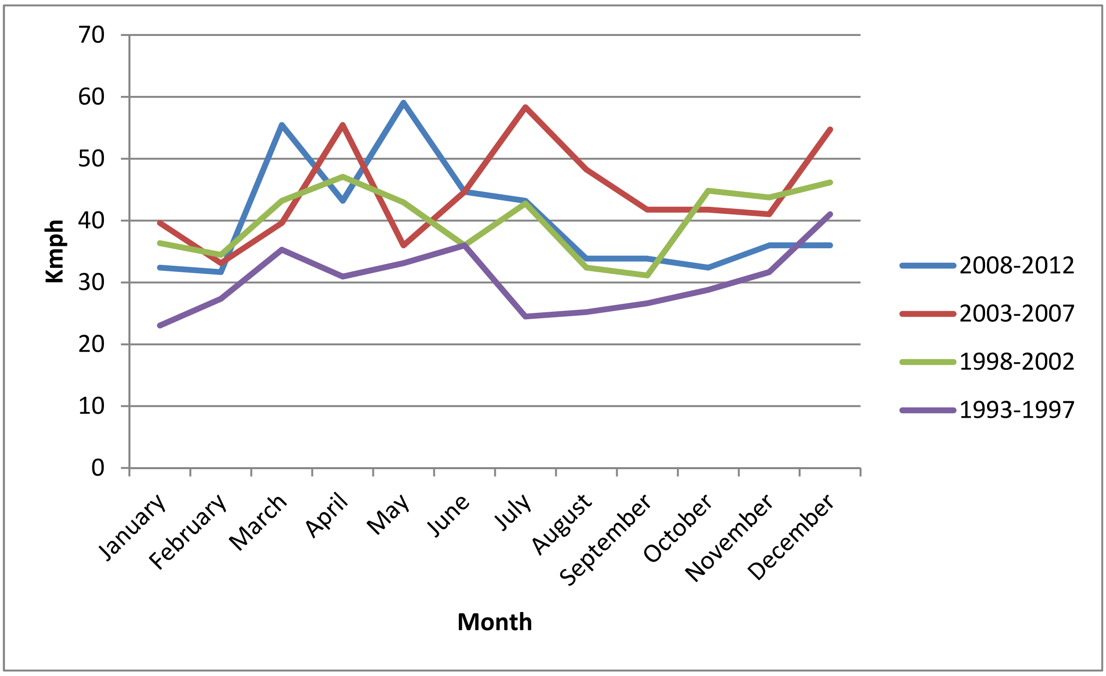

Figure 17: Wind speed in Pakse

In order to analyse wind speed, the team grouped together the monthly maximum wind speed by clusters of five years; 1993-1997, 1998-2002, 2003-2007, 2008-2012.

The culmination of this is presented in the Figure 17. This grouping was done to keep the graph simple. It is hard to discern a precise trend, though it appears that the maximum recorded wind speeds at the end of the dry season and early in the rainy season are considerably higher than in the early part of the analysis. Wind speeds are more uniform towards the end of the rainy season, including in the typical "storm season" of August and September. According to most typhoon or hurricane classification systems, a tropical storm experiences wind speeds of greater than 62 kilometres per hour[17].

3.2.4 Flooding frequency

Between 1902 and 2002, the Mekong level at Pakse reached or surpassed flood level of 12m.in total, 40 times. In any given year there was a 0.4 risk of being flooded (40%).(Figure 18 hereafter).

However, the observed frequency of flooding has varied widely as you can see below in the graph. 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.

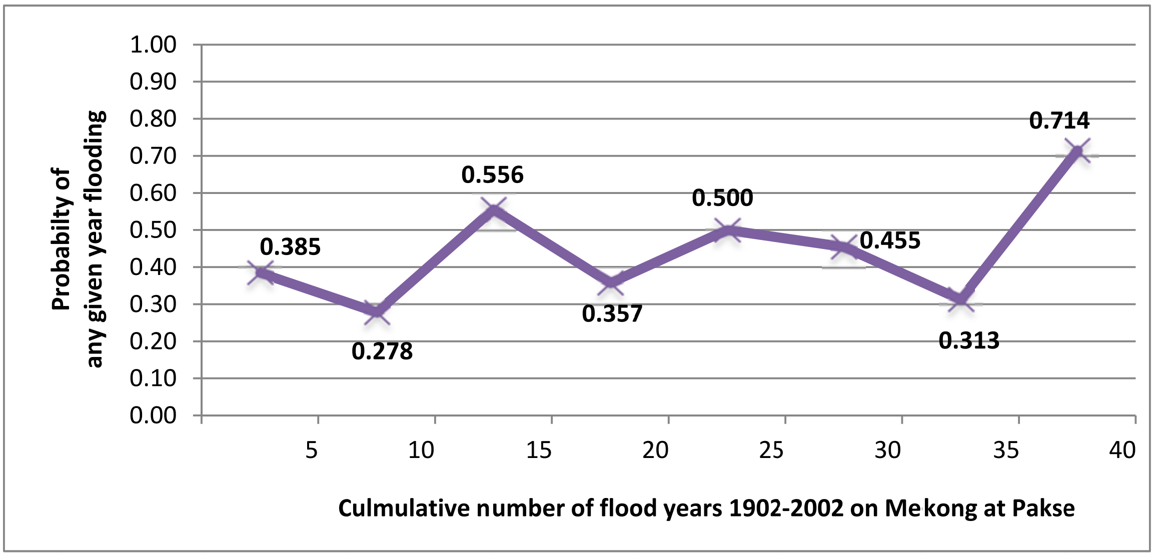

Figure 18: Observed changes in probability for any particular year at or above flood level at Pakse historical data from 1902 to 2002

3.2.5 Flooding sizes

Flooding is a significant problem for Pakse, and dominates the environmental discussions there. The Mekong River is one of the world's largest and 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.

It is important to note that flooding is an intrinsic part of river systems, with the nutrient rich sediments helpfully fertilising nearby fields and an entirely natural process. As the graph in Figure 17 clearly shows, even if we remove the 0.714 point, the probably of flooding at Pakse

[17]According to the Saffir-Simpson scale, RSMC Tokyo and the Indian Meteorological Department, Wind Speeds of greater than 62kmph constitute a tropical storm. Anything less than this is a tropical depression

from the Mekong river has historically varied between 0.576 and 0.278; with the peak probability (0.576) being more than double the lowest probability of flooding (0.278).

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

The Xe Don—Mekong river interchange is only one part of the flooding issue in Pakse. The Mekong itself can, and does, burst its banks and flood the surrounding area. 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 the city itself will have to deal with an even higher Mekong. If the water is instead diverted to below the city then it puts communities below Pakse at greater flood risk. Putting the water into the Xe Don River might instead cause more flooding in that basin.

3.2.6 Drought and Heat stress

While the temperature has 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 PDR, it has been suggested that the number of ‘hot’ days – defined as where the maximum temperature recorded for that day is more than 10% 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, the team looked at the trend in average temperatures for the three hottest months of the year –March, April and May –when temperature extremes are most likely to occur. The results of this are presented in Figure 19 hereafter.

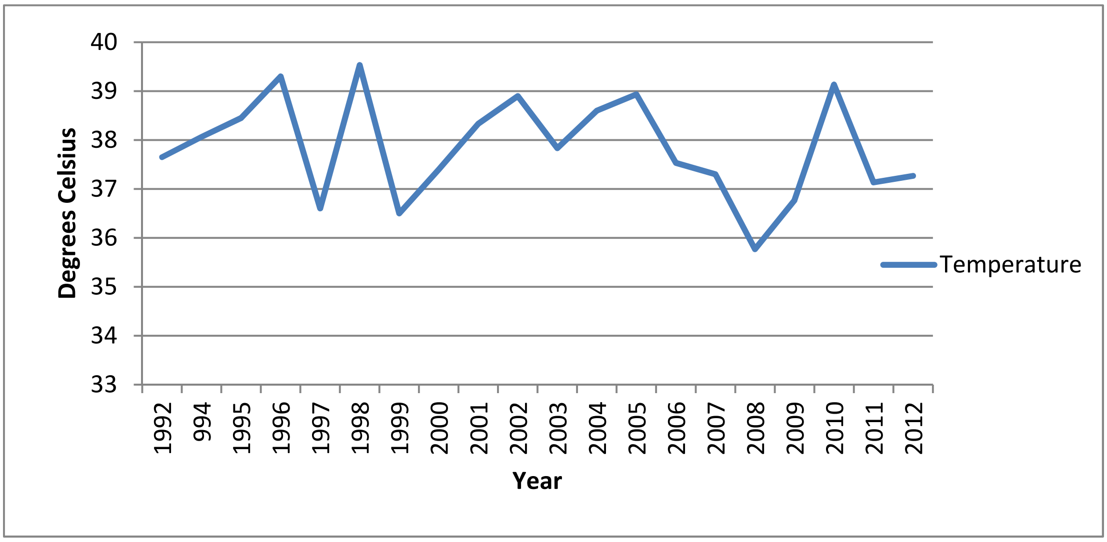

Figure 19: Trends in extreme temperatures for three month temperature (March, April and May)

3.2.7 Projections –rainfall and temperature

In order to make projections as to the future climate changes observed at Pakse, we have to predict what we expect to see in terms of emissions agreements and economic growth.

The assessment team have chosen two emissions scenarios to model for Pakse, namely B2AIM and P50.

3.2.7.1 The P50 Scenario

The P50 Scenario is a baseline scenario in which the government and policy makers do not implement any policy initiative successfully. 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 Green House Gas (GHG) emissions.

3.2.7.2 The B2AIM Scenario

The B2AIM scenario assumes that intergovernmental agreements on Greenhouse gases will emerge that by 2100 slow the emissions growth rates, and local policies will also help mitigate GHG emissions.

3.2.7.3 Where the scenarios are similar

Both B2AIM and P50 scenarios are very similar indeed scientifically as they apply the same sensitivity, which is that with a doubling of the CO2 level in the world, there will be a commensurate 3°C increase in temperature on a global scale. The two models both assume no stabilising in 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 globally an extra 1C of warming.

3.2.7.4 Main ways that they differ

The key difference between the two scenarios is that the P50 scenario assumes that government policies that reduce GHG emission growth fail to emerge and be agreed on up to year 2100. The B2AIM scenario assumes that governments will adopt a number of policy interventions.

By comparing the two scenarios B2AIM and P50 together, the goal is to see how much policy makes a difference to climate change at Pakse.

3.2.7.5 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 rain in October-November-December as the rainy season lengthens in Lao PDR. The rice harvest in Lao PDR typically takes place in October-November-December and the coffee harvest is usually November-December-January.

The increase in rainfall in December appears to be very strong indeed, and increases in rainfall have already been observed.

Table 2: Monthly precipitation forecast climate changes for Pakse within 2 scenarios: B2AIM and P50 in percentages

Year	2020	2030	2040	**2050**	2060	2070	2080	2090	**2100**
Scenario	**B2AIM**	**Precipitation (%) change from 1990 levels**							
January	2.75	3.67	4.58	**5.50**	5.98	6.84	7.69	8.55	**9.40**
February	-1.85	-2.47	-3.08	**-3.70**	-1.85	-2.11	-2.37	-2.64	**-2.90**
March	0.65	0.87	1.08	**1.30**	-1.08	-1.24	-1.39	-1.55	**-1.70**
April	-3.50	-4.67	-5.83	**-7.00**	-10.56	-12.07	-13.58	-15.09	**-16.60**
May	0.25	0.33	0.42	**0.50**	-3.25	-3.71	-4.17	-4.64	**-5.10**
June	0.05	0.07	0.08	**0.10**	6.36	7.27	8.18	9.09	**10.00**
July	5.05	6.73	8.42	**10.10**	12.03	13.75	15.46	17.18	**18.90**
August	2.90	3.87	4.83	**5.80**	3.82	4.36	4.91	5.45	**6.00**
September	1.40	1.87	2.33	**2.80**	3.50	4.00	4.50	5.00	**5.50**
October	4.55	6.07	7.58	**9.10**	9.67	11.05	12.44	13.82	**15.20**
November	3.75	5.00	6.25	**7.50**	8.97	10.25	11.54	12.82	**14.10**
December	5.40	7.20	9.00	**10.80**	7.70	8.80	9.90	11.00	**12.10**
Scenario	**P50**	**Precipitation (%) change from 1990 levels**							
January	0.60	0.80	1.00	**1.20**	-2.29	-2.62	-2.95	-3.27	**-3.60**
February	-7.15	-9.53	-11.92	**-14.30**	-2.48	-2.84	-3.19	-3.55	**-3.90**
March	1.95	2.60	3.25	**3.90**	-0.06	-0.07	-0.08	-0.09	**-0.10**
April	-3.50	-4.67	-5.83	**-7.00**	-12.98	-14.84	-16.69	-18.55	**-20.40**
May	1.20	1.60	2.00	**2.40**	-2.99	-3.42	-3.85	-4.27	**-4.70**
June	-2.15	-2.87	-3.58	**-4.30**	7.06	8.07	9.08	10.09	**11.10**
July	6.55	8.73	10.92	**13.10**	14.13	16.15	18.16	20.18	**22.20**
August	4.70	6.27	7.83	**9.40**	9.04	10.33	11.62	12.91	**14.20**
September	1.70	2.27	2.83	**3.40**	4.96	5.67	6.38	7.09	**7.80**
October	6.95	9.27	11.58	**13.90**	12.73	14.55	16.36	18.18	**20.00**
November	1.05	1.40	1.75	**2.10**	8.21	9.38	10.55	11.73	**12.90**
December	5.40	7.20	9.00	**10.80**	12.09	13.82	15.55	17.27	**19.00**

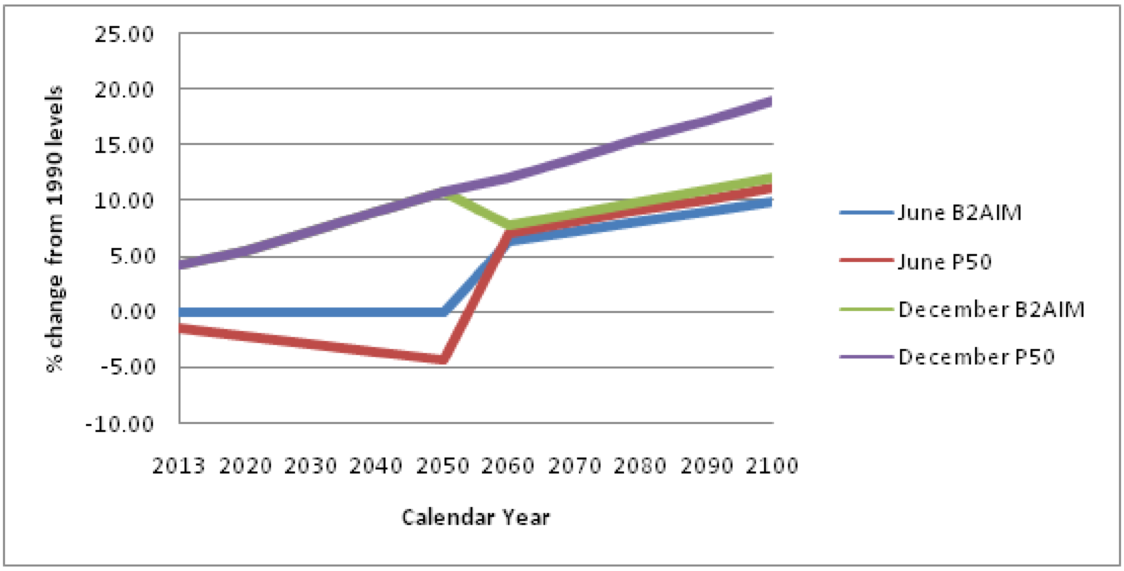

Figure 20: Percentage of change in precipitation a Pakse from 2013 to 2100

As shown in the Figure 21 hereafter, the average temperature changes are significant but there is relatively little difference between B2AIM and P50 data. This therefore suggests that policy interventions only have a modest impact on forecasted temperature changes in Pakse.

Table 3:Monthly temperature forecast climate changes for Pakse within 2 scenarios: B2AIM and P50

Year	2020	2030	2040	**2050**	2060	2070	2080	2090	**2100**
Scenario	**B2AIM**	**Temperature Change degrees C from 1990 levels**							
January	0.62	0.83	1.03	**1.24**	1.51	1.73	1.95	2.16	**2.38**
February	0.79	1.05	1.32	**1.58**	1.86	2.12	2.39	2.65	**2.92**
March	0.69	0.91	1.14	**1.37**	1.64	1.88	2.11	2.35	**2.58**
April	0.84	1.11	1.39	**1.67**	2.05	2.34	2.63	2.93	**3.22**
May	0.77	1.02	1.28	**1.53**	1.94	2.22	2.50	2.77	**3.05**
June	0.64	0.85	1.07	**1.28**	1.74	1.99	2.23	2.48	**2.73**
July	0.64	0.85	1.06	**1.27**	1.56	1.78	2.00	2.23	**2.45**
August	0.65	0.86	1.08	**1.29**	1.58	1.81	2.04	2.26	**2.49**
September	0.71	0.94	1.18	**1.41**	1.77	2.02	2.27	2.53	**2.78**
October	0.62	0.83	1.03	**1.24**	1.55	1.77	2.00	2.22	**2.44**
November	0.65	0.86	1.08	**1.29**	1.64	1.87	2.10	2.34	**2.57**
December	0.66	0.88	1.10	**1.32**	1.65	1.89	2.13	2.36	**2.60**
Scenario	**P50**	**Temperature Change degrees C from 1990 levels**							
January	0.59	0.79	0.98	**1.18**	1.70	1.94	2.18	2.43	**2.67**
February	0.74	0.98	1.23	**1.47**	1.99	2.28	2.56	2.85	**3.13**
March	0.76	1.01	1.27	**1.52**	1.79	2.04	2.30	2.55	**2.81**
April	0.86	1.15	1.43	**1.72**	2.30	2.63	2.95	3.28	**3.61**
May	0.72	0.96	1.20	**1.44**	2.20	2.51	2.82	3.14	**3.45**
June	0.68	0.90	1.13	**1.35**	1.87	2.14	2.41	2.67	**2.94**
July	0.71	0.95	1.18	**1.42**	1.78	2.04	2.29	2.55	**2.80**
August	0.68	0.90	1.13	**1.35**	1.79	2.05	2.31	2.56	**2.82**
September	0.74	0.98	1.23	**1.47**	1.97	2.25	2.54	2.82	**3.10**
October	0.56	0.74	0.93	**1.11**	1.71	1.95	2.19	2.44	**2.68**
November	0.59	0.78	0.98	**1.17**	1.81	2.07	2.32	2.58	**2.84**
December	0.59	0.79	0.98	**1.18**	1.83	2.09	2.35	2.61	**2.87**

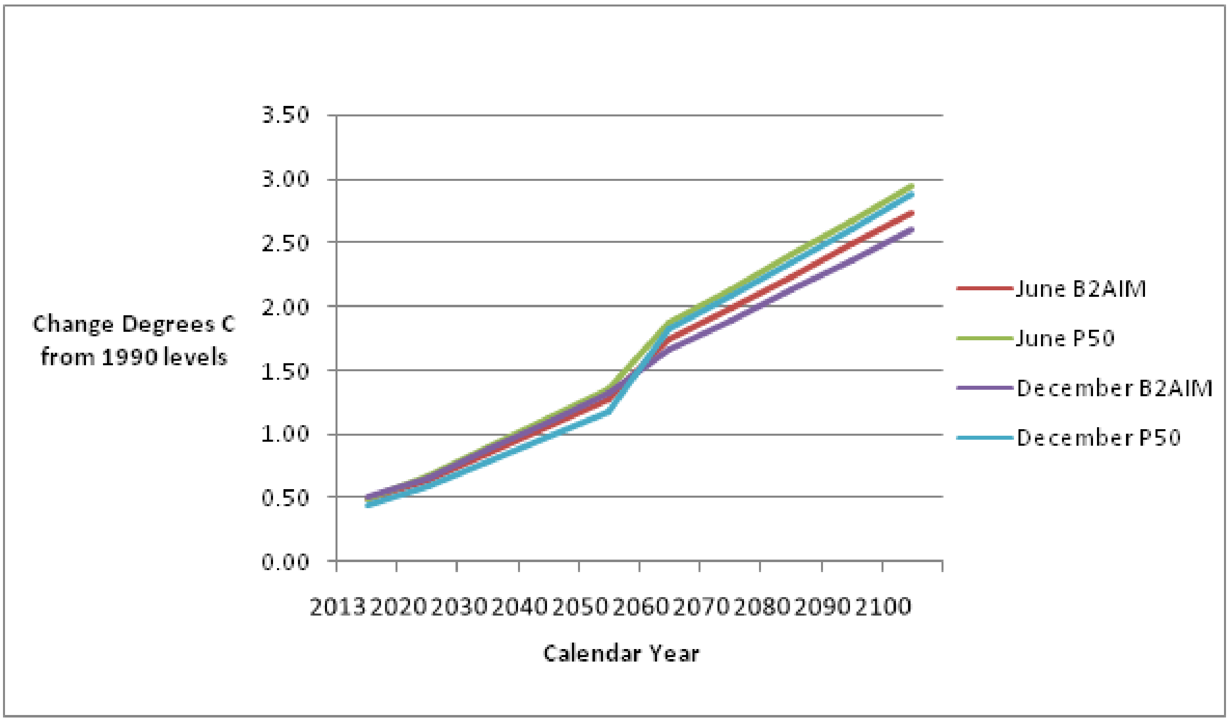

Figure 21: Change in temperature forecast from 2013 to 2100

3.2.7.6 Forecast changes in Atmospheric Pressure

The atmospheric pressure over Southern Laos is predicted to rise in coming years, and in terms of tropical weather atmospheric pressure increases are generally associated with more clear sunny weather and less thunderstorms. The Primary impact of the increase in atmospheric pressure will be more stable and nicer weather.

It is important to note that there is a prediction of increased atmospheric pressure just above Lao PDR of a magnitude greater than the increase over Lao PDR, with the atmospheric pressure over Southern Yunnan province forecast to increase by 5 Hectopascal (hPa).

This is of concern because high pressure systems have 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.

Table 4: Forecast atmospheric pressure changes for Southern of Lao PDR

Change from 1990 levels *All Units Hectopascal (hPa)*				
Scenario	**B2AIM**		**P50**	
Year	**2050**	**2100**	**2050**	**2100**
January	0.24	0.46	0.27	0.53
February	0.01	0.03	0.01	0.03
March	0.29	0.55	0.27	0.53

April	0.20	0.37	0.21	0.43
May	0.27	0.52	0.31	0.60
June	0.25	0.31	0.19	0.37
July	0.29	0.75	0.44	0.87
August	0.18	0.36	0.21	0.41
September	0.37	0.69	0.34	0.81
October	0.35	0.81	0.39	0.94
November	0.12	0.23	0.13	0.27
December	0.17	0.38	0.19	0.44
Average Monthly increase	**0.23**	**0.46**	**0.25**	**0.52**

3.3 Sensitivity

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

3.3.1 Socio-economic impacts

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

Flooding, identified as the most pressing climate-related threat to Pakse, has an impact on numerous local trade-related economic activities. At the most basic level, flooding impacts on 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 preparedness for such flooding events and has in turn built-up certain resilience to the economic impacts of this type of flooding (excepting the costs of repairs). It is in the case of longer-term flood events, such as in 2011 when the floodwaters reportedly reached 2.2m in height and lasted 3 months that this impact has the greatest effect. There is no evidence at this stage to suggest other climate-related changes beyond flooding will have an impact on local trade.

Flooding occurs solely in the rainy season when tourism numbers are at their lowest, so the impact on this source of economic activity is likely to be minimal in the short-term. However, the tourism trend shows a year-on-year increase in the number of tourists visiting Pakse, therefore the impact on livelihoods and income from low-season tourism will correspondingly increase as a factor for consideration in the future. Temperature variations are currently at a level considered unlikely to have an impact on tourist numbers. The threat of increase disease resulting from increased flooding events, as well as the potential increased likelihood of tropic storms are more likely to have an impact on tourist numbers and subsequently the tourism industry.

The current thinking about tropical agriculture and climate change is that there will be a positive impact on yields and agricultural productivity up to +2C increases in temperature. The current forecast is that Pakse will see monthly temperatures on average rise by c.0.68/0.69C by 2020 and we forecast that average monthly temperatures will increase by 1.37C 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 locally is coffee, which is grown on the nearby Bolovens Plateau, and both Robusta and Arabica coffees are planted widely. The Bolovens Plateau covers an area of around 500 km^2 with an elevation of 600m-1300m, and characteristic red volcanic soils.

For Arabica coffee to meet international quality standards, it needs to be grown at 1000m or above elevation, this is necessary for the coffee cherries to ripen slowly. The slow ripening gives the coffee its distinctive taste[18].

Climate change poses significant challenges for the coffee sector. The low-elevation Arabica coffee hugely planted in countries such as Vietnam 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. This infrastructure is shown inFigure 22 hereafter.

[18] Arabica coffee information from UN FAO Arabica Coffee Manual for Lao PDR (2005): http://www.fao.org/documents/en/detail/194344

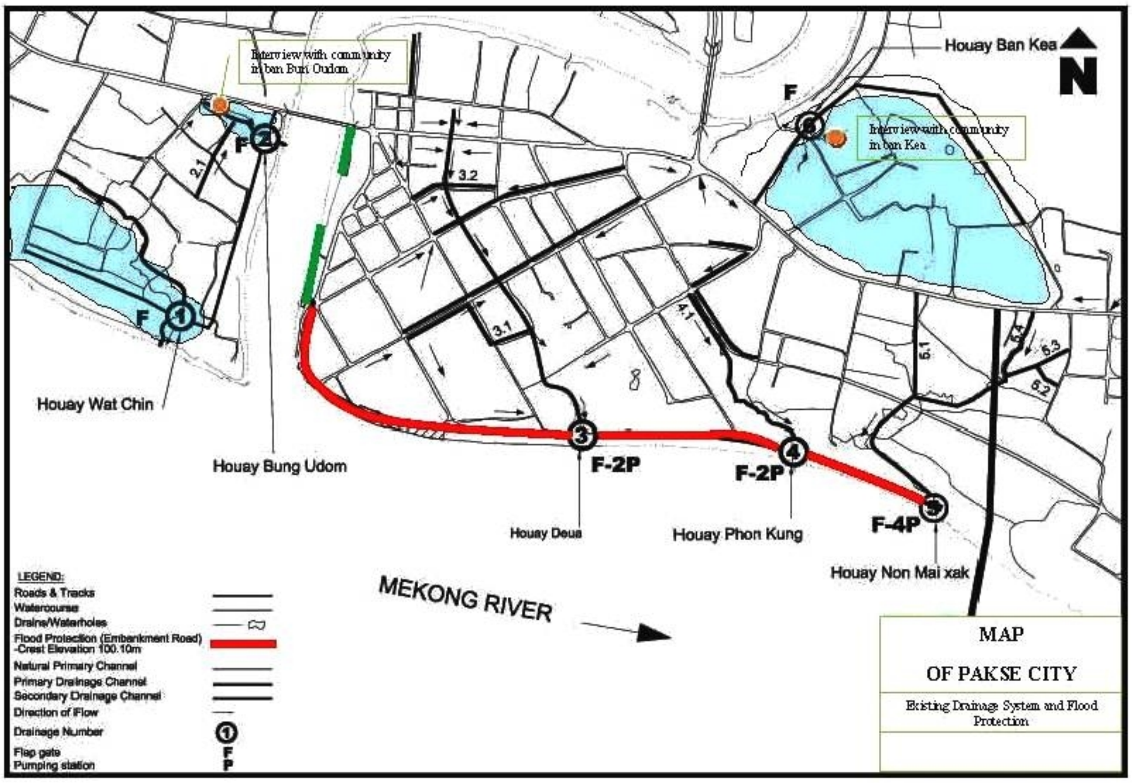

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Figure 22: Flood protection infrastructure map of Pakse

The red line is a man-made embankment which provides protection to the extensive number of homes and businesses which sit immediately behind it. The embankment is designed so that the level of the Mekong cannot go higher than it –even in mega-flood years. Even in 2011, with its very high peak water level, only around 10 centimetres of flood water was recorded in areas protected by the embankment, compared to up to two and a half metres in unprotected areas.

The green line is an area of ecosystems which were also restored during the Secondary Towns Urban Development Project (STUDP), and are providing protection on the east bank of the Xe Don. The embankments are then supported by a network of mechanical flood gates, which are activated automatically when there is sufficient water pushing against them. There are six flood gates in total, described here as numbered on the map shown in Figure 22: Gate 1 is on the north-east bank of the Mekong, and drains water into the catchment area to the north-east. Gate 2 is on the west bank of the XeDon and drains westward, close to the Ban Oudom community. Gates 3, 4 and 5 are on the south-east bank of the Mekong and (especially gates 3 and 4) are primarily designed to drain water away from the main commercial and residential areas of the town. Gate 6 is on the east bank of the Xe Don in the northern part of the town and primarily drains water to and from the catchment in the Ban Kea area.

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 their in-built mechanics and the hydrology of the river, and do not have a back-up or support system.

3.3.3 The operation of flood gates and water pumps in Pakse

1) ***Normal drainage into Mekong River at Pakse***

- Water flows down the slopes and drains
- Goes through the open Flood Gate
- Into the Mekong river
- Mekong river below flood level

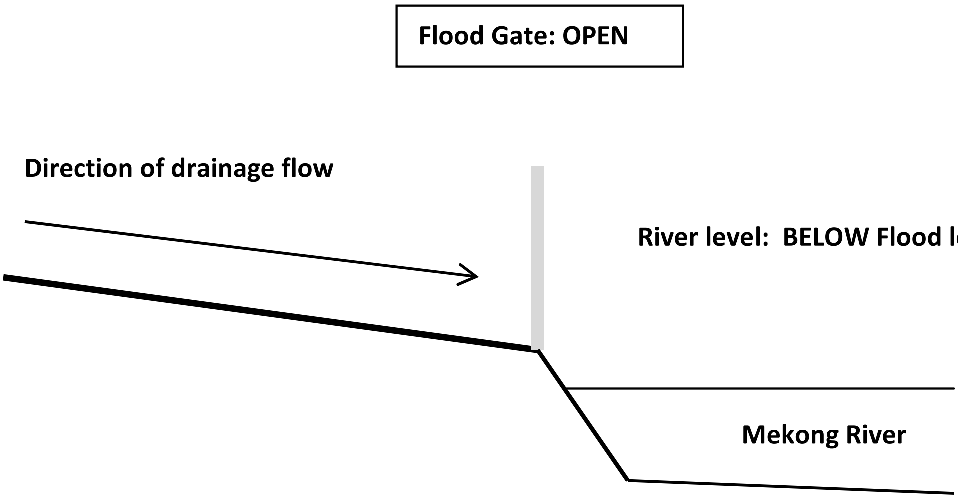

Figure 23: Flood gates operation for a normal drainage into the Mekong River at Pakse(Open gate)

2) *At flood level*

- When the Mekong River height reaches bottom of flood gate, flood gate closed
- Rainy season
- Increased volume of water draining to Mekong

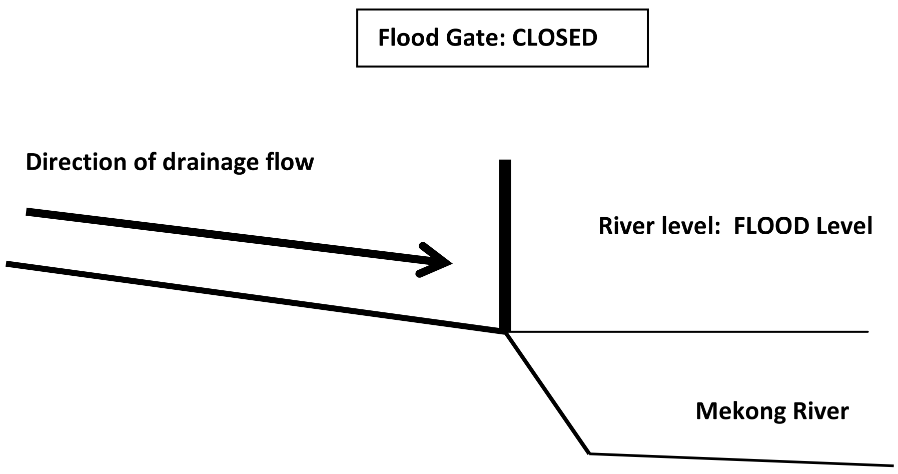

Figure 24: Flood gate at flood level

3) *During at or above flood level*

- Continued high flow toward Mekong River
- Water backs up against flood gate
- Water on both sides of the flood gate exerting high force on flood gate
- Flood gate, behaves simply like a wall
- :If gate opens, Mekong River floods Pakse
- :If gate kept closed, Pakse drainage floods Pakse

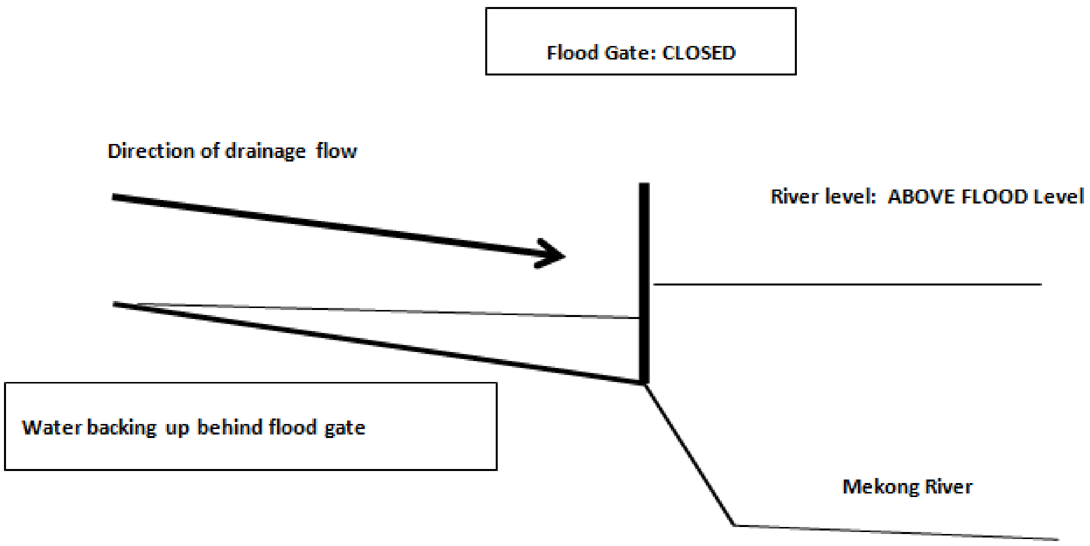

Figure 25: Flood gates during at or above flood level with water backing up behind flood gate

4) *Pumps reducing backed-up water behind flood-gates*

- Pumps next to flood gates or flood walls, allow urban managers to pump water that is below the height of the Mekong into the Mekong itself, without rising the height of the Mekong to any easily measurable extent
- A full flood pump system in Pakse is estimated to pump about 1 CUMEC at peak pump outflow, into the Mekong river typically flowing at around 28000 CUMEC
- Pumps specifically designed to pump dirty high-sediment water, turned on
- Water pumped over the top of the flood gates into Mekong river
- :Impractical to pump water through flood gate due to hydraulic force of Mekong mainstream
- Pumps both reduce flood water extent and maintain capacity to cope with high-magnitude rainfall events
- In no way at all do pumps allow river water into Pakse town, with a number of one-way valves preventing this, even if the pump fails

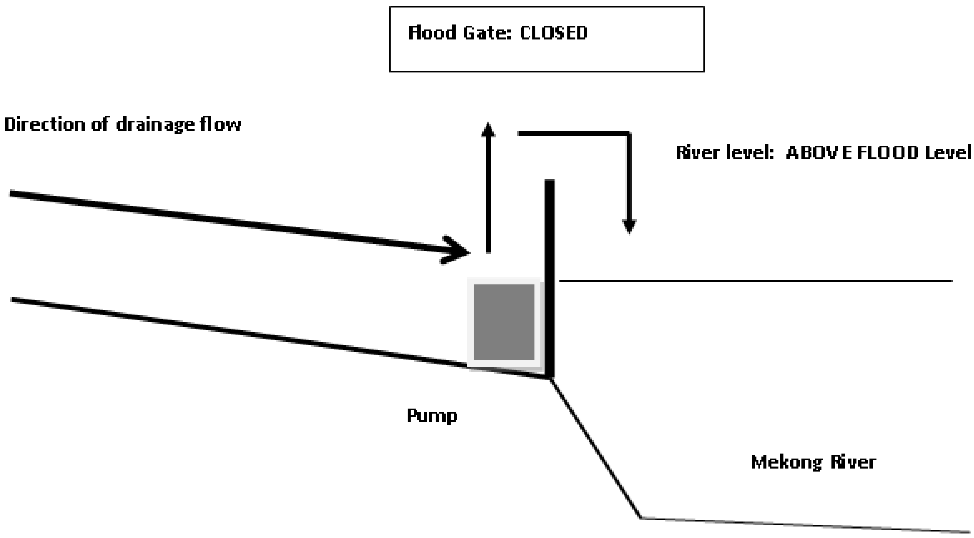

Figure 26: Flood gates with pumps reducing backed-up water behind flood-gates

Table 5: Summary table of the challenges and key mitigation factors of pump operation in Pakse

Operational challenges and mitigation for pump operation in Pakse	
Challenge	**Mitigation**
Supplying electricity to electricity to electrical pumps, when normal practice to turn off electricity in flooded areas	Connect electrical pumps to main local grid AND a secondary emergency grid, with wiring specified to cope with repeated immersion
Diesel pumps high fuel consumption and noise	- Choice between diesel or electric pumps used made after local appraisal - Noise issue mitigated by choice of modern low-noise diesel pump - Discussions with local residents about pump use
Dirty water difficult to pump because of mud and other solids in water and therefore can clog up easily	- Only dirty water certified pumps to be installed, which are designed to pump this type of water - Maintain pumps to "extreme use" manufacture guideline - Maintain good supply of spare parts and rubber seals and regularly inspect rubber seals for any signs of degradation - Training given to key maintenance staff responsible for pumps, including annual refresher training and competency checks
Cost of running pumps and maintaining them	- Special fund established to pay for operation and maintenance of pumps - Plan developed for medium/long term that these costs paid for from local taxes - Pumping system designed to be as energy-efficient as possible: o Low Friction dirty water valves used o Out-sized pipes used to minimize friction of water in pipes o where possible, avoidance of tight bends in pipes to reduce friction losses o Regular cleaning of pipes

Figure 27: Old sofa on one of the river basins showing a lack of maintenance

Another issue observed by the assessment team was the lack of maintenance of the flood infrastructure, especially the catchment areas. Housing and other infrastructure, such as expanded roads have encroached on these areas, reducing their capacity to cope with increasing amounts of runoff and rainfall. In addition to this lack of solid waste services means that, inevitably, waste ends of in the river, both large substantial items of waste, such as in the above picture and high volumes of smaller waste. This means that the flow of water to and from the catchment areas is impeded and their overall effectiveness reduced.

3.3.4 Solid Waste Management in Pakse

The Urban Development Authority (UDA) in Pakse, is responsible for planning and environmentally managing Pakse. Amongst its responsibilities is to provide solid waste management in Pakse. Around 35% 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 residents who access this service do so through their (urban) village authorities by signing a contract for waste collection. The price of the service is between 15,000 and 25,000 kip per month, depending on how much is disposed of, and collection of waste is done 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 now waste is overflowing the site according to local officials.

Regarding the remaining 65% of Pakse residents who are not able to access solid waste collection services, typically they will burn the waste outside their houses or throw it into the river[19].

As part of the proposed Asian Development Bank (ADB) " Lao People's Democratic Republic: Pakse Urban Environmental Improvement Project" they proposed that they will "*rehabilitate the entire landfill site in Ban Yong, Xanasomboun District, 17 km north of the Pakse town and upgrade the existing dump site within it to a controlled landfill standard, meeting appropriate environmental standards*[20]".

The Lanfill site will necessarily need to be expanded to meet the expansion of solid waste collection schemes, and the changes are detailed in the map below. Of particular note are the existing and proposed leachate ponds and drains, and these currently effectively prevent leachate from entering the local water table and keep it within the bounds of the landfill site.

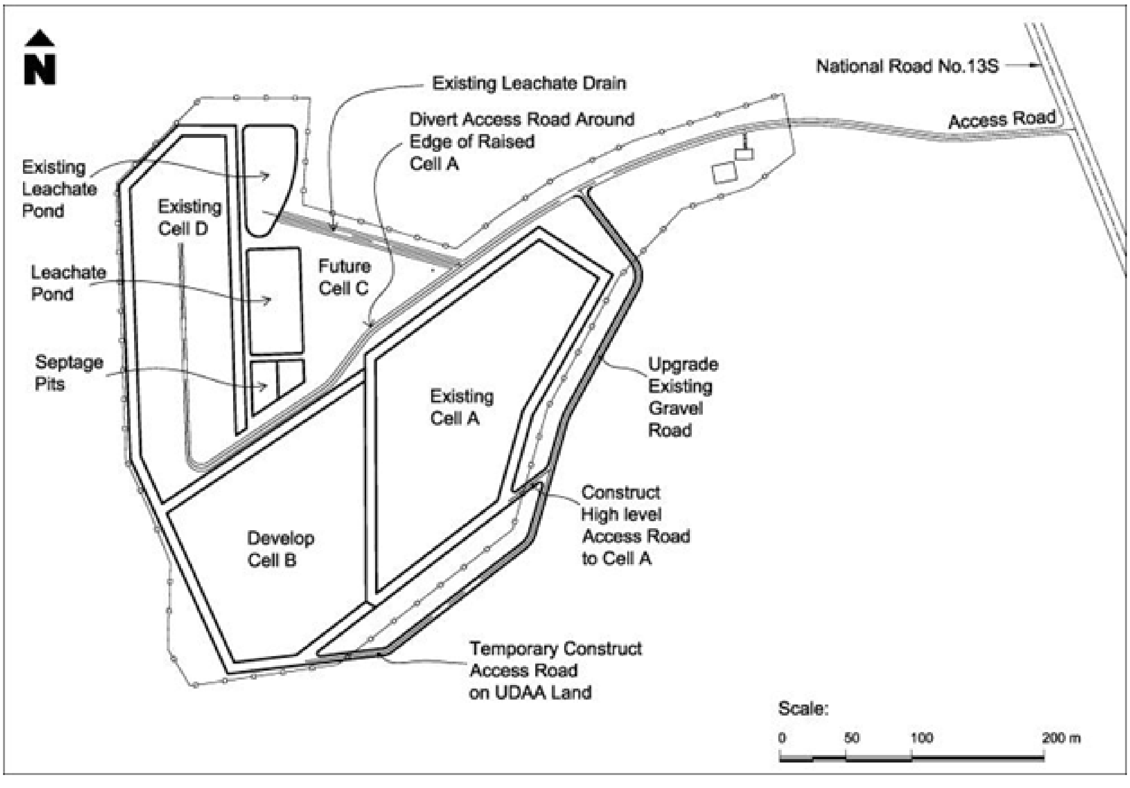

Figure 28: Current landfill site and changes proposed by the ADB

[19] Source: Assessment team meeting with UDA Pakse 9th October 2013

[20] Lao People's Democratic Republic: 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

3.3.5 Public health

Infrastructure problems do impact public health, not least because stagnant water left behind is near-perfect for mosquitoes to breed in. Malaria appears to be very much under-control in Lao PDR, 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.

Climate change impacts Public Health in a number of different but important ways and the table below is from research done on a global basis, and raises the challenging issue of climate change refugees. From a Public health situation there are two key challenges on a global basis.

1) That as climate change refugees move, they take with them diseases endemic in their home populations into new areas;
2) That by crowding together, risk of rapid disease spread is a huge challenge as they are so close together and physically often weak from travel.

The table below summarises some of the health impacts with respect to Global Climate Change.

Table 6: Global climate change and health impacts

Change	Adverse Effects
More very hot days, allergens	- More Deaths
Warming temperatures/rainfall/conditions favouring insects proliferation	- Vector-borne infections - Arboviruses (viruses spread by insects) - Malaria
Floods	- Movement of people/crowding o more infective diseases o water-borne infection - Enteric viruses, cholera
Decrease in crop yields, in fisheries	- Movement of people/crowding - Viral gastroenteritis - Viral respiratory epidemics

There is a clear link between physiological stress and viral disease rates, with the physiological stress depressing the immune system which viruses then exploit. Physiological stress is most commonly caused by changes in the environment, such as at the changing of the seasons, with significant increases in animal and human disease rates and fatalities at this time.

Physiological stress does not only impact humans and animals, but also plants. The consensus in the agronomy world appears to be that around95% of all plant viruses are spread by aphids, and with respect to the other 5% they have not yet proven that they are also spread by aphids.

The diagram below explains this linkage further.

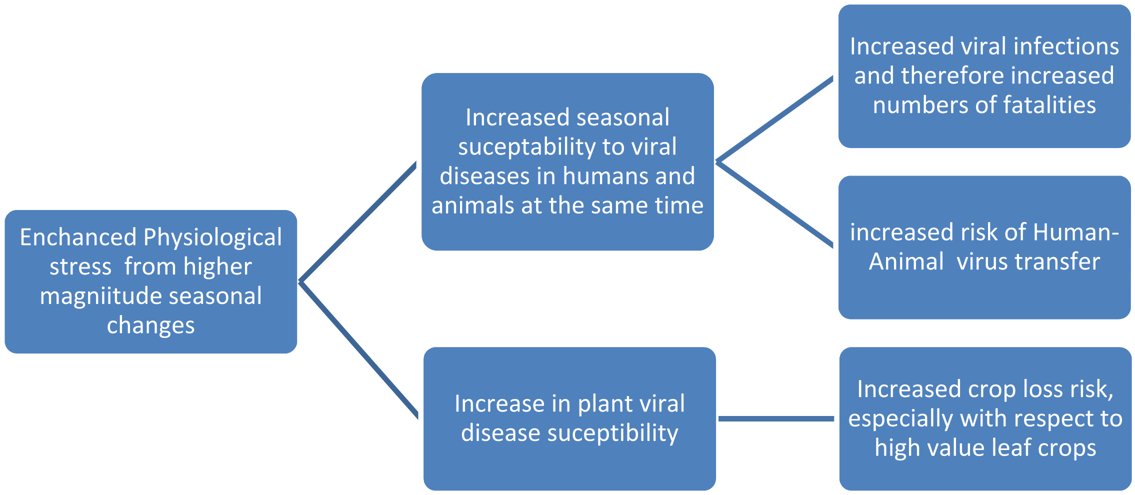

Figure 29: Physiological stress and disease in Lao PDR

The summary table below identifies which particular viruses pose the greatest emerging threats to public health in Lao PDR. It is important to note that almost all viruses listed here are vector-borne viruses, which means they are spread by an intermediary such as mosquitoes.

Table 7: Summary of emerging viral diseases in SE Asia

Name	Vector	Extent	Mortality rate	Recorded casesLao PDR	Comments
Dengue Fever	Mosquitoes	Over ½ world population at risk c. 50-100 million cases globally per year range constantly expanding	2.5%	2013: 38700 cases and 91 deaths	Currently no vaccine available. Currently no curative treatment available, but in severe cases supportive care in hospital shown to reduce mortality rates The 2013 Lao Dengue Fever outbreak recorded the highest number of fatalities recorded for a Dengue Fever outbreak in Lao PDR.
Chikungunya	Mosquitoes	Over 40 countries, including Lao PDR and rapidly expanding global and regarded as endemic in SE Asia	0%	38	Rapidly emerging disease: 1.39 Million Cases in India in 2006 with zero recorded mortalities. In 2005-2006 Outbreak in Reunion 34.3% of population impacted. Currently no vaccine Currently no treatment
Japanese Encephalitis (JE)	Mosquitoes	Endemic in SE Asia	As high as 60%, and 30% of those who survive the disease are brain damaged.	unclear but 30.000 -– 60.000 cases estimated per year in Asia	Pigs act as a super-host for JE, and therefore moving pigs away from people in endemic areas suggested as a way to reduce cases of the disease. Significant improvements noted in JE Vaccinations. However, JE remains the leading cause of Viral Encephalitis in Asia Strong warning from WHO about pig rearing in irrigated rice areas: “Certainly, the introduction of pig rearing as a

					secondary source of income for rice-growing farmers in receptive areas must never be encouraged."
Swine Flu	Close contact between pigs and pigs, and pigs and humans, and humans to humans in some Extent-Global?	During pandemic in Asia in 2009, 395.000 persons infected, 2.100 deaths; 242 cases in Lao, 1 death	Very low	1 during 2009 H1N1 pandemic	Includes H1N1 strain, but a number of other swine flu strains are also well known. Key risk factor is close contact with pigs. Pandemic emerged (in 2009) when a H1N1 strain became transmissible from humans-to-humans.
Bird Flu	wild birds appear to be key vector	Around 60% of humans known to have been infected with the current Asian strain of HPAI A(H5N1) have died from it	59% globally	2 with 2 deaths in 2007 (additional source for SEA with no mentions of Lao)	Scientific Name: H5N1. Birds within H5N1 typically die within 48hrs of infection observed. No human-to-human transmission observed. Close proximity to infected birds is key risk factor for bird-human transmission.

3.3.6 Impact of diseases in Pakse and management options

Drastic weather changes affect epidemic diseases directly and indirectly. Concretely, changes in temperature and precipitation among others have facilitated disease emergence[21]. The seasonality of infectious diseases is more worrying in summer in tropical areas is when the main factors are optimum for a quick outbreak. For bacteria diseases, most of them grow preferentially above 15C. The main group is *Vibrios.* They are responsible of a wide range of infections, from cholera to gastroenteritis-like symptons[22].

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 asin waterand soil. Direct contact between people is mainly due to crowded places which spread the agent quickly. Water-borne diseases are an important focus area of disease research. Extreme changes in water levels or temperatures increase boost vector populations with timing and niche creations. Human exposure to waterborne infections increases by contact with polluted drinking water, floods or food.

According to WHO, 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% of waterborne outbreaks, globally occur as a consequence of heavy rainfall events[23]. The risk of diarrhea is low unless there is a significant movement of people. The floods can cause a river water pollution from the sewage treatment plant which can lead to gastroenteritis and cholera in worst cases. Leptospirosis, a zoonotic bacterial disease, is an epidemic-prone infection transmitted directly from contaminated water. Transmission occurs with direct contact of skin or mocous membranes with water, vegetation or mud contaminated with rodent urine. Flooding spread the organism due to rodent proliferation.

Being not very common, people handling corposes may have a risk of getting tuberculosis aerosolized ballicus from lungs, gastrointestinal infections (E.coli, typhoid/paratyphoid fevers. Hepatitis A, shigellosis and cholera) from leaking faeces via faeco-oral route through direct contact with body and soiled clothes[24]

The caseof Pakse is a clear example of disease being spread after severe flooding occurance. Flooding for 3 months with high temperatures allow the high growing rate of vector which propague vector-borne diseases. People are kept in the same room for long periods, isolated

[21] Does Climate Change increase the risk of disease? Analyzing published literature to detect climate-disease interactions. Hoverman, J. T. (2013)
[22] Nature Climate change. Chemistry views (2012) http://www.chemistryviews.org/details/news/2360421/Climatic_Change_Causes_Bacteria_Outbreak.html
[23]The association between extreme precipitation and waterborne disease in UN.Curriero F.C. (2001)
[24] WHO http://who.int/hac/techguidance/ems/flood_cds/en/

by the sorrouding and stagnant water. In these conditions, the parasites have optimal conditions for spreading and also development. In 2013floods affected a large number of people as well as livestock. Runoff of manure into watersheds causes increase microorganism proliferation which can affect both human beings and animals. There is an advantage and a disadvantage with the fact that animal breeding is not usually enclosed. On the one hand, non-intensive animal rearing reates prevent zoonosis. However, once the floods comes even with a few parasites more risk and ease the illness to be spread through water.

- **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
4. "10 year floods"

It could be possible to consider other parameters to include such as the predicted intensification of the seasons that will make the dry season drier and the wet season wetter, but these changes are forecast to occur very slowly and perhaps only really noticeable after 2050. Likewise, we also looked at the issue of the rainy season finishing later, but again this is changing slowly.

Table 8: 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 markets
	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
“10 year floods”	Areas of Pakse flooded out with 2.5m deep floodwater that remained for 3 months in 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
		Houses unliveable as floodwater reached 2nd floor, travel only possible by boat to visit their own 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.

- **Scale of impact 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 flooding in Pakse remains a great challenge for the residents affected.

Table 9: Scale of impact 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 house	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
“10 year floods”	Areas of Pakse flooded out with 2.5m deep floodwater that remained for 3 months	Significant infrastructure damage to buildings, roads, and local water and	Expensive structural repairs and rebuilding

	in 2011 floods	electricity infrastructure, and to local shops and businesses	

- **Scale of impact on places**

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

Table 10: Scale of impact 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
"10 year floods"	The 2011 floods in Pakse saw affected areas inundated with flood water for 3 months, with flood waters typically at 2.5m depth	Significant damage to buildings in affected areas.	Lengthy and expensive rebuilding once floods eventually left affected areas

- **Scale of impacts on institutions**

Governmental institutions in Lao PDR continue to significantly grow in capacity and operational effectiveness, and will continue to need to grow their capacity further to cope with forecast climate changes.

Table 11: Scale of impacts on institutions

Change	Primary Impact	Secondary Impact	Tertiary Impact
Increased Temperature	Hotter and drier especially towards end of dry season	Damage to buildings at end of dry season including damage to building foundations	At risk groups, such as the elderly and hospital patients at risk from high interior temperatures causing potentially fatal physiological stress/heat stroke
Fewer rainy days but more rain per rainy day	Increased risk from heavier rain and therefore more flash flooding	Premature roofing failures, increased flash flooding and structural damage (from higher magnitude of forces applied to existing structures)	Reduce service provision for local population in areas such as education and administration
Annual Flooding in vulnerable parts of	Degrading infrastructure from	More structural building failures, small	Increased disease issue from water not draining

Pakse	frequent floods damaging the stability of the affected areas	landslips, and drains no longer aligning	properly leading to more mosquitoes
“10 year floods”	With all the key institutions located out of the flooded area, institutions are able to provide support and coordination	Security issues with so many uninhabited houses with family belongings on top floor	Given severity of situation, local institutions provided help and support effectively and communicated well in the previous 10 year flood, in 2011

The key theme reflected in this section has been that Climate Change is intensifying the seasonal changes and weather conditions. It can be seen 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 due to get even hotter.

The core secondary theme reflected in this section is that coping with climate change is going to be very expensive indeed financially.

- **Triggers and thresholds**

The dominant issue that Pakse faces in terms of change is the continual issue of flooding and flood levels. The chart below is a chart of the maximum height recorded annually of the Mekong River inPakse between 1902 and 2002. The red line is the 12n 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.

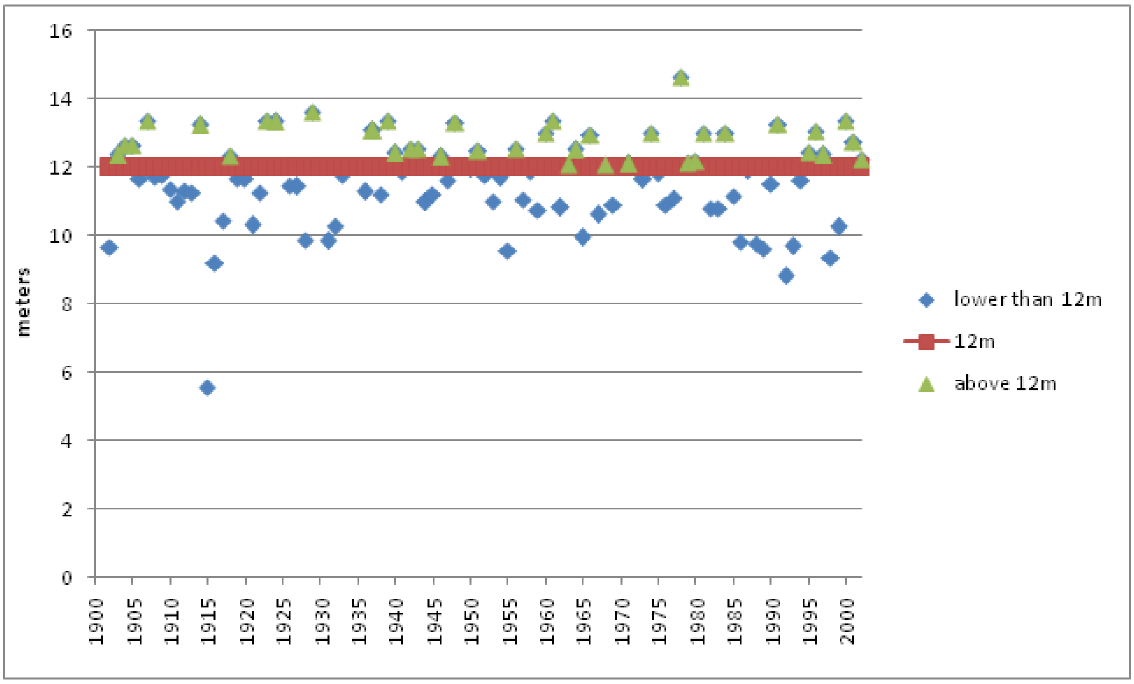

Figure 30: Mekong maximum levels for 100 years, from 1902 to 2002

Table 12: Triggers and thresholds

Trigger/Threshold	Change caused by reaching this trigger/threshold	Likelihood of reaching this trigger/threshold	Threat level evaluated as
More than 2 C warming	Rapid reduction in food production	Climate modelling outputs currently stating that: no single month at Pakse will average +2C warming before year 2060	**LOW**
Mekong River at Pakse above flood level (12m)	Flood waters stay for 3 months	Infrequent, estimated at one time per 10 years	**MODERATE/HIGH**
Mekong River at Pakse above flood level (12m)	Flooding of parts of Pakse, especially areas between Pakse International Airport and the Mekong river	Very frequent occurrence, at least once per year	**HIGH**
Mekong River at Pakse above flood level (12m)	Flooding of parts of Pakse, especially areas between Pakse International Airport and the Mekong river	Very frequent occurrence, at least once per year	**HIGH**
Flow to Mekong River and Xe Don River in excess of local drainage capacity	Localised flooding coming from the land side and not the Mekong as water from land drains to the Mekong	At least once per year	**HIGH**

Flood gates not working	Flood gates were intentionally installed to stop the most vulnerable areas of Pakse from flooding,	Flooding common (at least 1x per year) in areas of town with flood gates not working	**HIGH**

Case Study: The Story of Madame Hong

Madame Hong lives in Central Pakse with her family, in a flood-prone area. She and her family run a small ice-making enterprise alongside their house.

Almost every year their house gets flooded but only for a few days. However, in 2011 the floodwaters reached 2.2m in height and lasted 3 months. Many schools had to shut, electrical systems disconnected and people were not able to access the market.

Fortunately, Madame Hong and her family were able to safely evacuate and stayed with relatives in the nearby town of WatPhu. The family often checked in on the house using a small boat, and nothing from the house was stolen.

The cost of repairing their house and business was high, with the ice making facility alone needing 10,000 Baht of repairs. The upright posts of their house can cope with about 1 month of inundation without losing strength, as Madame Hong explained to us, but after 3 months of inundation, many structural repairs were needed.

We were told by Madame Hong that in total 50 households were affected in this way in her urban village (300 people).

- **The cost of business as usual**

Now that impacts have been established, this section aims to understand the costs of taking no action. Because data collection has been challenging, this estimate only considers one sector, housing damage, and the costs if no action is taken. Broader estimates for other sectors are not widely available, making quantifying the cost of no action in other sectors much more difficult.

The damage to housing as a result of annual and 'mega' flooding can be calculated based on damage (in dollar terms) estimates given to the team by the Department of Public Works and Transport. The estimations are organised around two assumptions. Firstly, it is assumed that there will be one flood per year. There can, of course, be several or no floods in a year, however, interviews with communities and local government suggested that households are affected by one flood per year.

Secondly, based on Mekong River flow data presented earlier, it is assumed that there will be one 'mega flood' once every ten year period (the last of which was in 2011). This estimation is based on observations over time.

The Department of Public Works and Transport informed us that an estimated US$1,000-1,200 of damage per household is recorded on average during a flood event. Based on this, and an estimated average household value of US$3,000, the percentage of housing damage per year is calculated at approximately 36.6%: or more than one-third of the average total cost of a house. Given there are approximately 750 houses in the affected area, over a five year planning cycleperiod this adds up to a total cost of US$4,125,000. A mega flood which assumes total loss of the houses in the affected area will result in US$2,250,000 of damage for each occurrence.

While this of course does not give a complete picture of the cost of business as usual, it gives a clear indication that, in this sector, the cost of taking no action is very high indeed.

Table below shows that, if the assumptions and local estimates are correct, there is US$825,500 of damage in a regular year.

Table 13:The cost of business as usual in the housing sector

Hazard	Indicator	Number of Housing Units	Unit cost (US$)	% Damage (100% = full loss)	Est. total value of damage (US$)	Flood cycle	Damage per planning cycle (5 years)
Annual Flood	Housing Units	750	3,000	36.6%	825,000	1 per year	4,125,000
Mega-flood	Housing Units	750	3,000	100%	2,250,000	1 every 10 years	n/a

3.4 Adaptive Capacity

Champasak province is the economic centre of the southern region in Lao PDR, fuelled by expansion of the agriculture and service sectors. This province in particular works hardly to reduce poverty and to improve rural areas[25]. The infrastructure development in urban and rural areas as well as linking urban and rural areas is one of the core elements of urban and rural poverty alleviation. Consequently to this, Pakse, the provincial capital, is the most important and developed city. It counts with an airport with daily regular flights from Vientiane, Bangkok and Siam Reap (Cambodia). It experiences an unprecedented construction boom and a rapid growth in domestic and foreign direct investment due to the proximity to Thailand, Cambodia and Vietnam.

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'.*[26]

[25] http://provincedechampassak.free.fr/champasakprovincedechampassak/pdf/pdfeng/investmentbrochureinchampasakprovince.pdf

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

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.

An example of some of the data requirements for these determinants is listed against three different response types in Table below.

Table 14:Adaptative capacity determinants

Determinant	Institutional/city	Community	Autonomous
Wealth	National percentage above the poverty line US$1.25 (PPP):66.2% (2008)[27]	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%[28]	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)[29]. National internet users per hundred people 9 (2011)[30]. 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 Thai Baht (c.$62 million USD) sales in Laos by 2015[31,32].
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 c.35% of households have access to solid waste collection services in 2013[33]. Nationally 63% of population have access to improved Sanitation Facilities (2010)[34]		

[27] World Bank
[28] http://www.mfwglaopdr.org/media/eng/BoL_MF%20Statistics%202013.pdf
[29] UNSDIR Country Assessment www.unisdr.org/files/33988_countryassessmentreport**laopdr**.pdf
[30] World Bank
[31] http://www.nationmultimedia.com/business/Siam-Kubota-eyes-Asean-expansion-via-units-in-Camb-30213334.html
[32] 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.
[33] Field visit to UDA-Pakse on 9th October 2013-11-22
[34] World Bank Lao data

Information	Ministry of Information, Culture and Tourism. Ministry of Post, Telecom and Communication. KPL –Lao News Agency35	Radio: 49 Radio Transmitters (2012) TV: 34 TV Transmission places (2012)[36]	Number who use radio/TV, read newspapers, etc. In 2012, 9.1 million newspapers and 2.7 million magazines were produced in Lao PDR[37]
Infrastructure (and housing)	National percent 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)[38] Urban People Access to improved water source: 77% (2010). National access to electricity: 71% (2010)[39]	Affordable building materials easily available in Lao PDR, including low-priced power tools; such as circular saws.
Social Capital	Social safety nets. The city occupies 140 km2 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 an economic upturn for the region. A large duty-free shopping area at Vangtao Chongmek border is under construction. Lao Brewery Factory/Champasak branch[40].	Nationally more than 4,000 Buddhist Temples (locally called Wats) Lao Disabled women centre in Vientiane Handicraft association	Pakse has hosted the National Games International airport with daily flights from Vientiane, Thailand and Cambodia

[35]http://www.kpl.net.la/index.htm
[36] Lao Statistical Yearbook-2012, Lao Statistics Bureau, Ministry of Planning and Investment
[37] Lao Statistical Yearbook-2012, Lao Statistics Bureau, Ministry of Planning and Investment
[38] World Bank Lao data
[39] World Bank:
http://web.worldbank.org/wbsite/external/countries/eastasiapacificext/laoprdextn/0,,contentmdk:22858227~pagepk:141137~pipk:141127~thesitepk:293684,00.html

Gender	Percentage of National Population women: 50.04%. Nationally 5% of Lao Households are Female-Headed Households (FHH) compared to 20% in Cambodia and Vietnam[41]	Percentage of Champasak Province population women: 50.31%[42]	

40 http://provincedechampassak.free.fr/champasakprovincedechampassak/pdf/pdfeng/investmentbrochureinchampasakprovince.pdf

41UN FAO 2012 http://www.fao.org/fileadmin/templates/rap/files/meetings/2012/121113_the-fao-gender.pdf

42 From Lao Statistical Yearbook 2012, Lao Statistics Bureau, Ministry of Planning and Investment

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, women, men, children, minority groups, trades people etc.

3.4.3 Autonomous

Autonomous adaptive capacity refers to the ability of people, organisations and environments to adapt separately and independent of external influence. 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.

4 HOTSPOT AREAS

The constant feedback obtained from government officials and residents has been that flooding is perhaps the biggest issue for Pakse and its future development. Therefore areas currently at risk of flooding are areas close to the Mekong and Xe Don rivers, subsequently these are the hotspot areas for the City of Pakse with respect to climate change.

Figure 31 below shows the most susceptible areas to flooding from the flow of the Mekong and Xe Don rivers. The most susceptible areas to flooding indicated on the Xe Don banks are not only affected by increased flows in the Xe Don, but also by the flooding Mekong. As the overpowering hydrological effect of the Mekong flow pushes water up into the Xe Don it combines with the Xe Don's own water volume to breach the bank—most commonly at the points indicated.

Figure 31:Flooding hotspots

Figure 32 below shows the areas area within the Pakseregion most susceptible to the spread of flood-related diseases (the light-pink shaded area). As already seen in the chapter of the present report on Public Health, flooding increases the spread of diseases and infections (mainly bacterial). The susceptibility of these areas takes into consideration account population numbers, flooding events, drainage as well as the opinions of local residents.

Figure 32:Flood-related disease risk area

Figure 33 hereafter shows the water flow during flash flood events resulting from heavy rain on the mountainous areas surrounding Pakse city. The arrows represent the path the water can follow during very intense rainfalls through the steepest sloped gorges. As can be seen, 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. The result of this is incidence of flash flooding during the rainy season in Pakse city. The Phou Xieng Tong Nationally Protected Area (NPA) is located due north of the City and crosses over into Salavan Province and east of Pakse is the Dong Houa Sow National Biodiversity Conservation Area (NBCA) and both have an important role of retaining water from heavy rainfall events. This reduces the flash flooding magnitude and such areas should be seen as an intrinsic part of the hydrology of Pakse.

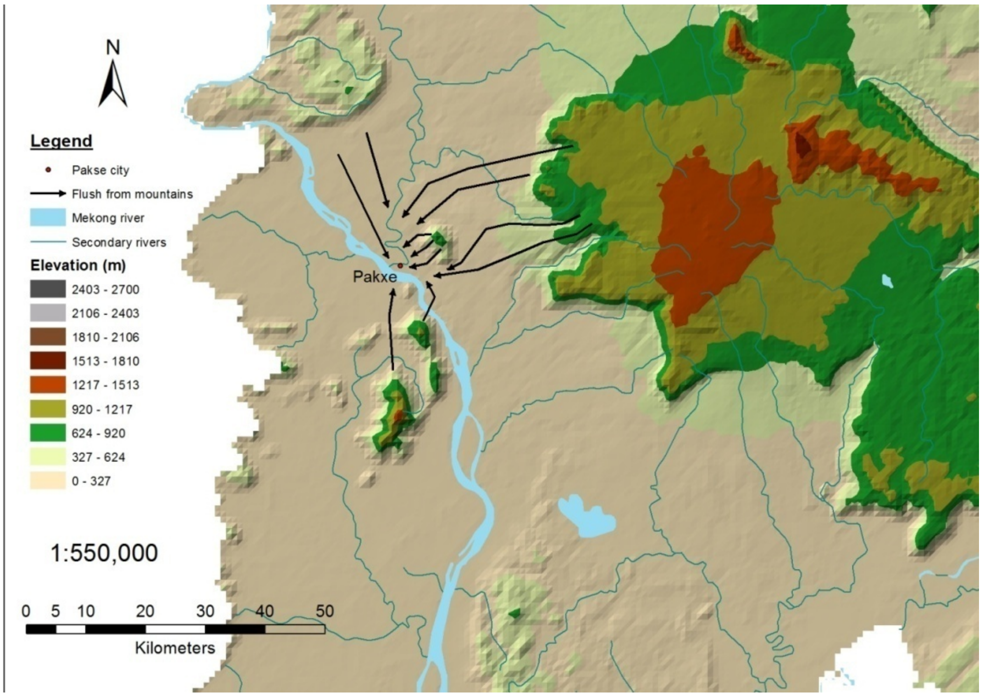

Figure 33:Flash flooding direction of flow

5 POSSIBLE 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
   - Channelization of 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 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 city
   - Enhanced vaccination programs for humans and animals in advance of season changes

5.1 City adaptation 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, we had drawn herethree individual scenarios for Stakeholder consultation.

5.1.1 Proposed adaptation strategies for further consultation

We have identified three strategies for adapting to the vulnerabilities addressed, for consultation with key stakeholders. Out of the consultation with these stakeholders, we hope to better understand their own preferences for adaptation. We will make it clear that they can select attractive features from different strategies presented, and we are not asking them to sign up to just one of these 3 strategies.

Strategy 1: Autonomous Adaptation Only

When talking with flood affected residents it is very clear how well they have coped with the recently frequent flood. None of the residents mentioned any desire to move away from the area because of the flooding. We also saw many small adaptation measures such as the family that had a flat bottomed canoe tied to the side of their house for use in floods.

The communities affected by the serious flooding, clearly showed strong levels of resilience and were impressive in coping with the regular floods extremely well.

However the key change they told us they wanted locally is 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.[43]

Strategy 2: Managed flooding

It is well documented and described, the areas that are actually at risk from flooding frequently in Pakse. In addition, with some simple terrain mapping it is possible to identify areas that would be affected by severe and infrequent floods.

This approach would be 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. In flood-prone areas, plant flood-tolerant trees and native plants as a flood barrier and reduce soil erosion.Enhance local government and community capacity to improve local services such as solid waste.

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 change in Pakse to achieve this.

The 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.

Table 15 hereafter shows the three proposed adaptation strategies (attached as annex):

[43] 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”.

6. RECOMMENDATIONS AND CONCLUSION

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.

Table 15: Proposed adaptation strategies for further consultation

	Strategy 1 Autonomous Adaptation Only	Strategy 2 Managed Flooding	Strategy 3 Engineering Focused Approach
Approach	The communities most clearly affected by flooding continue to live in the areas they live in and have learnt to adapt to the frequent flooding they experience. Though they are able to move to different areas they continue instead to live where they are living and adapt to the flooding. Faced with these challenges, the community itself have found ways to cope with the changes. The community itself adopts climate change adaptation approaches that are affordable, acceptable, and sustainable with strong community "buy-in".	The communities are helped to get away from areas that are at risk of flooding in future.Between 1902 and 2002 the highest level of the Mekong recorded was in 1978 at 14.63 metres and this was the only year in which the Mekong River at Pakse was recorded at being more than 14m in height between 1902 and 2002. This approach would re-zone the City of Pakse so that anywhere that would be flooded at a Mekong River height of 15m is classified as unsuitable and residents supported to move to a lower-risk location. And new developments would also have to adhere to the same standards. Areas unsuitable for development, planted with inundation tolerant local plant species to provide a natural buffer zone and recreation land for Pakse City residents.	Focussed around hard engineering solutions such as flood walls and intentional flooding of areas north of Pakse at peak storm flow, this approach has the goal of Pakse only flooding statistically one time per hundred years.At various key points a combination of flood gates and fixed electric pumps enable the City to get rid of any inundation that does occur. Significant investment is made also for rebuilding and enlarging the current drainage system. Therefore Pakse can be seasonally unaffected by flooding and climate changes to the benefit of all its residents.
Positives	Requires limited external investment. Community ownership strong. Possibly very similar performance to other scenarios but much cheaper and more community involvement.	Focussed on passive response and adaptation. Once established, very limited on-going costs. Strong focus on soft-engineering to cope with climate change in Pakse.	Stopping the flooding that is currently occurring almost every year in Pakse. Residents to not need to relocate. Permitting development on land previously unusable because of flood risk.
Negatives	Community unlikely to be able afford hard engineering such as flood walls and flood gate	Expensive to relocate urban communities away from the at-risk areas, especially if	Requires significant funding to go ahead, as hard engineering very expensive indeed.

	systems. More expensive for community, in terms of paying for infrastructure and modifications required. Social sustainability issues as perception that the "community paying for a problem they did not create.	householders do not want to move. Difficult to ensure that land vacated because of climate change is not sold on for development at a later date. Very hard to make this process be understood and supported by affected communities.	Difficult to prove that this approach is significantly more effective for Pakse than the other scenarios proposed despite its high cost. As communities in Pakse appear to be adapting autonomously to climate change unclear as to whether this approach actually meets a real community need.

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 report is published as abridged report and can be accessed online: http://unhabitat.org/books/95406/ 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.