Kingdom of Cambodia

Nation Religion King

TA-8179 CAM MAINSTREAMING CLIMATE RESILIENCE
INTO DEVELOPMENT PLANNING – PACAKGE A (45283-001)

Scoping Vulnerability Assessment and Adaptation Planning Training Workshop

Date of training: November 18-20, 2015
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Location: Battambang Province, Cambodia

Prepared for: Asian Development Bank
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SUMMARY

This three-day training on vulnerability assessment and adaptation planning was held from 18 – 20 November 2015 in Battambang, as the first in a series of VA & AP trainings under the Phase 2 of the SPCR Programme TA Package 1. About 75 participants attended the training drawn by each ministry sectors with 4 persons from MOWRAM, 4 persons from MAFF, 5 from MPWT, 3 from MRD and 22 from other agencies such as MoE, NCDRM, MEP, MoP, MoFA. A good representation came from departments in Battambang province and municipality who had been involved in the earlier study on climate resilience of Battambang city in the ADB TA 8186-REG: Climate Resilience in Cities.

The first day of the workshop consisted of the formal introductions and objectives of the training. This was followed by an overview presentation of the climate risks and vulnerability of Battambang City, and then presentation of three infrastructure assets that had been considered under the Climate Resilience in Cities study of Battambang – 1) Riverbanks situated along Sang Ker River in Battambang city, 2) the Railway station area, Tuol Ta Ek village, and 3) Kampong Seima Irrigation Canal. The latter was taken as the focus for more detailed VA & AP training exercises. The afternoon of the first day was dedicated to a site visit of the Kampong Seima Canal and the collection of baseline data about the canal, its surrounding area and condition.

The Kampong Seima Canal is considered of strategic importance for the overall resilience of Battambang City because in addition to its original irrigation function, it receives run-off and flood waters from the urban areas to the east, and waste water drainage and sewage disposal. In some areas slum houses have been constructed over the canal and it has also been put underground through a temple grounds. It is also used for fishing and recreation, and the road alongside the canal provides access around the west side of the town. It is in urgent need of rehabilitation to make it perform these functions effectively, and provide enhanced resilience for the City.

The second day consisted of a number of working group sessions, interspersed with presentations about carrying out the different stages of VA & AP. In the morning the baseline conditions of the Kampong Seima and its components were discussed, followed by vulnerability assessment steps. The final session of the day consisted of an introduction to Adaptation planning and a documentary video of Bioengineering.

The third day consisted of presentations of examples of adaptation measures in the different sectors – agriculture, water resources and infrastructure, and the GIZ funded urban planning project in Battambang. This was followed by working group sessions on Adaptation Planning with feedback and looking forward to the next steps. It is suggested that the Kampong Seima Canal rehabilitation be developed as one of the adaptation project proposals to be prepared through the SPCR programme - an idea which is strongly supported by the Battambang municipal government. Because it is a multi-sectoral project it is suggested that this project proposal would be led and coordinated through the Ministry of Environment. The results of the working group sessions are included in the appendices and these will be used in developing the feasibility study further.

An evaluation of the training programme was generally very positive, with participants considering that they had learnt much about the vulnerability assessment and adaptation planning process. They had a number of suggestions for improvement or clarification of the process.

1 1. INTRODUCTION

1.1 PROJECT OVERVIEW

The Ministry of Environment (MoE) is the executing agency of CDTA 8179-CAM: Mainstreaming Climate Resilience into Development Planning. The TA is aimed at enhanced resilience to climate change in Cambodia through strengthening institutional and technical capacity of the government to mainstream climate resilience into development planning, as well as improving coordination among various sectoral Line Ministries, sub-national, NGOs and Private Sectors.

The TA has four outputs: (i) SPCR coordination, technical support and capacity to mainstream climate resilience into development planning strengthened; (ii) detailed feasibility studies for selected NAPA projects conducted; (iii) Civil society support mechanism established and capacity of NGOs and CSOs to mainstream adaptation and DRR into their operations strengthened; and (iv) Climate change adaptation knowledge products developed and disseminated.

The International Centre for Environmental Management (ICEM) has been contracted to support MoE for Package 1 of this TA in February 2015 covering outputs i), ii) and iv).

The TA Package 1 undertaken by ICEM, directly supports technical capacities of government staffs to mainstream climate resilience into development planning and implementation of concerned ministries. Capacity building in vulnerability assessment and adaptation planning is one of the main objectives of this TA leading to improved resilience in development projects. The training workshop is the first training for national line agencies (especially for MoE, MOWRAM, MAFF, MPWT, MRD) and other ministries involved with the SPCR projects. It was organized during 18 – 20 November 2015 in Battambang City with support of Battambang Municipality.

This training drew upon the experiences of earlier vulnerability assessments carried out with the Battambang provincial climate change core group which focused on developing the climate resilience of Battambang city in the ADB TA 8186-REG: Climate Resilience in Cities. The target sites used as models for training are:

1. Kampong Seima Irrigation Canal system to the west of the town
2. The riverbanks situated along Sang Ker River near the Sor Kheng Bridge in the centre of town
3. Railway station area, Tuol Ta Ek village of Toul Ta Ek Sangkat with wetlands and settlements in the centre of town.

The main focus for this training and field visit was upon the Kampong Seima Irrigation canal. The training has contributed towards preparation of development of feasibility studies for project proposals for climate change financing.

The training workshop was presided over by HE Prof Dr Sabo Ojano, Secretary of State and Program Coordinator of SPCR, Ministry of Environment; HE Sok Kong, Deputy Governor of Battambang Province; and HE Pon Saroeun, Undersecretary of State and Deputy Program Coordinator of SPCR, Ministry of Environment.

1.2 WORKSHOP PURPOSE

The objectives for this training workshop included:

1. To introduce the members of the SPCR Adaptation Working Group to vulnerability assessment and adaptation planning processes in the context of the real situation and climate risks for Battambang city
2. To reinforce the vulnerability and adaptation planning skills and experience of the Battambang provincial climate change core group
3. To develop the understanding of climate resilience through green infrastructure and bioengineering adaptation responses
4. To identify potential resilience demonstration activities leading to the feasibility studies for future project proposals for climate change funding.

2 SUMMARIES OF TECHNICAL PRESENTATIONS

2.1 SESSION 1: OPENING AND INTRODUCTION

As indicated above, the training workshop was presided over by HE Prof Dr Sabo Ojano, Secretary of State and Program Coordinator of SPCR, Ministry of Environment; and HE Sok Kong, Deputy Governor of Battambang Province.

HE Sok Kong made the welcome remark about the training workshop and expressed warm welcome of VIP persons from Ministry of Environment, and all participants from line ministries, Battambang municipality, and relevant department of Battambang provinces. He thanked the MOE for considering and choosing Battambang as training site noting that MOE has always supported Battambang province for care of environment and conservation, especially wastewater and solid waste management in the town. He emphasised the importance of the training workshop that helps gather relevant information on climate change for preparing the Royal Government of Cambodia's strategic policy on response to climate change, and developing scientific knowledge on climate change including adaptation measures and resilient practices that can tackle with the local issues on climate change. HE Sok Kong continued to report the previous activities related to climate change resilience that Battambang provincial government has thus far carried out. This includes constructing river bank protection facility, growing vegetation on river bank and road in the city for recreation and tourist attraction, restoring the drainage sewer systems for collecting storm water and wastewater, and proposing to rehabilitate the railway station and slump community.

HE Prof. Dr. Sabo Ojano made the opening remark of the training workshop. He first stated the objectives of the training and the history of SPCR program aiming at building capacity and developing guideline, procedure and design standard related to climate resilience to line government agencies and relevant stakeholders in Cambodia. Cambodia is one of the nine pilot countries in the world that have been selected to implement the SPCR program. In this regard, the Royal Government of Cambodia (RGC) under the leadership of Samdach Prime Minister Hun Sen has adopted the Cambodia Climate Change Strategic Plan (2013-2030) which laid strong foundation for Cambodia to take firm action on climate change issues. From this long term strategy, RGC has made substantial consideration for mainstreaming climate change resilience into development planning and implementation. This includes development and rehabilitation of road and rural infrastructure, restoring water storage reservoir, improving canalization for efficient irrigation for agriculture of rice commercialization, flood protection and building dyke to protect salt water intrusion, and increased capacity and technicality for conservation of natural resources as well as biodiversity. In order to achieve the long term vision and strategies, all concerned stakeholders of SPCR program should join hands together, not only at national level, but also sub-national government, to plan and implement climate change resilience actions into integrated sectors, above all water resource, agriculture and infrastructure erection. Finally, HE Sabo reiterated that this training workshop would surely give practical skill and knowledge on vulnerability assessment and adaptation planning to all participants

from government and nongovernment organizations, although it is the first training event supported under the TA8179 project. There will be series of training workshops on advance VA&AP to be organized in accordance to specific sectors like water resource, agriculture, infrastructure and so on.

Dr. Seak Sophat, Deputy Team Leader of TA8179 delivered a presentation of workshop organization including briefly repeating training workshop objectives in order to reemphasize the usefulness of the workshop, expected outputs of the workshop, agenda and field work arrangement.

Dr. Jeremy Carew Reid, Adaptation Project Development Expert of TA8179, provided a presentation on Climate risks and vulnerability of Battambang city that utilized the past experiences from ADB supported TA 8186-REG project: Climate Resilience in Cities. This includes the formation of Battambang Climate Change Core Group, assessment methodology and parameters: Town master plan and zoning, and Specific local area/infrastructure system, map overlay of climate change events like flood and drought in order to identify climate change hotspots of Battambang, and briefing the challenges and issues of town development. From this assessment, the Battambang core group focused their case studies on three sites such as 1) Riverbanks situated along Sang Ker River, 2) Railway station area, Tuol Ta Ek village, and 3) Kampong Seima Irrigation Canal.

2.2 SESSION 2: BATTAMBANG CITY ADAPTATION CASE STUDIES

Sangke River Embankments

This presentation was delivered by Mrs. Kem Sokhuntheary, deputy director of Battambang Department of Public Work and Transport. She gave overall situation of the river embankment, especially Sangke River in Battambang town. East side of the riverbank was constructed by private sector using cement and steel reinforcing and the banks are now eroding, collapsing with each flood. However, banks south of the bridge have been left in a natural state. Flooding occurs several times a year and can last up to three months in certain sections of the city. Flooding due to localized intensive rainfall leading to pooling and river overtopping**.** Frequent and/or intense flooding erodes riverbanks, threatening buildings, roads, and other infrastructure. Frequent flooding impedes movement, erodes bridge footings and road infrastructure. Major floods occurred in 2002, 2011, 2012 and 2013 which caused major river bank erosion and collapse, roads on both sides were severely damaged, buildings lost and bridge footings undermined. However, past response have been implemented on development of an early flood warning system by local authorities, government provision of emergency supplies, financial support to those affected, reconstruction of riverbank from new concrete bridge to Sar Kheng Park and expanded canal system to west to city.

Railway and Surrounding Wetland Settlements

Mrs. Sok Kinna, Chief of Cadastre Office of Battambang Municipality, presented the current situation and issues of Railway Station. There are 238 families (about 695 people) that have reportedly been living within the area between 1980 and 1999 due to local civil instability and war. It was reported that the station has been closed down for nearly decade and part of the premise is being occupied by the slump people. This slum area is frequently hit by floods mainly due to torrential rain events of two to three hours, which are frequent during wet season. These people have faced serious health implications, above all water-borne diseases and solid waste.

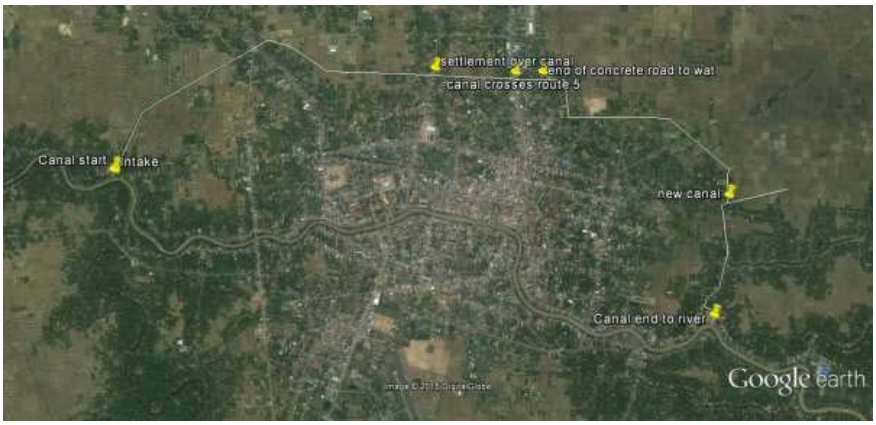
Kampong Seima Irrigation System Canal

Mr. Song Soeng, Chief of Public Work of Battambang municipality, offered a presentation on Site Description and Issues of Kampong Seima Irrigation Canal. The canal is mostly empty during the dry season – January through June. Sewage from domestic septic tanks emptied by trucks and effluent from surrounding settlement area are also drained into the canal. It was also reported that storm water and wastewater are discharged into canal as well. Informal settlements have been constructed along and on top of the canal where the slum community is locally known as Rikreay

Bralay Daempo. The slum people throw solid waste, and discharge wastewater directly into the canal there. The current situation of canal is seen as bank erosion, concrete linings damage, canal filling with sediments and blockage of water during flooding. Pumping station does not function, intake area seriously eroded and river undermining foundations of pump station; the culverts are too small and blocked with vegetation, sediment and solid waste and numerous earth driveways have blocked the canal. There is no waste collection service from canal settlements, and solid waste clogs established drainage canals and concrete canal lining breaks down, filling drains and blocking canal.

During dry season, villagers irrigate crops using portable pumps to draw water from the nearby Sangke river to the canal, some vegetation clearing and dredging, planting along the canal roads in some sections for beautification and stabilization, major new canal sections in north takes flow to agricultural areas and during wet season, water gates help to alleviate flooding. For detail slide presentation, see Appendix…. Figure 1 shows the alignment of the Kamong Seima Canal to the west of Battambang City.

Figure 1: Alignment of the Kampong Seima Canal to the west of Battambang City



(*Note the orientation with North to the right of the figure*)

2.3 SESSION 3: FIELD VISIT AND GUIDANCE

The site visit was made to Kampong Seima Irrigation Canal, drainage canal of Pormor Srey, and Intake canal from Stung Sangke river close to Kdol Pagoda in Battambang municipality (See Appendix….for detail locations of visits) following technical presentations and field work guidance (**SPCR VA-AP BASELINE ASSESSMENT: FIELD SURVEY TEMPLATE)** made by Mr. Peter-John Meynell. The chief objective of site visit was to expose participants to the current situation of the canal, and train participants about collecting data for vulnerability assessment and adaptation planning exercises for subsequent sessions of the training workshop. The participants were subdivided into four groups, with about 15 participants in each, led and facilitated by a team member of TA8179. Each group were distinguished by the colours of hats. With assistance of field survey template, each participant recorded data and information about each site visited and discussed with local villagers, village and commune leaders for detail information on each system. Battambang Core Group members also assisted the participants throughout the field visits. However, the participants were familiar with each site with presentations delivered by Battambang Core Group members. The data from this field exercise may be considered for the potential site for feasibility studies of adaptation project.

2.1.1 Vulnerability Assessment

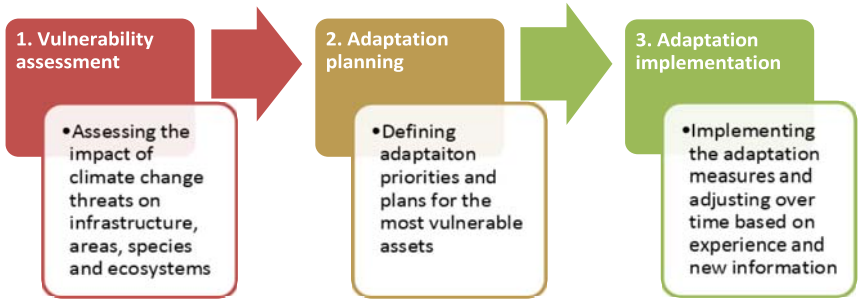
Dr Jeremy Carew Reid, *Adaptation Project Development Expert,* provided a presentation on Overview of the Vulnerability and Adaptation Planning Assessment (VA & AP) which are the integral part of the training workshop and showed the basic skills required on how to conduct the vulnerability and adaptation planning assessment. He further highlighted the key steps in undertaking the assessment: Vulnerability assessment, adaptation planning, and adaptation implementation. In addition, the planning stage is further subdivided into several sub-stages like: scoping, baseline assessment, impact and vulnerability assessment, and adaptation (including options, priorities and design).

For deep understanding and practices of vulnerability assessment, Mr. Peter-John Meynell, introduced participants the vulnerability assessment template which geared the participants to discuss among their group members about the analysis of data and information gathered from the Kampong Seima site visit in the afternoon of the first day training (18 Nov 2015). By working in groups, the participants were asked to discuss the topics such as Group 1: Description of system, its components and their condition; Group 2: Description of the watershed context; Group 3: Description of landscape surrounding the system; and Group 4: Past experience with extreme climate events.

2.1.2 Adaptation Planning, including Experiences from Cambodia

There are plenty of good practices of both national and international measures on climate change adaptation. Out international and national experts from TA8179 of ICEM and GIZ Battambang project shared cases of adaptation measures to the training participants.

Dr. Jeremy delivered the experiences on adaptation planning. He emphasized the planning processes ranking from Vulnerability assessment and adaptation planning which is shown in below figure. His presentation was followed by Documentary video on Bioengineering by incorporating good and challengeable experiences from neighbouring countries as well as in the region.



Adaptation planning

Strategic response to building resilience - green infrastructure

- Think first of how natural systems can meet flood protection, drainage and sanitation needs

- Apply bioengineering in place of or supplementary to hard "grey" engineered structures
- Rehabilitate and expand natural systems for multiple use as part of infrastructure
- Mimic and replicate natural system characteristics (e.g. engineered natural systems)

Dr. Mak Sithirith, Agriculture and Climate change specialist, gave a presentation on Examples of irrigation adaptation in Cambodia. He presented two cases studies on climate resilient agriculture: (i) the drip irrigation in Prey Veng Province; and (ii) Changing the rice cropping patterns in response to climate change. He highlights that the climate change affects agriculture. Droughts and floods have destroyed paddy and crops of many farmers in Prey Veng province, and thus, farmers have practiced a drip irrigation that allow them to diversify cropping patterns on small pieces of land and effective uses of water for different crops. Furthermore, he demonstrated the case in Tonle Sap floodplain where farmers change the rice farming practices from one crop a year to two crops a year, or from wet season rice to the early wet season rice and the recession rice. The change in rice farming practice is a response of farmers to climate change, particularly the flood and drought.

Dr. Seak Sophat delivered a presentation on Examples of flood management adaptation in Cambodia. This included the adaptation practices from around the world and Cambodia. The international examples of concrete adaptation technologies and practices in the Water Sector composed of Improving the Resilience of Protected Wells to Flooding, Post-construction Support (PCS) for Community-managed Water Supplies, and Rainwater Collection from Ground Surfaces—Small Reservoirs and Micro-catchments. In addition, experiences on water sector adaptation measures in Cambodia were gleaned from Prey Veng and Kampong Thom provinces under the TA8179 project activity to document the available adaptation measures. The prominent adaptation measures of good and challengeable practices were shared to the participants. The good practices are those of 1) Spillway and Fish Ladder in Stung Chinit Irrigation System, 2) Pumping Station and Concrete Canal in Angko Irrigation System, 3) Siphons in Angko Irrigation System, and 4) Water gate of 30 Sep Dam.

The challengeable adaptation measures include: 1) Secondary canal 5 of Stung Chinit Irrigation System and it erodes from year to year due to strong water flow; 2) Main canal in 30 Sep dam, water gate and bridge collapse at main canal of Prasat Irrigation System in Kampong Thom province; 3) Prek Chik canal taking water from Boeung Snae Reservoir in Theay Commune, Ba Phnum District; and 4) Bopea canal in Lvea and Rom Chek communes in Preah Sdach district of Prey Veng province.

Mr. Hak You, National Infrastructure and Climate Change Specialist delivered presentations on Examples of Infrastructure adaptation in Cambodia. The presentation included:

1) **Extreme climate conditions are becoming more frequent with climate change:** The Most Problems are Flood & Drought, and it happens not only in rural area, but it happens more in the urban area. For an example: in 2013 flooding Battambang Town.
2) **Extreme events impact on the performance and integrity of infrastructure systems:** The effects of Water flow, Scouring, Wave, Storm run-off, damage the infrastructure.
3) **Infrastructure is a long-term investment:**
   - Ensure investments made in today's dynamic world remain good decisions during their full operating life.
   - What happen, if without Adaptation Measure? One example of canal bank erosion in Prey Veng province, and one example of road dyke erosion in Prey Veng province.
   - What is the right choice of the adaptation measure? Shall we choose a Rigid Structure (**Grey engineering**)? Or a Flexible Structure (**Green engineering**)? For dealing with the hydraulic characteristic.
   - Adaptation Work is a costly work? Two comparisons of the Green with the Grey engineering and the Green engineering with Do Nothing; showing that the Green is cost less than the

Grey and the Green is still a good choice even compare to Do Nothing, because it is less maintenance required and last longer.

4) **Two Examples of climate resilient works (in Cambodia) for a thought;**
   - **Peamro Bridge** – is located on NR11, in Peamro District, Prey Veng Province, constructed by MPWT. The bridge abutments and foundations are protected by Slope protection – Rock-filled gabion and tensile geotextile. River bed protection – Geotextile and amour-rock. The construction was completed in September 2010, and up to date it passes five years with no erosion noted, vegetation growth, still in good condition.
   - **Boeung Snae Dyke (Reservoir)** – it is located on road 317, in Baphom District, Prey Veng Province, in a flood-plain, constructed by MOWRAM. A multi-functions dyke (reservoir, access road), the dyke bank slope is constructed with two-berms gently and protected by rock-riprap with wire mesh covered, and gentle toe apron protected by rock-amour. The date of completion is 2008, and up to date it passes seven years with no erosion noted, vegetation growth, still in good condition.

5) **How does the Gabion work? And what its benefits? And when can it be applied?**
   - **Gabions**: designed to stabilize slopes etc. through erosion control and protection, and also allow for the vegetation growth;
   - **Benefits**: Engage communities in construction & maintenance, Provide livelihood opportunities for community;
   - **It can be applied**: Rock/Gabion revetment application is for erosion control and protection, cause by water flow, wave, scouring, storm water run-off etc.
     - Riverbank, Canal, Dyke, Bridge protection…
     - Costal, Shore protection…
     - Slope protection…

Mr. Yong Tonghann, Technical Adviser, Battambang municipality/GIZ project, voluntarily offered a presentation on Climate Change Adaptation in Battambang City based on the experiences from GIZ funded urban development project in Battambang city. The project focused on preparation of urban development plan and building capacity of Battambang government officials to carry out the spatial planning methodologies in relation to climate change adaptation, and implementation of the plans adopted by the core group. Based on the adopted plan, the project provided support to make the city greenery system by planting trees, public garden and protect the riverbank from erosion.

2.4 IDENTIFYING ADAPTATION DEMONSTRATION PROJECTS

This presentation was presented by Dr. Jeremy, it focused on: adaptation options, priorities and planning, and adaptation planning working group exercise.

1) **Adaptation options:** To list of the adaptation options for addressing each of the most significant impacts. Consider on: Learn from the past; Improve existing assets; adapt the system and components; Consider new technologies and approaches.
2) **Adaptation priorities:** is the production resulting from Feasibility and Effectiveness of adaptation in addressing impact, as formulated below.

Priority of adaptation = Feasibility x Effectiveness, where,

Feasibility should be defined like: Is the action technically feasible; What is the time required to implement; What are the capacities of community/user; What is its cost; Is government budget available.

Effectiveness should be defined like: the range of "Can the impact be avoided completely?"; "To what extent will it deal with the impact?"; "How long will the adaptation measure last?".

3) **Adaptation planning:**

- **Plan for each vulnerable asset/system/sector -** The target system; Adaptation measures; Other development influences; Adaptation phasing; Reforms required within sector.
- **Take an integrated approach**: The aim – to increase resilience in vulnerable communities, development sectors and areas: Structural engineering; Bioengineering; Natural systems management; Land use planning; Traditional local strategies; Sector specific policies and procedures; Economic instruments; Social responses; Institutional options.
- **Other lessons**: To explore non engineering approaches first; Maintain and bring back natural systems; Maintain and design for multiple uses of waterways and drainage facilities; Always combine natural vegetation and methods; Involve users to understand how they use and what they need from the canal.
- **Bioengineered canals, drainage systems and slopes:** Bioengineering makes use of living materials as a substitute or complement for grey engineering; especially for slope and embankment stabilization and erosion control; also increasingly as a key ingredient in urban drainage systems.

4) Adaptation planning working group exercise

The exercise will go through 1-hour session in working groups, to review adaptation options and consolidate into an adaptation plan: 1) Snapshot of climate vulnerability; 2) Objectives and measures; 3) Phasing of implementation; 4) Stakeholders & policies.

3 SUMMARIES OF FIELD WORK AND GROUP DISCUSSION

3.1 FIELD WORK BASELINE

The participants were divided into 4 groups, who come from different ministries' adaptation working group members. The field work is taken by all participants working on Vulnerable Assessments of Kampong Seima Irrigation System located in Kampong Seima, Battambang province.

Group-1: discussed on the **Identify the main components of the system and their condition**

The canal system was built in 1977 with the length of 10km and original width 20m. From 1977-79, the scheme was able to irrigate 250 ha. From 1984-85 additional construction up to 10km length and served as irrigation and city flood protection. Currently, the canal still provides irrigation function and acts as a retention canal of wastewater and storm run-off from the Battambang city. The canal is mostly empty during the dry season, and flooding every year about 0.5m depth by storm water from the city during rainy season. The group discussion defined the system in 4 sections, as:

	Main components	Their conditions

Section 1:	**The canal starting from Pumping Station to NR57 with total length of 2.5km**, made by natural earth with no erosion control. There is a Pumping station (Intake, pumping house, and settlement tank) and 4 locations of twin pipes.	The Pumping station is old and not functioning since 1995, Intake area seriously eroded and the river undermining foundations of the Pumping House; Culverts small and blocked with vegetation, sediment and solid waste; The canal is very much shallow in some location; There are some trees, agricultural fields and shops along the canal.
Section 2:	**The canal starting from NR57 to NR5 with total length of 2.0km**, made by natural earth with no erosion control. There are 6 locations of Drainage pipes and an informal settlement with 33 houses built on top of the canal.	The size of the canal is small and shallow; There are many solid waste in the canal; Water quality in the canal is bad (black color); Serious health issues.
Section 3:	**The canal starting from NR5 to Por Mor Srey Irrigation with total length of 5.0km**, made by natural earth with no erosion control. There are houses along the canal; A concrete road built on the canal right-of-way, approaching to the pagoda; There is crocodile farming along the concrete road; The canal extended by underground culvert within the pagoda area.	Not clear about the canal right-of-way and the size of the canal is small, due to the housing alignment; With vegetation blocking in some location; Solid waste in the canal; and The water quality in the canal is bad (black color);
Section 4:	The canal starting from Por Mor Srey Irrigation to Kdol Pagoda with total length of 1.6km, made by natural earth with no erosion control. The canal is small and it is managed by water user committees; at the edge of the canal is Stung Sangke River.	The size of the canal is small and shallow; With vegetation blocking in some location; The communities pump the water from Stung Sangke River into the canal for cropping and gardening during the dry-season;

Group 2: Description of the watershed context

The canal runs 10 km through six communes, crossing by two national roads No.5 (O Char village of O Char Sangkat) and No.57 (SalaBalat village of O Mal Sangkat). The canal system was built in 1977 during the Khmer Rouge Regime 20 m wide. From 1977-79, the scheme was able to irrigate 250 ha, mostly in Wat Kor village. From 1984-85: additional construction up to 10 km length and served as irrigation and city flood protection. Currently, the canal still provides irrigation – during the dry season mainly from city wastewater.

- The drainage system of the canal is influenced by three watershed systems: (i) upland forest: (ii) the floodplain watershed; and (iii) the urban watershed. The upland forest watershed covers huge areas running from the mountains along the Cambodia-Thai border down through to Tonle Sap Lake. The area is covered by different types of forest including deciduous forest, bush and flooded forest. The clearance of forest in the upland areas of the Stung Sangke River Watershed has contributed to increased water flow into the river, causing flush floods along the river.

- Large part of the canal is located close to Battambang City, and the urban watershed system has contributed to yearly urban flood in Sangkat Toul Ta Ek in Battambang Town. The guiding of human settlement on the canal have changed the canal functions from the irrigation system to the sewage system The water flow from the canal intakes at Wat Kor village down to areas at Toul Ta Ek has been dysfunctional and the water quality is poor. Due to the shallowness and narrowness of the canal in this part, the floodwater from urban areas could not recede quickly, resulting in flood at this part of the canal every year.
- The floodplain watershed is located in the downstream of the canal in Ek Phnom district, comprising many wetland areas including small ponds, reservoirs and small stream. The area absorbs huge water from upstream of Sangke Watershed areas and downstream area of Tonle Sap. When the heavy rain occurs in the upstream, rainwater flows down through the canal to the area. At the same time, wastewater from the city is discharged into this areas as well and then return to Stung Sangke River. However, during wet season, when the water level in Tonle Sap Lake rised up, it floods the areas downstream of Stung Sangke around Ek Phnom District. This area has been utilized by local people to cultivate the wet season rice. The discharge of wastewater from Battambang city into this area has affected the farming productivity of the areas.

Group 3: Description of landscape surrounding the system;

Field visit was done with the whole system of Kampong Seima irrigation canal where it runs through six communes, crossing by two national roads No.5 (O Char village of O Char Sangkat) and No.57 (Sala Balat village of O Mal Sangkat). This irrigation canal system was built in 1977 during the Khmer Rouge Regime with pumping station and intake at the midstream of Stung Sangke.

- Group 3 was assigned to collect information and discuss in depth of the features of the landscape surrounding the irrigation canal system. Three specific locations or sections were divided and focused by the group are such the pump station and intakes, Po Rek Rey community (resettlement over the canal), and new canal (Po Mor Srey Canal). These specific locations of the system would be discussed to identify and describe the geographical, natural and manmade features in the immediate vicinity of the system, include any slopes, vegetation, soil types proximity to water bodies, cultural features and environmental issues (e.g. pollution, erosion, solid waste, etc.)
- Results of discussion describing the landscape surrounding these three specific locations or sections regarding to four features (landscape and natural features, manmade features, cultural features and environmental issues) are detailed in the appendix 3.

Group-4: Past experience with extreme climate events.

The group members visited five points of the canal by starting from Pumping station (starting point of canal: upstream of Sangke River), Deumpor Rik Reay community (slum community), Ochar culverts (national road #5), Por Morsrey new canal (collection and release of flood water), and Wat Kdol (intake canal of Stung Sangke downstream site). The group mainly focused on collection of information on impacts of extreme climate events (flood and drought) through interview local people and local authority at points where the group visited. The information of extreme climate events and their impacts on Kampong Seima irrigational canal was consolidated from findings of group members through group meeting in training room on morning of 19 November 2015. Appendix …. below presents the result of group discussion and consolidated results of the group on past experience and response to extreme events on canal.

3.2 VULNERABILITY ASSESSMENT

All groups discussed the Vulnerability Assessments of the Kampong Seima Irrigation System and its main components. The assessments focused mainly on the **threats** of **Floods** and **Droughts** and their

Impacts, and the Adaptive Capacity. The Impact (I) is the product of Exposure (E) and Sensitivity (S), and the Vulnerability (V) is the result of the division of the Impact by Adaptive Capacity (AC), by the following relationship:

Group-1 discussion result: **For the Whole System of the Kampong Seima Irrigation** due to **Flood** is high Impact due to its high Exposure and high Sensitivity, low Adaptive Capacity and result in high Vulnerability. The same result due to **Drought**.

The Exposure is high because: a) the Pumping station is close to Stung Sangke River, with impacts from water flow and scouring causing bank erosion, b) the whole canal is receiving storm and waste run-off from the Battambang city directly, that cause storm flood, water is polluted, and sedimentation of solid waste, c) the whole canal lacks of water and is dusty during dry-season.

The Sensitivity is high because: a) the Pumping station is old and the riverbank is easily eroded by water flow and scouring, b) the whole canal is natural earth made with the size become smaller and shallower, that can not retain more floods, easily eroded by water run-off.

The Impacts threated by Flood: Stung Sangke River eroded the riverbank at the Pumping Station; the storm water causes flood to some part of the canal every year and cause bank erosion; solid waste and wastewater slurry cause sedimentation the canal made it shallower and clog the culverts, polluted the environment and causes illness diseases; inaccessible along the canal top roads etc.

The Adaptive Capacity is low because: a) the whole Pumping station is old and damaged and there is no finance for rehabilitating and for riverbank protection, b) the whole canal has become smaller and shallower and there is no finance for rehabilitating.

Discussion on the Adaptation **Measures/Options** – the group suggested: 1) Study and prepare a proper master plan for water catchment and drainage system in the city, 2) Land use planning (zoning, Boundary…), 3) develop solid waste and wastewater management and treatment facilities, 4) Use rock-filled gabions for protecting the riverbank, 5) Rehabilitate the canal system by dredging and elevate the bank higher, 6) Protecting the bank of the canal by grass, bamboo and rock-riprap, 7) Rain garden), 8) Promote to have septic tank at all houses, business and industries buildings, 9) Resettlement, 10) Awareness raising about hygiene.

Group 2: discussion result

The flood and drought are the key threats caused by climate change. The canal system, the pumping station, the culverts, the bridge, roads, the watershed, the agricultural land, etc., are highly exposed and sensitized to floods, causing impacts including flood damages infrastructure including road, canal, bank erosion, culvert collapse; settlement/house; and agriculture fields. The pumping station is located close to the river bank and it is exposed to heavy flood, and because infrastructure always highly expose to flood incidence.

The group 2 concludes that the canal system, the pumping station, the culverts, the bridge, roads, the watershed, the agricultural land are more highly vulnerable to flood than the drought. The level of vulnerability varies throughout the system. The flash flood in 2013 that made the area highly vulnerable while in other years floods were less servere. However, the section of canal located to Battambang City is highly vulnerable due to floods caused by urban water flood every year.

The vulnerability to drought is rated as medium so far as drought does not reach the level that pose major concern, although crop failure, shortage of drinking water and health issues occurred.

According to hydrological data, there is no serious drought so far. The drought does not affect the pumping station. The infrastructure is still in place and it is still operating when there is a need of water and when there is water available. It could resist to the drought and does not damage. The sensitivity to drought is low. The structure is not affected by drought.

The adaptation capacity to climate change particularly the flood is low. The flood occurred in 2013 since it was built in 1977, but the maintenance of the system is poor. There is lack of people's participation in the maintenance. The culverts and bridges were built too small and do not function well when there is a high flood. There was no plan to maintain it.

Group-3 discussion result:

Vulnerability assessment was conducted and discussed in the workshop. The group-3 did not discuss the assessment of the vulnerability of the whole system, but considered six components or assets of system such as 1) pumping station and intake, 2) culverts and bridges, 3) canal bed and banks, 4) canal dyke and roads, 5) watershed, and 6) surrounding land use were firmly discussed and assessed based on the proposed template considering the threat, exposure, sensitivity, impact, adaptive capacity of the system and vulnerability.

Regarding to the threat, three main threats were discussed 1) flood from rainfall, 2) flood from Stung Sangke and 3) Drought. The flood from rainfall and from Stung Sangke threats over the whole system components while the drought was discussed and agreed to be threatening only one component of the system which is component-6, surrounding land use. The component-2 (culverts and bridges) was assessed to have very high vulnerability to the flood from rainfall and flood from Stung Sangke while the component-3 (canal bed and banks) was assessed to have very high vulnerability to flood from Stung Sangke. Most components were assessed to be medium vulnerability to the flood from both rainfall and Stung Sangke (See appendix 5)

Group-4 discussion results:

With availability of baseline assessment, the group conducted another discussion to discuss and identify threat, degrees of exposure, sensitivity, and existing adaptive capacity of components of the canals to climate events. The group divided whole system of the canals into six components include (i) pumping and intake, (ii) culvert and bridges, (iii) canal beds and banks, (iv) canal dykes and roads, (v) watershed, and (vi) surrounding land uses. The group discussed and identified degrees of exposure, sensitivity, and adaptive capacity for each system component and then come up with whole system. The degree of impact was calculated by using matrix table of determining impact between degree of exposure and degree of sensitivity. Similarly, degree of vulnerability was calculated by using matrix table of determining vulnerability between degree of impact and degree of adaptive capacity of the system components and whole system. As results, group discussion found degrees of impact and vulnerability to climate events (especially flood) of system components and whole system are at high. For detail results of identification of impacts and vulnerability of system component and whole system are placed in Appendix…..

3.3 ADAPTATION PLANNING

Group-1: The Adaptation measures and options were discussed and suggested by group 1 to deal with the three main threats:

(1) **Flooding of Sangke River** cause bank erosion, (2) **Flood cause by storm water and wastewater from the city every year** erode the canal bank; sedimentation made canal become shallower; polluted water cause illness disease; top of the canal become smaller cause inaccessible, and (3) **Drought** cause lack of water, dust, impact on cropping, vegetation growth.

In generally, Group 1 discussion suggested 10 points, for the whole system of the canal for the adaptation measure/options:

1. Study and prepare a proper master plan for water catchment and drainage system;
2. Land use planning (zoning, boundary…);
3. Solid waste and wastewater management and treatment;
4. Promote to have septic tank at all houses, business buildings;
5. Promote to have rain garden;
6. Use rock-filled gabions for protecting the riverbank;
7. Rehabilitate the canal system by dredging and elevate the bank higher;
8. Protecting the bank of the canal by grass, bamboo and rock-riprap;
9. Resettlement;
10. Awareness raising about hygiene;

In specific each components of the system, Group 1 discussion suggested adaptation measures/options mainly focusing on the Green Engineering (such as Gabion revetment, combined Bamboo and rock-riprap) for dealing with river hydraulic action (such as flow, scouring, wave) and planting grass for canal bank protection. (See appendix 6).

Group 2: Group 2 has identified the following adaptation measure:

A. The Whole System:

1. Rehabilitate the canal bed and raise the level of dyke, rehabilitate the slope and plan along the canal and slope, build the canal body as a read, renovate the pumping station.

2. Mobilization of local communities in the management and maintenance, organizing farmer water user group to manage the canal system, and dissemination of information and legal framework to communities

3. Resettlement of communities living along the canals

B. Pumping station & intake:

1. Build the spillway that could store water for dry season pumping
2. Renovation of pumping station and its accessories. Enlarge the intake and rehabilitate that areas so that we could pump water.
3. The responsible institutions must organize their staff to manage the station.
4. Organize communities and maintain the system;
5. Establish the Farmer Water User Group;

C. Culverts and bridges:

1. To renovate the culverts and bridges according to the floods volumes, and the flow of water, and based on technical requirements.
2. Involvement of local government, technical institutions in the management of culverts and bridges; and Participation of local communities in managing the culvers and bridges.
3. Commune Fund, and Provincial funds require to be developed to support the canal development and maintenance —Commune Plan and Commune Funds.

D. Canal bed and banks

1. Plant the grass or small tree on the slope of the canals.

2. Management and maintenance of the canal beds frequently by Farmer Water User Groups/local administration;

E. Canal dyke and roads:

1. Raise the level of road to avoid flooding the roads, built the concrete roads;
2. Planting the trees along the canal dykes and roads;
3. Community participation in the management and maintenance of the road.

F. Watershed:

1. Develop the land use planning and agro-eco analysis—land use for agriculture, settlement areas, wetland, especially conduct the study on the hydrological regime in the watershed areas and develop the plan to release water from the watershed area;
2. Developm the wetland areas so that it becomes the reservoir to store wastewater.
3. Built the city belt canal to protect town from flooding.

G. Surrounding land use:

1. Develop the land use planning and agro-eco analysis—land use for agriculture, settlement areas, wetland,
2. Build the reservoir and rehabilitate canal that could increase water flow;
3. Protect and restore the natural wetland areas that could store floods.

Group 3:

Based on the vulnerability assessment, the adaptation measures/options were discussed and suggested. There are many adaption measures were risen up by group 3 to deal with the three main threats, (1) flood from rainfall, (2) flood from river (Stung Sangke stream), and (3) drought.

Regarding to the threat (flood from rainfall), the adaptation measures/options were suggested are such;

1. Canal Rehabilitation (canal bed and depth) and plantation of vegetation on the canal bank,
2. Enhancement of culvert pipe and preparation of garbage collection system at sluice gate of the drainage or irrigation canal
3. Level up the levee and embankment of the canal and planting the tree and vegetation to protect bank and embankment erosion

And the adaptation options were suggested to deal with the threat “flood from river (Stung Sangke stream)” are below;

1. Preparation of (Stung Sangke) riverbank protection by using the domestic materials (such as alive pole and fence, vegetation-bamboo and reed,
2. Planting vegetation and trees on the bank and embankment of river (Stung Sangke)
3. Enhancing the drainage and irrigation system to collect storm water, trapping of runoff and flood.

Group 3 has proposed the following adaptation options to deal with the drought;

1. Constructing the sluice gate, and reservation of water for using in dry season,
2. Preparing of pumping machine for securing while the water shortage,

3. Developing sewage water treatment system, and treatment of waste water before discharging into the irrigation canal
4. Developing the waste/garbage management community.

Those adaptation measures were discussed and suggested by group 3 in according to these three threats, flood from rainfall, flood from river and drought within the whole system and in specific system components. Generally, the main adaptation measure was, however, strongly focused on maintenance and management of the system (See appendix 6).

Group 4:

After group identified degrees of impact and vulnerability, the group conducted discussion to identify impacts of climate events on system components and whole system. The group also identified suitable adaptation measures to respond to impacts and these are relatively identical to other three groups already mentioned above. However, for specific discussion of results of group 4 can be seen in Appendix…….

4 TRAINING WORKSHOP EVALUATION

The total number of workshop participants is 75 persons, but the actual number of participants who returned the assessment report was 38 people. The participants are listed by each ministry sectors like 4 persons from water resource, 4 persons from agriculture, 5 from urban infrastructure, 3 from rural infrastructure and 22 from other sectors.

All those participants coming from different organizations and departments related to climate change issues include in the following:

- Staff of the ministry department relate to policy planning on climate change and adaption
- Disaster risk reduction, flood management, local administration
- Climate change department of Ministry of Environment
- Climate change and adaptation planning, climate change strategic plan
- Project relates to Biodiversity and development
- NGOs staff working with community for climate change adaption in Battambang province
- Agricultural and climate change adaptation
- Mainstreaming of climate change impact and DRR and gender of Ministry of Women Affairs
- Small scale Irrigation system of MOWRAM
- Urban master plan project of Battambang Municipality
- Mainstreaming Climate change project
- Flood and rural road

1. The benefit of the workshop

There was no negative comment on the theme of the workshop. The participants had comment that the workshop was useful for them and their task at their organization, as follows:

- The workshop help participant to gain knowledge of climate change, vulnerability assessment. They could use the knowledge from the workshop for further uses.
- Learning about vulnerability assessment and information analysis
- The workshop provided critical capacity building to government staff on vulnerability assessment and adaptation planning
- Participants gain general knowledge of climate change vulnerability assessment
- Participant were able to learn from the real case study of field trip for discussion on the Seima irrigation

2. Knowledge gain through the workshop

Another way, participant has scored their knowledge gained from their participation of the workshop on the contents, through discussions during the workshop. The contents are scoping, baseline assessment, impact and vulnerability assessment, adaptation, adaption implementation. Almost all participants scored themselves in Medium and Good, follow by very good, and very few reported very poor and poor. Following are the observation of the knowledge gaining from the workshop which includes field trip.

Table 1: Participant understanding of the workshop contents among total participants (N=38)

Topics	Very poor	Poor	Medium	Good	Very good
Scoping	0%	0%	26%	53%	21%
Baseline assessment	0%	5%	34%	55%	5%
Impact and vulnerability assessment	0%	0%	29%	55%	16%
Adaptation	3%	13%	42%	34%	8%
Adaption implementation	3%	8%	53%	29%	8%

3. Workshop performance

In similar way, the participant had scored the workshop performance and arrangement between Medium and Good, and follow by very Good. There were very few people reporting very poor and poor performance. Below are participants comment on how they are going to use the knowledge from the workshop for their work place.

Table 2: participant scoring the workshop performance and arrangement (N=38)

Description	Very poor	Poor	Medium	Good	Very good
Overall coordination of the workshop	0%	0%	13%	82%	5%
Logistic	0%	3%	16%	74%	8%
Duration and schedule	0%	3%	61%	34%	3%
Sector allocation to each group	0%	0%	11%	63%	26%
Site visit	0%	0%	8%	58%	34%
Support from TA	0%	0%	3%	68%	29%
Support from provincial staff	0%	0%	18%	71%	11%
Material of workshop	0%	3%	32%	58%	8%
Transportation arrangement	0%	0%	26%	63%	11%

4. Suggestion and comment on the workshop

The workshop had already quite good comment by the major of participant, however, some improvement should be identified through participation suggestion of each key point. Following are key points suggested by participants to improve the workshop includes contents of the workshop, methodology, and future collaboration with existing similar projects, comment for future workshop, and other comments.

a. Key point for improve the content of the workshop

- The workshop should more deeply discussion in the group by selecting issues for debate to find out the real practice of climate change impact vulnerability and adaptation planning.

- The workshop is too short to understand the topic. Should extend more time for discussion. It should cover to a long term planning.
- Participant suggest to have longer field trip to see more cases of the climate change vulnerability assessment and adaptation planning method.
- The organizers should provide sufficient materials and pictures of the case study for more conceptualize the workshop theme include case studies of other projects in and outside the countries.
- The workshop should apply more field trip and should taking place in the morning rather than evening. The field trip should be more than this for able to capture a comprehensive information
- Slide presentation should be more clear and more handout should be provided
- The workshop organizers should more focus on encourage participant and authorities to participate in the workshop activities
- The content is too long, scope cover many thing, and it does not fit in the time frame. The workshop content should reduce and lead participant to focus on the specific topics

b. Key point for improve the workshop methodology

- The organizer should include questions and answers to the workshop for engaging the participant to be more active.
- The organizer should allocate more time for each group discussion session for able to explore the adaption method and planning according to the field trip. It is very good to have more time for debate between technical staff and local authorities as well as community member
- The workshop should include more case studies, which participants will be able to judge the vulnerability and adaption planning discussion
- Next workshop should visit the same infrastructure because participants already identify the condition of this irrigation.
- Specific lesson learn should be provided to participants for example, infrastructure, agriculture, and engineering
- Should conduct a workshop on vulnerability and adaptation of climate change by discussion on flood protection system of Battambang province along the Kampong Siema to Eak Phnom District.

c. Key point for improve future collaboration with other similar project of the participants

- Should join and collaborate with urban climate change adaptation program of Battambang Municipality
- Should conduct the workshop in the region, that lead participant to learn from other country in the region
- Should cooperate with local authorities of specific location for keep tracking the issue of climate change impact and vulnerability

d. Further comments

- Suggest to have more study tour (in and outside the country) to the similar project for learning.
- Meeting room service is concern, include micro-phone or loud speaker and meeting room arrangement should be well prepared
- Should include local administration person in the workshop
- Comment on the finance and budget support as well as ADB to the study project
- Translate to Khmer using proper Khmer language

- Should arrange the accommodation and travel for all participants
- The invitation letter should be reached to the participant more than 2 days before the workshop start, in order to arrange relevance staff to participate in the workshop
- Should be provided a good time for snack and lunch time. It is critical for participant working over the meal time.
- Should conduct this kind of workshop all provinces

In short, the workshop was completed within the schedule and covered all contents. Participants reported they gained substantial knowledge from the workshop as it provided with basic and principle skills on VA&AP. The participants expressed high satisfaction of the training workshop, however, some suggested that they need further training, especially the advance level focusing on sectors. The suggestion of next workshops should cover all aspect of the projects of key five ministries.

5 CONCLUSIONS AND NEXT STEPS

The Vulnerability Assessment and Adaptation Planning training in Battambang considered a number of different infrastructure assets, but had a more detailed focus on the Kampong Seima irrigation canal. This canal has been recognised as having a strategic importance for the overall resilience of Battambang city, providing multiple different uses and functions beyond its original irrigation purpose.

The participants who were drawn from the five key Ministries with which the SPCR programme is working, Ministry of Environment, MOWRAM, MAFF, MPWT and MRD, as well as representatives from the other agencies involved in the programme, MEP, MoP, MoFA, NCDRM, NCDD and CDC, came to appreciate that the Kampong Seima Canal now receives the rainwater run-off from the urban areas, and thus is used for draining localised flood waters. The canal also receives urban drainage and waste waters, and is highly polluted in parts. Nevertheless, it is still used for water supply, irrigation and for fishing and recreation. In some parts of the canal, houses have been built over it, discharging waste into the canal and leading to very unsanitary conditions.

The training therefore provided a detailed consideration of an infrastructure asset that had aspects to be addressed by all sectors, and as such was a useful, if complicated, case to study. The training evaluation results show that all participants appreciated and learnt from this example of multi-sector VA & AP.

Because of its strategic importance for the resilience of Battambang City, the need for its rehabilitation and strengthening of the features that will improve its resilience functioning, has been endorsed both by the provincial and municipal governments.

It has therefore been suggested that the Kampong Seima canal rehabilitation be the subject of one of six feasibility studies for adaptation projects to be developed by the project. Because it is a multi-sector asset, it is suggested that this proposed project would come under the overall lead and coordination of the Ministry of Environment.

In order to progress this feasibility study over the next months, the SPCR TA team will be undertaking more detailed surveys and studies to develop the understanding of what will be required for rehabilitation and enhancing the resilience of the Kampong Seima Canal.

6 PHOTOS

Opening speech for the training on VA and AP under SPCR by H.E. Prof. Dr. Sabo Ojano on 18 November 2015

H.E. Pon Saroeun, Under Secretary of State, MoE (left)
H.E. Prof. Dr. Sabo Ojano, Secretary of State, MoE (middle)
H.E. Sok Kong, Deputy Provincial Governor, Battambang (right)

Site description and issues of riverbanks situated along Sang Ker River in Battambang city

Participants from SPCR Adaptation Working Group and Battambang Climate Change Core Group

Group Photo of Participants

Group visited illegal settlement on canal

Group visited Kampong Seima canal to collect baseline information

Group Exercise to discuss about overall situation around the canal

Participant presented their finding from field

Participants SPCR Adaptation Working Group looked at photos of field visit in Prey Veng, Kampong Thom and Battambang

Participants are watching video on "Bringing Nature Back"

Mr. Ou Chanthearith, Program Manager wrapped up this 3-day training

Mr. Ou Chanthearith, Program Manager (left)
H.E. Sem Saroeun, Director General, MoE (middle)
Dr. Peter John, Team Leader (right)
During closing training

7 APPENDIX 1. AGENDA

VULNERABILITY ASSESSMENT AND ADAPTATION PLANNING TRAINING WORKSHOP

BATTAMBANG, 18 - 20 NOVEMBER 2015

Day/Session	Presentation/training activity	Presenter/facilitator
Day 1 - 18 November 2015		
Session 1: Opening and Introduction		
7:40 - 8:00	Registration	PMU Staff
8:00 - 8:25	Welcome Speech (TW/MCRDP/DOC1)	Provincial Governor
8:25 - 8:50	Opening Speech (TW/MCRDP/DOC2)	HE Prof Dr Sabo Ojano, Secretary of State, MOE, and SPCR Program Coordinator
8:50 – 9:00	Workshop Photogram session	Facilitated by TA8179 team
9:00 - 9:15	Introduction – Objectives and agenda (TW/MCRDP/DOC3)	Dr Seak Sophat, *Deputy Team Leader/ Senior Strategic Program for Climate Resilience Management Specialist*
9:15 – 10:00	Climate risks and vulnerability of Battambang city (TW/MCRDP/DOC4)	Dr Jeremy Carew Reid, *Adaptation Project Development Expert*
10:00 – 10:15	Plenary discussion	Facilitated by TA8179 team
10:15 - 10:30	*Coffee break*	
Session 2: Battambang city Adaptation case studies		
10:30 – 10:50	Site description and issues of riverbanks situated along Sang Ker River in Battambang city (TW/MCRDP/DOC5)	Mrs. Kem Sokuntheary, Deputy Director, Dept. of Public Work and Transport, Battambang
10:50 - 11:10	Site description and issues of Railway station area, Tuol Ta Ek village (TW/MCRDP/DOC6)	Ms. Sok kinna, Chief, Battambang municipality Cadastral Office
10:10 - 11:30	Site description and issues of Kampong Seima Irrigation Canal (TW/MCRDP/DOC7)	Mr. Song Soeng, Chief, Battambang municipality Public Work Office
11:30 - 11:45	Plenary discussion	
11:45 – 12:00	Introduction to the Baseline Field Exercises[1] (TW/MCRDP/DOC8)	Dr Peter-John Meynell, *Team Leader/ Senior Strategic Program for Climate Resilience Management Specialist*
12:00 – 13:30	Lunch Break	
Session 3: Baseline field visit		
13:30-17:00	Field visit to Kampong Seima Irrigation Canal	Facilitated by TA8179 team
18:00 - 20:00	Welcome dinner	To be announced

[1] Need to define the 4 working groups at this point.

Day/Session	Presentation/training activity	Presenter/facilitator
Day 2 - 19 November 2015		
Sessions 4: Baseline assessment working group		
8:00 – 8:10	Recap of the first day workshop	Dr Peter-John Meynell, *Team Leader/ Senior Strategic Program for Climate Resilience Management Specialist*
8:10 – 8:25	Introduction to Baseline working session (TW/MCRDP/DOC9)	Dr Peter-John Meynell, *Team Leader/ Senior Strategic Program for Climate Resilience Management Specialist*
8:25 – 9:00	Working Group Session on Baseline assessment (group discussion)	Facilitated by TA8179 team
9:00 – 9:40	Baseline working groups report to plenary and discussion	Representative of group Facilitated by TA8179 team
9:40 – 10:00	Coffee break	Facilitated by Hotel
10:00 – 10:40	Overview of the Vulnerability and Adaptation Planning Assessment (VA & AP) (TW/MCRDP/DOC10)	Dr Jeremy Carew Reid, *Adaptation Project Development Expert*
10:40 – 10:50	Plenary discussion	Facilitated by TA8179 team
Sessions 5: Vulnerability Assessment		
10:50 – 11:15	Introduction to Vulnerability Assessment template (TW/MCRDP/DOC11)	Dr Peter-John Meynell, *Team Leader/ Senior Strategic Program for Climate Resilience Management Specialist*
11:15 – 12:15	Working Group Session on Vulnerability assessment	Facilitated by TA8179 team
12:15 – 14:00	Lunch break	
14:00 – 15:00	Vulnerability Assessment working group plenary report-back	Facilitated by TA8179 team
15:00 – 15:15	Plenary discussion	Facilitated by TA8179 team
15:15 – 15:30	Coffee break	
Sessions 6: Introduction Adaptation planning		
15:30 – 16:00	Introduction to Adaptation Planning (TW/MCRDP/DOC12)	Dr Jeremy Carew Reid, *Adaptation Project Development Expert*
16:00 – 16:15	Documentary video on Bioengineering (TW/MCRDP/DOC13)	
16:15 – 16:40	Plenary discussion	Facilitated by TA8179 team
16:40-17:00	Wrap up of Day 2	

Day/Session	Presentation/training activity	Presenter/facilitator
Day 3 - 20 November 2015		
Sessions 7: Adaptation Planning – Cambodian experiences		
8:00 – 8:10	Recap on adaptation planning session	Dr Jeremy Carew-Reid, *Adaptation Project Development Specialist*
8:10 – 8:25	Examples of irrigation adaptation in Cambodia (TW/MCRDP/DOC14)	Dr Mak Sithirith, *Agriculture and Climate change specialist*
8:25 – 8:40	Examples of flood management adaptation in Cambodia (TW/MCRDP/DOC15)	Dr Seak Sophat, *Deputy Team Leader/ Senior Strategic Program for Climate Resilience Management Specialist*
8:40 – 8:55	Examples of infrastructure adaptation (TW/MCRDP/DOC16)	Mr. Hak You, *Climate Change and infrastructure Specialist*
8:55 – 9.30	Climate Change Adaptation in Battambang City (TW/MCRDP/DOC17)	Mr. Yong Tonghann, *Technical Adviser, Battambang municipality/GIZ project*
9:30 – 9:55	Panel Discussion	Facilitated by TA8179 team
9:55 – 10:10	Coffee Break	
10:10-10:25	Introduction to Adaptation Planning working group session (TW/MCRDP/DOC18)	Dr Peter-John Meynell, *Team Leader/ Senior Strategic Program for Climate Resilience Management Specialist*
10:25 – 12:30	Working Group Session on Adaptation Planning	Facilitated by TA8179 team
12:30 -14:00	Lunch Break	
14:00 – 14:40	Adaptation Planning working group plenary report-back	Facilitated by TA8179 team
14:40 – 15:00	Plenary report back	Facilitated by TA8179 team
15:00 – 15:15	Coffee Break Circulation Workshop Evaluation sheet	
Sessions 8: Identifying adaption demonstration projects		
15:15 – 15:30	Introduction to demonstration project design session (TW/MCRDP/DOC19)	Dr Jeremy Carew-Reid, *Adaptation Project Development Expert*
15:30-16:30	Working Group Session on demonstration project design	Facilitated by TA8179 team
16:30 – 16:50	Demonstration project design working group plenary report-back	Facilitated by TA8179 team
16:50 – 17:00	Wrap up of workshop Collect workshop Evaluation	Mr. Peter-John Meynell, Team Leader
	Close of the workshop	HE. Sem Saroeun, Director General of Admin and Finance, MOE Mr. Ou Chanthearith, MCRDP Program Manager

8 APPENDIX 2. PARTICIPANT LIST

APPENDIX 3. KEY BASELINE ISSUES FOR KAMPONG SEIMA CANAL

3.1 Baseline Assessment for Group 1:

Task: Identify the main components of the system (e.g. pump station and intakes, bridge culverts, canal banks, canal dykes and roads, drainage outflows) – Describe the components and their condition

	Description of natural and manmade features and assets of the system	Condition Signs of degradation	Causes of degradation	Existing approaches to maintenance
System components **1: Canal starting from Pumping Station to NR57 (TL=2.5km)**	Pumping station (Intake, pump house, sedimentation tank); Twine pipes = 4 locations; Canal = 2.5km, made by natural earth with no erosion control	It was built in 1970s and in old condition and not in operating since 1995. Intake area seriously eroded and the river undermining foundations of the Pumping House; Block by vegetation; Shallow and small size in some location, there are some trees, agricultural fields and shops along the canal; Culverts too small and blocked with vegetation, sediment and solid waste	The pumping station is not in operation and then no maintenance. And erosion caused by river flow and scouring; Grass grow in canal; Sedimentation of solid waste and soil erosion; Sedimentation of solid waste and soil erosion;	No maintenance;
2: Canal starting from NR57 to NR5 (TL=2.0km)	Drain pipes = 6 locations; Illegal settlements = 33 houses, built on top of the canal; Canal = 2.0km, made by natural earth with no erosion control	There are many solid waste in the canal and the size is small; Water quality is bad (black colour); Flooding every year by storm water from the city during rainy season; Serious health issues	No solid waste collection service; Wastewater discharge and storm run-off from the town directly and the in-place dumping;	No maintenance;
3: Canal starting from NR5 to Por Mor Srey (TL=5.0km)	There are houses along canal; One concrete road build on the canal way, approach to a pagoda, caused the canal wide smaller; Within the pagoda area, the canal extended by underground	Not clear about the canal right-of-way; The size of the canal is small; Vegetation blocking canal; Solid waste in the canal; Water quality in the canal is bad (black colour);	Population settlement; No solid waste collection service; Local wastewater in-place dumping;	No maintenance;

	culvert; Canal = 5.0km, made by natural earth with no erosion control			
4: Canal starting from Por Mor Srey to Kdol Pagoda (TL=1.6km)	Canal is small; The canal is managed by a water user committees; The edge of the canal is Stung Sangke River Canal = 1.6km, made by natural earth with no erosion control	The size of the canal is small and shallow; Water quality in the canal is bad (black colour); The communities pump the water from Stung Sangke river into the canal form cropping and gardening during the dry-season;	Population settlement; Sedimentation of erode soil and solid waste; Grass grow	No maintenance;

3.2 Group 2: Describe the watershed context of the system

Task: Describe the location of the system within the watershed, the condition of the watershed and the occurrence of extreme events within the water shed (flood, droughts, landslides etc.). Document with photographs and sketches

Location within the watershed *(what is upstream, midstream, downstream)*	Three important watersheds: (i) upland watershed areas; (ii) Urban watershed; and (iii) floodplain watershed. 1. Upland watershed: Forest areas in the upper part of the River; Rice field watershed; Residential areas along the river. 2. Urban watershed (Toul Ta Ek): Battambang Town Residential areas Rice fields 3. The floodplain watershed area: Floodplain areas influenced by Tonle Sap water and by Sangke River; Rice field with less number of trees; In the wet season, the area is under the water; Cropping fields;

	☐ Crocodile farms; ☐ Fishing areas; ☐ Tourist area
Watershed condition *(identify features – land use, human settlements, ecological assets and services – and trends in their condition)*	1. Upland watershed: ☐ Temples; ☐ Farmland; ☐ Human settlements; ☐ Trees growing along the river banks and canals; ☐ Gravel roads along the rivers and roads without culverts; 2. Urban watershed (Toul Ta Ek): ☐ Canal with small size; ☐ Human settlement on the canals since 1990s. ☐ Polluted water and poor hygiene; ☐ Liquid waste flow via canal; ☐ The canal is getting shallow 3. The floodplain watershed area: ☐ Farmers are doing wet season rice in the wet season; ☐ Residential areas; ☐ The dump of liquid waster from urban areas into the floodplains; ☐ Farmers pump water from canal for dry season rice cultivation; ☐ Dump site of solid wastes;
Experience with extreme events *(what, where, when, impact)*	Flashed flood occurred in 2013 at the end of September, affecting animals and peoples and it lasted for 4 days. 1. Upland watershed: ☐ Flooded in 2013 at the end September and it lasted in 4 days; ☐ Residential people moved to highland areas, particularly along the roads; ☐ Villagers moved to temples—a highland area. ☐ Damaging crops.

	Bank erosion; 2. Urban watershed (Toul Ta Ek)—Urban water floods the areas near the canal and residents every year. 3. The floodplain got flooded in 2013, and every year water submerges the areas. However, in the dry season, farmer experience lack of water.

3.3 Group 3: Description of the specific location

Task: Description of the specific location - *Identify and describe the geographical, natural and manmade features in the immediate vicinity of the system, include any slopes, vegetation, soil types proximity to water bodies etc.*

Note: The group has devised into three sections; *pump station and intakes, Po Rek Rey community (resettlement over the canal), and new canal (Po Mor Srey Canal).* The description of these specific locations/ sections is below;

A. Pumping station and intake area:

Landscape and natural features *(include slope, soil conditions, vegetation, water bodies)*	There are step slop and (Stung Sangke) riverbank erosion at the pumping station and water intake. Sedimentation at water intake, and alluvium-sand soil There are vegetation and grass grown along the embankment of canal and Stung (i.e. Stung Sangke) Water sources from Stung Sangke and rainfall (catchment area)
Manmade features *(e.g. roads, housing, drainage infrastructure etc.)*	Housing and glossary stores built along the road and Stung Sangke's embankment, A paved road (i.e., bitumen or asphalt road) was constructed along the Sangke mainstream, and a laterite road constructed as embankment of Kampong Seima Canal, The pumping station was built in Pol Pot era-it consists of building, sediment trapping pond and bridge culvert, Sluice at bridge culvert-irrigate the water for home use and rice field.
Cultural features	Wat (Buddhist Pagoda) Traditional (wet season) rice cultivation
Environmental issues *(e.g. pollution, erosion, solid waste)*	The canal system was polluted by plastic, can, and glass garbage, and liquid waste water was directly discharged from home (i.e., local people built their toilet in the canal)

	Canal land encroachment-local people encroached the canal land for their residential and agricultural area

B. Po Rek Rey community-resettlement over the canal:

Landscape and natural features *(include slope, soil conditions, vegetation, water bodies)*	The landscape condition is the low land. There are shrub mixed up with big forest trees, and fruit trees (i.e., orchard vegetation). The area consists of agricultural area (i.e. farming), residential, town and vehicle garage..., The source of water is from rainfall, and from the town's drainage canal.
Manmade features *(e.g. roads, housing, drainage infrastructure etc.)*	People resettled over the canal, and canal land was grabbed Drainage/irrigation canal was closely installed, and put under ground of pagoda, Paved roads (bitumen road, concrete road and laterite road) were built around the area, Crocodile farms
Cultural features	Buddhist pagoda Hook and line fishing practices along the drainage/irrigation canal
Environmental issues *(e.g. pollution, erosion, solid waste)*	Environment of the system was polluted by the wastewater from town, household, crocodile farms, garage and others. Also the system was polluted by garbage, Canal land encroachment-causes to narrow down the canal bed.

C. New canal- Po Mor Srey Canal area:

Landscape and natural features *(include slope, soil conditions, vegetation, water bodies)*	It is the floodplain area, and lowland rice field There is vegetation grown along the canal bank. There are shrub and big trees exist in the area, Water source is from rainfall and Battambang town. And sometime the local community has pumped the water from Stung Sangke stream for irrigating to their agricultural land.
Manmade features *(e.g. roads, housing, drainage infrastructure etc.)*	Housing and glossary house-store/store were built along the road and canal embankment New canal (Po Mor Srey canal) was designed and built in order to drain the water out of the city, and irrigate the water for agricultural production. The canal was constructed with sluice, bridge culvert, and trees were grown along the canal embankment or laterite road, Local grasses were grown at the canal bank to protect the bank erosion

Cultural features	Kdol pagoda (Buddhist pagoda) Wet rice cultivation-traditionally
Environmental issues *(e.g. pollution, erosion, solid waste)*	Solid waste and waste water from town and dumping site close to the canal (i.e., about 1 km long) Canal land encroachment

3.4 Group 4: Past Experience and Response to Extreme Events

Group 4 of the training was a mix participant from MPWT, MOE, MOWRAM, NCDD, GIZ (Urbanization Specialists) of Battambang, Department of land and urbanization of Battambang city, member of climate change group of Battambang together with other participants of group 1, 2 and 3 of the training have visited whole system of Kampong Seima irrigation canal in Battambang Town. The group members visited five points of the canal by starting from Pumping station (starting point of canal: upstream of Sangke River), Dempor Rik Reay community (slum community), Ochar culverts (national road #5), Por Morsrey new canal (collective and release of flood water), and Wat Kdol (ending point of Kampong Seima canal). The group mainly focused on collection of information on impacts of extreme climate events (flood and drought) through interview local people and local authority at points where the group visited. The information of extreme climate events and their impacts on Kampong Seima irrigational canal were consolidated from findings of group members through group meeting in training room on morning of 19 November 15. Table 4.1 below presents result of group discussion and consolidate results of the group on past experience and response to extreme events on canal.

Table 4.1: **Past experience and response to extreme events**

Date of event	Biophysical description	Impact on system	Components affected	What was the response to the impact?	How effective was the response?
1. System	Start at upstream part and finish at downstream of Sangke River It passes through villages, slum areas, residential area, and agricultural, social and cultural areas. The space of canal is not clear	Flood most part of the canal Flood some houses along canal Flood road along both side to the canal	Embankment of canal Banks and bed of canal	Local authority prior informed villagers about the flood Observed and keep inform level of flood water Prepared hill to move people and animals during flood.	

				Provided awareness on health Red Cross provided foods Build new canal	
1. Pumping Station	Sangke River Villages Kampong Seima canal	Flooding station Duration of flood 3-6 days Flood by water from upstream of Sangke River Less water in Sangke river and canal during drought occurred	Flood of station Some houses in village were flooded.	Local authority prior informed villagers about the flood Prepare hill to move people and animals during flood. Move pumping machine closer to the river	Villagers were aware of flood and they were prepared for flood
2. Dempor Rik Reay Community	Irrigation and drainage Canal Located in low land Some houses were built over the canal	Flood water flooded most of houses in community Flood over the canal Flood over roads along the canal	Most of houses were flooded Flood over roads along the canal Lack of clean water to use Health problem (mosquito, garbage, bad odours Long flood duration at the community Livelihood of community was down during flood.	Red Cross provided foods Villagers use big jar to store rain water Organized as a community to be earlier to community and inform for extreme climate events Establish saving group of community Local authority provided awareness on health	Temporary intervention
3. Ochar Canal	Collective water from Kampong Seima canal were collected from several Sangkats of the town	Caused flood upstream along Kampong Seima Encroachment of land, land filling	Caused flood upstream along Kampong Seima	N/A	Don't know

		on canal Small canal	Encroachment of land, land filling on canal		
4. Por Morsrey Canal	Located in low land area Twin dykes	Completed flood during extreme flood Collection of flood water from Kampong Seima canal	Completed flood during extreme flood Collection of flood water from Kampong Seima canal	Build new canal	Not sure for effective of this new canal because it has just finished in 2015
5. Wat Kdol	Wat School Villages	Almost flood during extreme flood The low land nearby of agriculture plantations were flooded	N/A	Observed and keep inform level of flood water No intervention	N/A

APPENDIX 4. POWER POINT PRESENTATIONS (PORNY)

APPENDIX 5. COMPLETED VA MATRICES (X4)

Results of Group 1:

Y **(**Date: 19 November 2015**)** **(Group 1)**

Asset	Threat	Exposure	Sensitivity	Impact	Description of Impact	Adaptive Capacity	Vulnerability
(**Whole System**)	(Flood)	[2]	(**H**) [3]	(**H**)	(flooding of Sangke River cause bank erosion) (flooding by storm water and wastewater from the city cause floods every year and erode the canal bank and bring in with some solid waste and slurry; cause sedimentation made canal	(**L**) [4]	(**H**)

[2] Pumping station is close to Stung Sangke River. And the whole canal is receiving storm and waste run-off from the Battambang town directly.
[3] Pumping station is old (built in 1970s) and damage not function. And the whole canal is shallow and earth made.
[4] No financial for maintaining and/or rehabilitating the whole system.

Asset	Threat	Exposure	Sensitivity	Impact	Description of Impact	Adaptive Capacity	Vulnerability
					become shallower and clog the culverts; polluted water cause illness disease; top of the canal become smaller and damage cause inaccessible)		
	(Drought)	(**H**)	(**H**)	(**H**)	(lack of water, dust, damage crops, grasses grow)	(**L**)	(**H**)
(**Component 1 Pumping station & intake**)	(River flood)	(**H**)[5]	(**H**)[6]	(**H**)	(flood of Sangke River erodes riverbank and sink the station in some years)	(**L**)[7]	(**H**)
(**Component 2 Culverts and bridges**)	(Storm flood)	(**H**)[8]	(**H**)[9]	(**H**)	(Solid waste come into the canal with storm and wastewater and clog the culvert, collapse the culverts)	(**L**)[10]	(**H**)
		(**H**)[11]			(Cause the canal		

[5] Pumping station is close to Stung Sangke River.
[6] Pumping station is old (built in 1970s) and damage, the riverbank is easily eroded by water flow and scouring.
[7] No financial for rehabilitating the whole system.
[8] Storm and wastewater run-off from the Battambang town directly and cause flood every year. And also bring in with some solid waste and slurry.
[9] The culverts are small and easily clog by solid waste and sedimentation.
[10] No financial for rehabilitating the system.
[11] Storm and wastewater run-off from the Battambang town directly and cause flood every year. And also bring in with some solid waste and slurry.

Asset	Threat	Exposure	Sensitivity	Impact	Description of Impact	Adaptive Capacity	Vulnerability
(**Component 3 canal bed and banks**)	(Storm flood)		(**H**) [12]	(**H**)	shallower, ease erosion) **L** (	(**L**) [13]	(**H**)
(**Component 4 canal dyke and roads**)	(Storm flood)	(**H**) [14]	(**H**) [15]	(**H**)	(flood last long, the canal is earth that easily eroded)	(**L**) [16]	(**H**)
(**Component 5 watershed**)	(Storm flood)	(**H**) [17]	(**H**) [18]	(**H**)	(Battambang city becomes a watershed to the canal system, heavy rain-fall)	(**L**) [19]	(**H**)
	(Drought)	(**H**)	(**H**)	(**H**)	(Not sufficient reservoir, lack of water for crops)	(**L**)	(**H**)
(	(Storm	(**H**)	(**H**)	(**H**)	(flood, erosion, solid waste, wastewater)	(**L**)	(**H**)

[12] The canal is small and shallow that easily blocked by solid waste and sedimentation. And also it is made by natural earth that easily eroded.
[13] No financial for rehabilitating the system.
[14] Storm and wastewater run-off from the Battambang town directly and cause flood every year.
[15] Natural earth made.
[16] Communities' budget can solve for small cases only.
[17] Heavy rain-fall in Battambang city.
[18] Not sufficient water reservoir.
[19] No financial for developing the system.

Asset	Threat	Exposure	Sensitivity	Impact	Description of Impact	Adaptive Capacity	Vulnerability
[illegible]	flood)						
Component 6 Surrounding land use *(agricultural, residences, commercial areas)*	(Drought)	[illegible]	[illegible] (**H**)	[illegible] (**H**)	[illegible] (Not sufficient reservoir, lack of water for crops)	[illegible] (**L**)	[illegible] (**H**)

Results of Group 2:

[illegible]

(**Asset**)	(**Threat**)	[illegible]	[illegible]	[illegible]	(**Description of Impact**)	[illegible]	[illegible]
(**Whole System**)	**Flood**	[illegible][20]	**H**[21]	**H**	- **Flood damages infrastructure including road, canal, bank erosion, culvert collapse etc.** - **Flood damage settlement/house.. etc.** - **Flood damage agriculture fields**	**L**	**H**

[20] Exposure is medium for the whole system, but in some part, it is high for some areas.
[21] There is no proper system to protect the system given its weak system

					- **Flood could cause health problems,** -		
	Drought	**H**[22]	**H**	**H**	- **Drought damage crop,** - **It causes health issues** - **Human lacks drinking water** -	**L** **Except the water pump station structure others weak, small,**	**H**
N[illegible]	[illegible]flood	**H**[23]	**H**[24]	**H**	**The flood would cause the erosion and river bank collapse** **The silt will block the intake.** **The pumping station is submerged by the**	**L**[25]	**H**

[22] It could affect the crops and human
[23] The pumping station is located closed to the riverbank and it is exposed to heavy flood.
[24] The flood occurred in 2013 since it was built in 1977, but the maintenance is poor
[25] The maintenance is very poor. There is lack of people participation in the maintenance

(**Component 1 Pumping station & intakes**)					**water.** **The outlet is blocked with small dykes**		
	Drought (Ä	**M**[26]	**M**[27]	**M**	**The drought does not reach the level that pose major concern.**	**M**[28]	**M**
N (**Component 2 Culverts and bridges**)	**Flood**	**H**[29]	**H**[30]	**H**	**The flood is huge and the capacity of culverts does not respond to the flow of the floods** **Some areas along the canal got shallow.** **Some reads do not have culvert and bridges**	**L**[31]	**H**

[26] According to hydrological data, there is no serious drought so far.
[27] The drought does not affect the station
[28] The infrastructure is still in place and it is still operating when there is a need of water and when there is water available
[29] Because infrastructure always highly expose to flood incidence.
[30] The culverts and bridges were smally installed and do not function well when there is a high flood
[31] The culvert and bridges are small. There was no plan to maintain it.

	Drought	**L**[32]	**L**[33]	**L**	**Drought does not affect the culverts and bridges.**	**H**[34]	**L**[35]
N LJ (**Component 3 canal bed and banks**)	**Flood**	**H**[36]	**H**[37]	**H**	**Erosion** **Bank collapse** **The canal bed and banks got damage and shallow.**	**L**[38]	**H**[39]
N y (**Component 4 canal dyke and roads**)	**Flood**	**H**	**M**[40]	**H**	- **Road understand damage , affect by flood, erosion, damage by users during flood** - **Disturb users and stop economic activities**	**M**[41]	**H**
	Drought	**L**	**L**	**L**	- **Impacts are not much.** - **But drought could cause dusty**	**M**[42]	**M**

[32] It could resist to the drought and does not damage
[33] The sensitivity to drought is low. It is structure does not affect by drought
[34] It is high, because made from reinforcement concrete
[35] It does not affect by drought
[36] Flood damages the canal bed and banks as a give high flow.
[37] Flood erodes the canal and it drops the silt somewhere given there is no proper protection. The canal is small and it is risk to getting shallow.
[38] The soil condition and canal bank and bed have not been properly maintained. There is no community participation in maintained the canal
[39] Erosion, the level of canal affect by flood, destroy level of canal
[40] What we have seen it indicates that the sensitivity to flood is somehow medium
[41] There is lack of proper maintenance.
[42] Maintenance is not inadequate.

N [illegible] (**Component 5 watershed**)	**Flood**	**H**[43]	**H**[44]	**H**		**L**[45]	**H**
	Drought	**L**	**L**	**L**	- **More water settlement on canal**	**H**[46]	**L**
N [illegible] ([illegible] 5 [illegible] **Component 6 Surrounding land use** *(e.g. agricultural fields, residences, commercial areas)*	**Flood**	**H**[47]	**H**[48]	**H**	- **Crop damage** - **House damage** - **Property destruction** - **Loss of life and agriculture.**	**L**[49]	**H**
	Drought	**H**[50]	**H**[51]	**H**	- **Crop damage** - **Damage to rice farming**	**L**	**H**

Results of Group 3:

Asset	Threat	Exposure	Sensitivity	Impact	Description of Impact	Adaptive Capacity	Vulnerability

[43] Flood is high in 2013
[44] The area is low and it is sensitive to flood
[45] The capacity to adaptation to flood is low.
[46] The capacity to adapt to drought is low
[47] It is a lowland area and it is easy to get it flooded.
[48] The area is sensitive to floods.
[49] Institutional and policy framework are inadequate and local capacity is weak to address the flood issues
[50] It is vulnerable for crop
[51] It affects agriculture

Whole System							
Component 1 Pumping station & intake	Flood from rainfall	**VL**	**M**	**L**	Stung Sangke's riverbank has slightly eroded by rainfall	**H**	**L**
	Flood from Stung Sangke	**H**	**M**	**H**	Riverbank of Stung Sangke eroded by strong water current Sedimentation at water intake caused to block the pumping intake Flood brought the garbage and debris into the system	**H**	**M**
Component 2 Culverts and bridges	Flood from rainfall	**H**	**VH**	**VH**	Storm water runoff brought the garbage and debris into the system caused to block the culvert or drainage pipeline Storm water is overflow of the road caused to damage road	**L**	**VH**
	Flood from Stung Sangke	**H**	**VH**	**VH**	The flood flows over the road structure caused to damage road Flood brought the garbage and debris caused to block the drainage pipeline and damage the drainage Flooded the city caused to damage of lot of public and private property, and services	**L**	**VH**
Component 3 canal bed and banks	Flood from rainfall	**M**	**M**	**M**	Rainfall runoff caused to erode the bank of canal and canal bed, Sedimentation and transportation of garbage and debris from area to area caused to shallow down the canal The canal losses of capacity to transport the water to irrigated area	**L**	**M**

	Flood from Stung Sangke	**H**	**VH**	**VH**	Flood water runoff caused to erode the bank of canal and canal bed, Sedimentation and transportation of garbage and debris from area to area caused to shallow down the canal. Consequent the canal losses of capacity to transport the water to irrigated area	**L**	**VH**
Component 4 canal dyke and roads	Flood from rainfall	**M**	**M**	**M**	Storm water and rainfall flooded the road and canal embankment Eroded the road/canal embankment-making a hole Disturbance in transportation and damage property	**L**	**M**
	Flood from Stung Sangke	**M**	**M**	**M**	River flows flooded the road and canal embankment Eroded the road/canal embankment-making a hole Disturbance in transportation and damage property	**L**	**M**
Component 5 watershed	Flood from rainfall and from river	**L**	**H**	**M**	Flooded the watershed area caused to damage the soil structure and making poor soil quality	**M**	**M**
Component 6 Surrounding land use *(e.g. agricultural fields, residences, commercial areas)*	Flood from rainfall and from river	**M**	**M**	**M**	Flooded the watershed area caused to damage the soil structure and making poor soil quality Caused to damage the crop production, infrastructure and service	**L**	**M**
	Drought	**H**	**H**	**H**	Lack of water supply for cropping, and caused to low agricultural production and low income Waste water effluent the irrigation system-i.e., the irrigation canal become to sewage drainage canal	**L**	**H**

Results of Group 4:

VA-AP VULNERABILITY ASSESSMENT

With availability of baseline assessment, the group conducted another discussion to discuss and identify threat, degrees of exposure, sensitivity, and existing adaptive capacity of components of the canal to climate event. The group divided whole system of the canal into six components include (i) pumping and intake, (ii) culvert and bridges, (iii) canal beds and banks, (iv) canal dykes and roads, (v) watershed, and (vi) surrounding land uses. The group

discussed and identified degrees of exposure, sensitivity, and adaptive capacity for each system component and then come up with whole system. The degree of impact was calculated by using matrix table of determining impact between degree of exposure and degree of sensitivity. Similarly, degree of vulnerability was calculated by using matrix table of determining vulnerability between degree of impact and degree of adaptive capacity of the system components and whole system. As results, group discussion found degrees of impact and vulnerability to climate events (especially flood) of system components and whole system are at high. Table 4.2 presents results of identification of impacts and vulnerability of system component and whole system. The completed results in Table 4.2 are converted into scorecard as Table 4.3 presents score cards of system component and whole system.

Table 4.2: **VA-AP VULNERABILITY ASSESSMENT OF GROUP 4**

Asset	Threat	Exposure	Sensitivity	Impact	Description of Impact	Adaptive Capacity	Vulnerability
Whole System	Flood (flood from river and flood from rain)	**H**	**H**	**H**	Serious erosion at the bank close to station The station is flooded during extreme flood; Serious erosion and collapse of banks of canal; The diameter/size of culvert is small can't release water to down-stream easily when flooding. The levels of placed culverts are different. Blocking of culverts by garbage, soil, and vegetation. Slope of embankment is not right. Some place are too steep Flow of wastewater and garbage into canal	**L**	**H**
	Drought				Less water in canal and river		

Component 1 Pumping station & intake	Flood (flood from river and flood from rain) Drought	**H** **M**	**M** **L**	**M** **M**	Erosion and collapse of bank near the station It was flood during extreme flood But the building still look in good condition even it is almost 40 years old. Station is located at highland area Water in Sangke River is at the bottom. It is far from the station	**M** **M**	**M** **M**
Component 2 Culverts and bridges	Flood (both flood, flood from river and flood from rain)	**VH**	**VH**	**VH**	The diameter/size of culvert is small can't release water to down-stream easily when flooding. There is not standard size and high of culverts to be placed. There are blocking of culverts by garbage, soil, and vegetation.	**L**	**VH**
Component 3 canal bed and banks	Flood (both flood, flood from river and flood from rain)	**VH**	**VH**	**VH**	Erosion and collapse of banks of canal The bed of canal is shallow Slope of embankment at some place is not right. Some place are too steep No slope preparation to protect erosion	**VL**	**VH**
Component 4 canal dyke and roads	Flood (both flood, flood from river and flood from rain)	**VH**	**VH**	**VH**	Encroachment on the embankment of canal (land filling, building house on embankment) Erosion on both side on slopes of canal	**L**	**H**

Component 5 watershed	Flood (both flood, flood from river and flood from rain)	**H**	**M**	**H**	Most watershed of canal were flood The capacity of watershed in absorbing rainwater decrease due to the changing of land from agriculture to urbanization. There is a rapid increasing in urbanization, conversion of agriculture land to housing building,.. The increase of quantity of wastewater flow directly to the canal	**L**	**H**
Component 6 Surrounding land use *(e.g. agricultural fields, residences, commercial areas)*	Flood (both flood, flood from river and flood from rain)	**M**	**H**	**M**	Erosion of top soil to canal Flow of wastewater and garbage into canal The use of agricultural pesticide and herbicide pollute water in Canal	**L**	**M**

Table 4.3: Scorecard of exposure, sensitivity, impact, adaptive capacity, and vulnerability of the system component and whole system of Group 4

System/component		Exposure	Sensitivity	Impact	Adaptive Capacity	Vulnerability
Whole system		**High**	**High**	**High**	**Low**	**Very High**
Component 1 Pumping station & intake	**Flood from rainfall**	**High**	**Medium**	**Medium**	**Medium**	**Medium**
	Drought	**Medium**	**Low**	**Medium**	**Medium**	**Medium**
Component 2 Culverts and bridges	**Flood from rainfall**	**Very High**	**Very High**	**Very High**	**Low**	**Very High**
Component 3 canal bed and banks	**Flood from rainfall**	**Very High**	**Very High**	**Very High**	**Very Low**	**Very High**

Component 4 canal dyke and roads	**Flood from rainfall**	**High**	**Medium**	**High**	**Low**	**High**
Component 5 watershed	**Flood from rainfall**	**High**	**Medium**	**High**	**Low**	**High**
Component 6 Surrounding land use	**Agriculture/ Residential**	**Medium**	**High**	**Medium**	**Low**	**Medium**

APPENDIX 6. SUMMARY VA MATRICES (X4) IN MAIN TEXT (NEED TO CORRECT GROUPS 3'S MATRIX) (PHEAK)

Group 1:

System/component		Exposure	Sensitivity	Impact	Adaptive Capacity	Vulnerability
Whole system		High	High	High	Low	High
Component 1 Pumping station & intake		High	High	High	Low	High
Component 2 Culverts and bridges	Flood	High	High	High	Low	High
Component 3 canal bed and banks	Flood	High	High	High	High	High
Component 4 canal dyke and roads	Flood	High	High	High	Low	High
	Drought	High	Low	Medium	Medium	Medium
Component 5 watershed	Flood	High	High	High	Low	High
	Drought	High	High	High	Low	High
Component 6 Surrounding land use		High	High	High	Low	High
	Flood	High	High	High	Low	High

Group 2

System/component		Exposure	Sensitivity	Impact	Adaptive Capacity	Vulnerability
Whole system	Flood	High	High	High	Low	High
	Drought	High	High	High	Low	High

Component 1 Pumping station & intake	**Flood**	**High**	**High**	**High**	**Low**	**High**
	Drought	**Medium**	**Medium**	**Medium**	**Medium**	**Medium**
Component 2 Culverts and bridges	**Flood**	**High**	**High**	**High**	**Low**	**High**
	Drought	**Low**	**Low**	**Low**	**High**	**Low**
Component 3 canal bed and banks	**Flood**	**High**	**High**	**High**	**Low**	**High**
Component 4 canal dyke and roads	**Flood**	**High**	**Medium**	**High**	**Medium**	**High**
	Drought	**Low**	**Low**	**Low**	**Medium**	**Medium**
Component 5 watershed	**Flood**	**High**	**High**	**High**	**Low**	**High**
	Drought	**Low**	**Low**	**Low**	**High**	**Low**
Component 6 Surrounding land use		**High**	**High**	**High**	**Low**	**High**
	Flood	**High**	**High**	**High**	**Low**	**High**

Group 3:

System/component		Exposure	Sensitivity	Impact	Adaptive Capacity	Vulnerability
Whole system						
Component 1 Pumping station & intake	**Flood from rainfall**	**Very Low**	**Medium**	**Very Low**	**High**	**Very Low**
	Sangke River flood	**High**	**Medium**	**High**	**High**	**Medium**
Component 2 Culverts and bridges	**Flood from rainfall**	**High**	**Very High**	**Very High**	**Low**	**Very High**
	Sangke River flood	**High**	**Very High**	**Very High**	**Low**	**Very High**
Component 3	**Flood from**	**Medium**	**Medium**	**Medium**	**Low**	**High**

canal bed and banks	rainfall					
	Sangke River flood	High	Very High	Very High	Low	Very High
Component 4 canal dyke and roads	Flood from rainfall	Medium	Medium	High	Low	Very High
	Sangke River flood	Medium	Medium	High	Low	Very High
Component 5 watershed	Flood from rainfall	Low	High	Very High	Medium	High
Component 6 Surrounding land use	Flood from rainfall	Medium	Medium	High	Low	High
	Drought	High	High	High	Low	Very High

Group 4:

System/component		Exposure	Sensitivity	Impact	Adaptive Capacity	Vulnerability
Whole system		High	High	High	Low	Very High
Component 1 Pumping station & intake	Flood from rainfall	High	Medium	Medium	Medium	Medium
	Drought	Medium	Low	Medium	Medium	Medium
Component 2 Culverts and bridges	Flood from rainfall	Very High	Very High	Very High	Low	Very High
Component 3 canal bed and banks	Flood from rainfall	Very High	Very High	Very High	Very Low	Very High
Component 4 canal dyke and roads	Flood from rainfall	High	Medium	High	Low	High

Component 5 watershed	**Flood from rainfall**	**High**	**Medium**	**High**	**Low**	**High**
Component 6 Surrounding land use	**Agriculture/ Residential**	**Medium**	**High**	**Medium**	**Low**	**Medium**

APPENDIX 7. SUMMARY OF ADAPTATION MEASURES FOR WHOLE SYSTEM AND BY COMPONENT (?) – FOR MAIN TEXT (X4)

Results of Group 1:

Asset	Threats	Impacts	Adaptation measures/options
Whole system	**(FLOOD)**	(flooding of Sangke River cause bank erosion) (flooding by storm water and wastewater from the city cause floods every year and erode the canal bank; sedimentation made canal become shallower; polluted water cause illness disease; top of the canal become smaller cause inaccessible)	1. (Study and prepare a proper master plan for water catchment and drainage system) 2. and use planning) 3. (Solid waste and wastewater management and treatment) 4. (Promote to have septic tank at all houses, business buildings) 5. Promote to have rain garden) 6. (Use rock-filled gabions for protecting the riverbank) 7. (Rehabilitate the canal system by dredging and elevate the bank higher)

Asset	Threats	Impacts	Adaptation measures/options
	(DROUGHT)	(Lack of water, dust, impact on cropping, vegetation growth)	8. (Protecting the bank of the canal by grass, bamboo and rock-riprap) 9. (Resettlement) 10. (Awareness raising about hygiene)
Component 1 Pumping station & intake	**(FLOOD)**	(flood of Sangke River erodes riverbank and sink the station in some years)	1. Use gabions to protect the bank (it is easily installed, cost effective, resilient to hydraulic forces, allow vegetation grow) 2. Re-construct a floating pumping station and protect the bank by gabions (the same as 1. above) 3. Grow bamboo with rock-riprap (Bamboo is easily grew and resilient to water, slow down the water flow velocity and erosion control, cost less and easily re-planting) **4.** Build concrete retaining wall
Component 2 Culverts and bridges	**(FLOOD)**	(Solid waste come into the canal with storm and wastewater and	**1.** Replace new culvert with twine 1m diameter **2.** Protect the culverts with rock-riprap and grass

Asset	Threats	Impacts	Adaptation measures/options
		clog the culvert, collapse the culverts)	
Component 3 canal bed and banks	**(FLOOD)**	(Cause the canal shallower, ease erosion)	1. Rehabilitate the canal 2. Protect the slope with grass 3. Install box culvert at the road way accessing to pagoda and install permeable block paving with grass
Component 4 canal dyke and roads	**(FLOOD)**	(Flood last long, the canal are earth made that easily eroded)	1. Elevate the canal bank about 0.5m higher than the flood level and widening the slope bank 2. Protect the slope with grass 3. Lay laterite toping the canal road for several years and pave concrete later
	(DROUGHT)	(Lack of water every years)	Not suggested
	(FLOOD)		**1.** Study and prepare a proper master plan for water catchment and drainage system

Asset	Threats	Impacts	Adaptation measures/options
Component 5 watershed		(Battambang city becomes a watershed to the canal system, it is heavy rain-fall area)	**2.** Rehabilitate and improve the existing systems **3.** (Build rain garden)
	(DROUGHT)	(Not sufficient water reservoir, lack of water for crops)	Not suggested
Component 6 Surrounding land use *(e.g. agricultural fields, residences, commercial areas)*	**(FLOOD)**	(flood, erosion, solid waste, wastewater)	1. and use planning (zoning, Boundary) 2.) Sedimentation Pond to treat wastewater (4ha) 3. Resettlement 4. (Promote to have septic tank at all houses, business buildings) 5. Awareness raising about hygiene
	(DROUGHT)	(Not sufficient water reservoir, lack of water for crops)	Not suggested

Results of Group 2:

Asset	Threats	Impacts	Adaptation measures/options
Whole system	Flood Drought	- **Road, canal, bank erosion, culvert collapse etc.** - **Flood damage settlement/house. Etc.** - **Flood damage agriculture fields Flood could cause health problems,**	**1. Rehabilitate the canal bed and raise the level of dyke, rehabilitate the slope and plan along the canal and slope, build the canal body as a read, renovate the pumping station.** **2. Mobilization of local communities in the management and maintenance, organizing farmer water user group to manage the canal system, and dissemination of information and legal framework to communities** **3. Resettlement of communities living along the canals**
Component 1 Pumping station & intake	**Flood** **Drought**	**The flood would cause the erosion and river bank collapse** **The silt will block the intake.** **The pumping station is submerged by the water.** **The outlet is blocked with small dykes.** **The drought does not reach the level that pose major concern.**	**6. Build the spillway that could store water for dry season pumping** **7. Renovation of pumping station and its accessories. Enlarge the intake and rehabilitate that areas so that we could pump water.** **8. The responsible institutions must organize their staff to manage the station.** **9. Organize communities and maintain the system;** **10. Establish the Farmer Water User Group;**
	Flood	**The flood is huge and the**	**4. To renovate the culverts and bridges according to the floods**

Asset	Threats	Impacts	Adaptation measures/options
ŏ **Component 2 Culverts and bridge**	**Drought**	**capacity of culverts does not respond to the flow of the floods** **Some areas along the canal got shallow.** **Some reads do not have culvert and bridges** **Drought does not affect the culverts and bridges.**	**volumes, and the flow of water, and based on technical requirements.** **5. Involvement of local government, technical institutions in the management of culverts and bridges; and Participation of local communities in managing the culvers and bridges.** **6. Commune Fund, and Provincial funds require to be developed to support the canal development and maintenance —Commune Plan and Commune Funds.**
N LJ **Component 3 canal bed and banks**	**Flood** **Drought**	**Erosion** **Bank collapse** **The canal bed and banks got damage and shallow.**	**3. Plant the grass or small tree on the slope of the canals.** **4. Management and maintenance of the canal beds frequently by Farmer Water User Groups/local administration;**
N **Component 4 canal dyke and roads**	**Flood** **Drought**	- **Road understand damage , affect by flood, erosion, damage by users during flood** - **Disturb users and stop economic activities**	**4. Raise the level of road to avoid flooding the roads, built the concrete roads;** **5. Planting the trees along the canal dykes and roads;** **6. Community participation in the management and maintenance of the road.**
N **Component 5 watershed**	**Flood and drought**	- **Road understand damage, affect by flood, erosion, damage by users during flood** - **Disturb users and stop economic activities**	**4. Develop the land use planning and agro-eco analysis—land use for agriculture, settlement areas, wetland, especially conduct the study on the hydrological regime in the watershed areas and develop the plan to release water from the watershed area;** **5. Development the wetland areas so that it becomes the reservoir to store wastewater.**

Asset	Threats	Impacts	Adaptation measures/options
			6. Built the city belt canal to protect town from flooding.
Component 6 Surrounding land use *(e.g. agricultural fields, residences, commercial areas)*	**Flood and Drought**	- **Crop damage** - **House damage** - **Property destruction** - **Loss of life and agriculture** - **Lack of water for drinking in the dry season.** - **Disturb users and stop economic activities** -	**4. Develop the land use planning and agro-eco analysis—land use for agriculture, settlement areas, wetland,** **5. Build the reservoir and rehabilitate canal that could increase water flow;** **6. Protect and restore the natural wetland areas that could store floods.**

Results of Group 3:

Asset	Threats	Impacts	Adaptation measures/options
Whole system	Flood from rainfall	Slightly erode of Stung Sangke riverbank, and erode of canal's bank Shallow down of canal caused by sedimentation and debris, and garbage caused to block drainage and canal. Then it loses of capacity to drain water	4. Canal Rehabilitation (canal bed and depth) and plantation of vegetation on the canal bank, 5. Enhancement of culvert pipe and preparation of garbage collection system at sluice gate of the drainage or irrigation canal 6. Level up the levee and embankment of the canal and planting the tree and vegetation to protect bank and embankment erosion

Asset	Threats	Impacts	Adaptation measures/options
		out or irrigate the water to irrigated area Flood the road and canal embankment, and causes to erode the road and canal embankment by water runoff and puddle Disturbing and difficult to transportation	
	Flood from river (Stung Sangke stream)	Eroding of Stung Sangke riverbank and sedimentation and debris at water intake and block Eroding of bank of canal and stream Flood brought the garbage and debris, and make to block the canal and drainage gate Flooded certain part of the Battambang city (damage of the road, drainage and canal Flooded causes to lose soil quality and crop production	1. Preparation of (Stung Sangke) riverbank protection by using the domestic materials (such as alive pole and fence, vegetation-bamboo and reed, 2. Planting vegetation and trees on the bank and embankment of river (Stung Sangke), 3. Enhancing the drainage and irrigation system to collect storm water, trapping of runoff and flood.
	Drought	Lack of water supply for agriculture and household use The sewage water influents the irrigation canal	5. Constructing the sluice gate, and reservation of water for using in dry season, 6. Preparing of pumping machine for securing while the water shortage, 7. Developing sewage water treatment system, and treatment of waste water before discharging into the irrigation canal 8. Developing the waste/garbage management community.

Asset	Threats	Impacts	Adaptation measures/options
Component 1 Pumping station & intake	Flood from rainfall	Slightly erode of Stung Sangke riverbank causing by rain	Growing local grass on bank and embankment of canal
	Flood from river (Stung Sangke stream)	Eroding of riverbank by water current Sedimentation and debris at water intake and block Transport the garbage into the system	Preparation of (Stung Sangke) riverbank protection by using the domestic materials (such as alive pole and fence, vegetation-bamboo and reed. Or constructing of riverbank protection by using the concrete or gabion wall
Component 2 Culverts and bridges	Flood from rainfall	Transport the garbage into the system causing to block the drainage canal pipe/gate Flood over the road and canal embankment	Enhancement of culvert pipe and preparation of garbage collection system at sluice gate of the drainage or irrigation canal, and growing grass on canal/stream bank to protect water erosion
	Flood from river (Stung Sangke stream)	Flood over the road and canal embankment Transport the garbage into the system causing to block of or damage of the drainage canal pipe/gate Flood certain part of city (damage of property and service)	Enhancement of culvert pipe and preparation of garbage collection system at sluice gate of the drainage or irrigation canal, and growing grass on canal/stream bank to protect water erosion
Component 3 canal bed and banks	Flood from rainfall	Erode of canal's bank and bed Shallow of canal caused by sedimentation, debris and garbage intake. Loses of capacity to drain water out or irrigate the water to irrigated area	Canal Rehabilitation (canal bed and depth) and plantation of vegetation on the canal bank

Asset	Threats	Impacts	Adaptation measures/options
	Flood from river (Stung Sangke stream)	Eroding of riverbank by flood Sedimentation, debris and garbage get into the system causes	Canal Rehabilitation (canal bed and depth) and plantation of vegetation on the canal bank
Component 4 canal dyke and roads	Flood from rainfall and from river (Stung Sangke stream)	Flood over the road and canal embankment Erode of canal embankment and making road puddle Disturbing and difficult in transportation	Level up the levee and embankment of the canal and planting the tree and vegetation to protect bank and embankment erosion
Component 5 watershed	Flood	Flooded the watershed area causes to poor soil quality	Enhancing the drainage and irrigation system to collect storm water, and developing the pond to trap and collect water runoff and flood. Planting vegetation and trees on the bank and embankment of river (Stung Sangke).
Component 6 Surrounding land use *(e.g. agricultural fields, residences, commercial areas)*	Flood	Flooded the watershed area causes to poor soil quality Damage of crop production, infrastructure and service	Enhancing the drainage and irrigation system to collect storm water, and developing the pond to trap and collect water runoff and flood. Planting vegetation and trees on the bank and embankment of river (Stung Sangke).
	Drought	Lack of water supply for irrigation and use Low crop production The sewage water influents the irrigation canal	Constructing the sluice gate, and reservation of water for using in dry season, Preparing of pumping machine for securing while the water shortage, Developing sewage water treatment system, and treatment of waste water before discharging into the irrigation canal Developing the waste/garbage management community

Results of Group 4:

Asset	Threats	Impacts	Adaptation measures/options
Whole system	Flood (flood from river and rain)	Serious erosion and collapse of banks of canal and station Garbage and sediment block the culvert The capacity of culvert place is not proportion to collective quantity of water from upstream The size of culverts and level of place culvert are difference The encroachment on embankments, banks and canal The building houses on embankment, banks and canal The decreasing of capacity of watershed in absorbing rainwater into the ground The increase of urban expansion and urbanization The increase of wastewater from city and flow into canal	Prepare slope near to station by using gabion and plant trees Replace new culverts with bigger size to be proportion to collective quantity of water from upstream Build concrete slope protection and barrage at the sensitive are of water flow Prepare banks of canal by using geotextile, rocks, or concrete at the sensitive area of water flow Prepare bed of canal by using rock at sensitive area of water flow Build barrage for trapping garbage Clean and increase size and depth of the canals Collect and treat wastewater through constructed wetland discharging into the canal Prepare resettlement program to relocate people who are living over the canal and embankments Raise level of roads both side of canal Plant tree and grass along slopes Build sub-canals to collect rainwater to flow into canal Prepare plan for urbanization, control on land filling Establish maintenance team and educate people to participate in maintenance the station
Component 1 Pumping station & intake	Flood (flood from river and rain)	Serious erosion and collapse of bank of river at the station Flood the station	Prepare slope near station by using gabion and plant trees Raise up stand of pumping machine in station Establish a maintenance team and educate people to participate in maintenance the station
Component 2 Culverts and bridges	Flood (flood from river and rain)	Garbage and sediment block culverts The capacity of culvert is not proportion of collective quantity of	Replace new culverts with bigger size to be proportion to collective water from upstream Regulate sizes and levels of placing culverts Build concrete slope protection and barrage in front culvert cross

Asset	Threats	Impacts	Adaptation measures/options
		water from upstream The size of culverts and level of place culvert are difference	national #5 and culvert of road 57 Build barrage for trapping garbage
Component 3 canal bed and banks	Flood (flood from river and rain)	Bank erosions and collapse of embankment No is no grass plant along banks of the canal	Clean and increase size and depth of the canals Prepare banks of canal with earth soil by planting grass for protecting erosion Prepare banks and bed by using geotextile, rocks, or concrete at the sensitive area of water flow Collect and treat wastewater through constructed wetland discharging into the canal Prepare resettlement program to relocate people who living over the canal and on embankments
Component 4 canal dyke and roads	Flood (flood from river and rain)	The encroachment on embankments, banks and canal Erosion of slopes of dyke/roads	Raise level of roads on both side of canal Plant tree and grass along slopes Prepare resettlement program
Component 5 watershed	Flood (flood from river and rain)	Most of watershed were flooded Decrease capacity of watershed in absorbing rainwater and increase urbanization The increase of wastewater flow into canal	Build sub-canal to collect rainwater to flow into canal Develop plan for urbanization, control on land filling, and raise up level
Component 6 Surrounding land use *(e.g. agricultural fields, residences, commercial areas)*	Flood (flood from river and rain)	Erosion of top soil into the canal Bring garbage and wastewater into canal	Build sub-canal to collect rainwater to flow into canal Develop plan for urbanization, control on land filling Increase in planting trees