Output: Increased Climate Resilience

A. Overview

1. The Royal Government of Cambodia (RGC) is one of the pilot countries participating in the Pilot Program for Climate Resilience (PPCR) – one of the three sub-programs of the Strategic Climate Fund (SCF). The PPCR provides incentives for scaled-up action and transformational change in integrating consideration of climate risks and resilience in national development planning, consistent with poverty reduction and sustainable development goals. The priority sectors for PPCR in Cambodia include water resources, agriculture and infrastructure. In June 2011, the PPCR sub-committee endorsed Cambodia's Strategic Program for Climate Resilience (SPCR) with a funding envelope of up to $86 million ($50 million in grants and up to $36 million in concessional credit). Of this, an allocation of $17 million ($10 million loan and $7 million grant) was endorsed for “Climate-proofing of Roads in Kampong Chhnang, Kampong Speu, Prey Veng, and Svay Rieng Provinces” as part of the ADB-funded “Provincial Roads Improvement Project”. This document describes in detail the activities envisioned under one of the five outputs of the main project: Increased climate resilience. The monitoring indicators of this output are shown in the Appendix.

2. The proposed activities contribute to a key output of the investment component III (Improving Climate-resilient Infrastructure) of SPCR for Cambodia. The activities under this output include piloting approaches to strengthen civil works design and planning, as well as to reduce risks of damages resulting from climate change impacts through implementing ecosystem-based adaptation measures and emergency management responses. Through such activities, the planning capacity for climate-resilient infrastructure by the executing agency – the Ministry of Public Works and Transport (MPWT) – and provincial organizations will be enhanced. While data and information on global and regional climate change impacts are improving, it is still challenging to inform the design of engineered structures with precision, especially in Cambodia, where the lack of available climate change impact assessments and data adds to this uncertainty. However, several low risk options and no-regrets resilience measures such as piloting water capture and storage systems, planting appropriate species to restore ecosystem functions, and emergency management systems may be undertaken.

3. The outcome of the proposed Provincial Roads Improvement Project is the safe, climate-resilient, cost-effective, all-year access road network in agricultural provinces of Kampong Chhnang, Kampong Speu, Prey Veng, and Svay Rieng. The project includes rehabilitation of a 157.6 km long road and the development of a cross border facility. The total project cost is $78.8 million.

4. The project has 5 major outputs: (i) civil works for provincial roads improvement; (ii) road asset management; (iii) road safety and safeguards; (iv) climate resilience, which includes mapping of vulnerability to climate change, adjustments to road design, implementation of adaptation measures and emergency management activities; and (v) efficient project management support to the MPWT. Adjustments in civil works based on climate risk assessment are integrated into output one and complementary soft measures fall under output four. This document describes output 4 in detail.

5. One of the requirements of the Climate Investment Funds (CIF) including PPCR is the

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1 The other two sub-programs of the Strategic Climate Fund are Forest Investment Program (FIP) and Scaling up Renewable Energy Program (SREP) for low income countries.
inclusion of knowledge management component. This will be supported out of the PPCR grant resources of this proposed project. While the learning objective is cross-cutting at a technical level, the focus will be to better understand how roads can be planned, designed, and maintained to cope with the negative impacts of climate change. A better understanding of how roads may inadvertently increase vulnerability to climate change should also be identified. As such, the state of the roads where climate adjustments have been made will be monitored through the road asset management database of MPWT. Lessons on institutional structuring for integrating climate resilience into infrastructure development projects and decision-making will also be examined. A team of consultants will be recruited to assist MPWT in implementing this output. Each consultant will be responsible for monitoring and assessing such learning mechanisms and include them in their final reports and recommendations. Technical monitoring of road assets protected will be specifically conducted through Activity 4.6 described below. The national adaptation specialist will be responsible for compiling these and feeding them into the country-wide and CIF-wide learning mechanism.

B. Climate Change Impacts on Cambodian Rural Roads

6. The most recent climate change projections, developed through Cambodia’s Ministry of Environment, suggest that under a high emission scenario, wet season rainfall will decrease until 2025 and then increase again by 2050 and 2080. However, under a low emission scenario, wet season rainfall will increase in 2025 and then decrease again by 2050 and 2080. Probabilities are unavailable for these projections and the results are inconclusive in terms of informing the project other than to highlight the need to apply flexible and low-risk climate resilience approaches. All studies reviewed showed an average overall warming across Cambodia, and assumed warming of 0.79°C in average temperature by 2030, for the project design.

7. Given that detailed climate change impact assessments are not available for the project design, other sources of information were assessed in detail. These include: (i) a review of the literature, such as post disaster needs assessments and hydrological modeling reports; (ii) a review of current climatological records and trends from the Department of Meteorology of Cambodia; (iii) interviews with local government units; and (iv) community level field surveys of 700 respondents. A review of existing climate trends in the project area and current vulnerabilities of the infrastructure was also assessed from an engineering perspective. This data served as the basis for the proposed project design summarized below.

8. Flooding in Cambodia is a natural occurrence and the agro-ecosystems are adapted to seasonal floods. Most people are concerned when the intensity and occurrence changes. These events also create the greatest damage to infrastructure, as seen during typhoon Ketsana in October 2009, which was estimated to cause approximately $15 million in direct damages to the transport sector and a further $11 million in indirect losses through economic loss of access to roads.

9. There are two major flood types in Cambodia: (i) flashfloods, resulting from heavy downpour upstream on the Mekong River, which affect provinces along the Mekong and the southeastern areas of the country (e.g. 2001); and (ii) central area large scale floods, resulting from a combination of runoff from the Mekong River and heavy rains around the Tonle Sap Lake, which affect the provinces around the lake and the southern provinces (e.g. 1996 and 2000).

The proposed knowledge management activities will be closely coordinated with a separate $7.0 million technical assistance project endorsed as part of SPCR for Cambodia. If there is a need, there is also an opportunity of seeking an additional $250,000 from PPCR sub-committee to support knowledge management.
10. In the past, these annual floods produced more benefits than harm. Devastating floods affecting a significant population used to occur almost every five years (in 1961, 1966, 1978, 1984, 1991, and 1996). Recently, however, harmful floods have occurred every year since 1999, and the worst hit in 2000. Floods seem to be getting worse and more frequent, perhaps due to climate change and human activities including inappropriate land use planning that degrade the environment. Flooding patterns have significantly changed in several provinces, including Kampong Cham, Kampong Chhnang, Kampong Thom, Kandal, and Takeo. It is this change that often causes concern because the population, as well as the built environment, is often not equipped to manage them.

11. Drought is not adequately monitored in Cambodia but has devastating effects for a country, which relies heavily on agriculture. There are four characteristics of agricultural drought in Cambodia: (i) unpredictable delays in rainfall onset in the early wet season, (ii) erratic variations in wet season rainfall onset, amount, and duration across different local areas, (iii) early ending of rains during the wet season, and (iv) common occurrence of mini-droughts of three weeks or more during the wet season which can damage or destroy rice crops without irrigation. Communities in the project area regularly run out of water during the dry season, and this project will also address this through small-scale piloting of adaptation measures.

12. Flooding and soil moisture content is a primary concern for protecting investments in road works and will be addressed as a priority in the adaptation strategy of this project. There is no strong evidence of major landslides damaging the road due to the relatively flat topography. However, when materials are extracted for construction of the embankments, borrow pits alongside the road are increasingly eroded and cause safety problems to people, livestock, and infrastructure. Side-slope erosion is frequent as well as damage to small bridges by fast flowing and rising water levels during the wet season. At the same time, communities identified that they often lack water during the dry seasons. Segments of the road are being encroached upon by rising lake levels, such as near Lake Vaico in the southeast where the road embankment will be raised and slope-slides re-enforced for higher lake levels. Further details on the civil works adjustments are discussed below.

1. **Vulnerability in the Southeast (Prey Veng and Svey Rieng Provinces)**

13. The southeast project roads fall between the Mekong and Tonle Sap catchment areas and the hydrology of the area is not yet well studied. Climate change impact assessments on local hydrology are, therefore, not available due to a lack of basic data. Current observations in rainfall trends and projections in the southeast show that average annual and peak monthly rainfall have increased by 20% between 1980 and 1999 but have not changed since. Despite Prey Veng being highlighted as a province that is highly vulnerable to flooding in Cambodia's National Adaptation Programme of Action (NAPA), the project road does not run through the highly flood-prone areas of the Province. The southern segment of the project road in Svey Rieng, however, does run through the Lake Vaico area, and the road is relatively low-lying through this area. Borrow-pits are close to the road and are deep, and easily erode during rainfall; the same is true for the road itself. The behavior of Lake Vaico in terms of changes in lake levels is unknown. Furthermore, a number of irrigation and water management projects have taken place in the region, including Viet Nam, just south of this area. These have created changes to water flows but are still not studied well.

14. Community level survey and interviews with local governments suggest that damage to the road or lack of access as a result of floods or drought is a concern. Approximately 52% of respondents run out of water during the dry season and 30% would see the use for more borrow-pits for water capture and storage, primarily for livestock, fish ponds, and small-scale irrigation.
Approximately 80% of respondents see the benefit of planting grasses, shrubs and trees to restore soil stability and to provide shade and fruits.

2. Vulnerability in the mid-west (Kampong Chhnang and Kampong Speu)

15. The environmental features in the mid-west provide for greater potential risks to the project roads. Segments of the road cross the Tonle Sap floodplain (Tonle Sap and Bassac River) and annual seasonal flooding benefits local rice production. Flooding is a more prominent feature in the area, as is evident by the drainage structures in the existing infrastructure. Observed rainfall data show that average annual rainfall has already increased 20% from 1960 to 1999 and is projected to increase another 30% up to 2020, including peak monthly rainfall. This signals a great concern for increased risks from flooding, due to more intense average monthly rainfall and overall increases in moisture levels. The challenge in this area is related to managing the distribution of water throughout the year and changes in water availability.

16. The community surveys show that up to 40% of those in the project provinces run out of water during the dry season. Borrow-pits are used primarily for irrigation, followed by fishponds and livestock. Government officials, likewise, expressed an interest for water capture and storage, primarily for irrigation and some drinking water, to conserve large amounts of excess water available during the rainy season. Hydrological studies in Kampong Chhnang show that water supply is sufficient to meet irrigation demands, yet communities consistently identify dry season water shortages as a challenge. The causes for water shortages appear to be a water management issue, including between upstream and downstream users, rather than an issue of lack of infrastructure. Commune water councils have been established to help regulate water sharing. Concern over road damage caused by excess water has been identified by government officials in the areas immediately west and east of National Road 5, on 150B and 151B, and in the western-most section of the road, where water flows off the Phnom Aoral Mountains towards the road across large plains.

17. The proposed adaptation strategy, therefore, includes a combination of engineering, non-engineering, and planning activities to manage the changes observed and predicted in the project area. The engineering changes have been mainstreamed in the project design itself (through Output 1) in order to integrate climate risks and adaptation into core development planning activities. These include elevation of the road in areas where major flooding is becoming increasingly common, and changing the selection of sub-grade materials to withstand higher moisture contents. Furthermore, 151B, which leads directly to the bank of the Tonle Sap River, will be paved with hand-laid concrete rather than raising levels. This means that the road may be inaccessible only for short periods during extreme floods but would be intact once the floods recede. In order to better manage the uncertainties related to future climate changes, support activities through Output 4 will focus on: (i) improving planning and understanding of climate change; (ii) implementing measures to better manage seasonal water distribution through water capture and storage; (iii) restoring ecosystem functions for flood and drought management; and (iv) piloting emergency management systems.

18. Coordination with other donor-funded adaptation activities will be important. In particular, many of the activities proposed in this project are similar to those financed by the Nordic Development Fund (NDF) and executed by the Ministry of Rural Development (MRD) for the rehabilitation of rural roads. In particular, both projects will be undertaking training, vulnerability mapping, review of engineering guidelines, and pilot adaptation measures such as ecosystem restoration, water capture and storage, and emergency management systems. In particular, joint training would deliver high levels of efficiency and learning across projects. Furthermore, most of
the type of information for vulnerability mapping will be the same for both projects, except for the roads’ location. Therefore, the budget allocation under this output has been minimized for training and vulnerability mapping, recognizing the overlap between the two activities and opportunities for cost savings. To further support coordination in the country on climate change activities, the project will provide annual updates to the National Climate Change Coordination Committee.

19. Through other activities funded through the Global Environment Facility, such as the NAPA and National Communications, a significant amount of assessment work has taken place. More detailed and climate change assessments have taken place recently under the Second National Communications. This project will build on that body of work, which is expected to be made publicly available by the end of 2011. Some important gaps in data were identified during the project design, such as hydrologic information especially in the southeast. Very little is known about groundwater or integrated water resource management in Cambodia. Where there have been some hydrological modeling, for example by the Cambodian Development Resource Institute, climate change has not been incorporated in such studies.

C. Climate Resilience Output Activities

20. Overall, this output will seek to strengthen the outcome of the project to provide safe, cost effective, climate-resilient all-year access provided in the road network of agricultural provinces of Kampong Chhnang, Kampong Speu, Prey Veng, and Svay Rieng. It will do so by: (i) protecting the road infrastructure from the impacts of climate change and climate variability, and (ii) piloting adaptation measures to protect the road against long-term risks posed by climate change.

21. The climate resilience activities fall under two outputs of the project: Output 1: Project roads and Cross Border Facility at Prey Var-Mocva are rehabilitated and, Output 4: Increased resilience of project roads to climate change.

22. Output 1: Climate resilience related adjustments are made to civil works in Kampong Chhnang and Svey Rieng provinces through (i) the design of road embankments and roadside ditches which are susceptible to erosion, (ii) using less moisture susceptible materials or hydraulically-stabilized materials (usually with cement or lime) within the road structure so that structural layers do not lose significant strength upon flooding and soaking, and (iii) by using green engineering to improve the water conservation characteristics of the watershed and to divert run-off water away from the road (through activities of Output 4).

23. Factors considered in making engineering adjustments included cost-effectiveness, current climate variability and potential future risk. It is important to note that existing climate change impact assessments are insufficient to provide a scientific probability of future climate change and, therefore, the civil engineering adjustments based on expected future changes are difficult to calculate quantitatively. A margin of safety risk factor is therefore applied instead.

24. A number of studies have examined the types of risks to roads as a result of climate change. The Committee on Climate Change and United States Transportation (2008), advocate planning for: (i) damage to roads, subterranean tunnels and drainage system due to flooding; (ii) increase in scouring of roads, bridges, and support structures; (iii) damages to road infrastructure due to landslide and mudslide; and, (iv) deterioration of structural integrity of roads, bridges and tunnels due to increase in soil moisture levels. Adaptation measures have also been suggested by the World Roads Association such as: (a) applying a safety factor; (b) considering a longer return period for exceptional events when designing hydraulic structures; (c) considering storm water volumes over a longer period; (d) reducing the gradients of slopes and taking into account the
materials used; (e) protecting the base of fills and discharge structures; (f) enclosing the materials; (g) using waterproof materials or treat them to make them so; (h) checking the condition of slopes regularly; (i) regularly checking the condition and function of the drainage system and hydraulic structures; and, (j) improving the implementation of alternative routes in the event of a road closure.

25. **Output 2:** Reduce the vulnerability of the projects roads to climate change, as below:

4.1 MPWT completes and uses the detailed vulnerability map for climate change for project provinces:

The vulnerability map would comprise a number of layers, based on an agreed set of physical and socio-economic indicators. The following are proposed: (i) climate change trends and projections; (ii) impacts of climate changes on hydrology, ecology, and soil; (iii) natural environment including topography, geology, land use, and climate hazards; (iv) social environment including poverty levels and population density; (v) built environment, in particular MPWT’s existing and planned transportation network; and (vi) hazards risk mapping. Integrated climate change and hydrological impact modeling will be done for Kampong Chhnang based on existing studies. This will be used for the vulnerability maps and to inform the water capture and storage activities that are part of Activity 4.5.

4.2 Review the sustainability and capacity of MPWT’s current engineering designs, standards and guidelines to withstand climate change and propose amendments.

The Ministry currently uses a set of standards and guidelines for engineering design for its transport investments. Current standards do not consider long-term implications of changes to the integrity and sustainability of transport infrastructure. MPWT will review its geometry, bridge, drainage, and pavement guidelines and make adjustments based on learning from this project and expertise.

4.3 Design and implement training program for MPWT, including the Social and Environmental Office, in coordination with MRD activities being planned.

A series of trainings will be organized together with MRD to train Ministry staff on the science and implications of climate change on the countries’ infrastructure, focusing on the transport sector.

4.4 Planting program engaging vulnerable communities including women is implemented to reduce flooding and water from damaging roads and surrounding areas.

The project will undertake a planting activity with three main purposes: (i) to extend road slope-side stabilization, (ii) to provide shading and fruit trees around borrow-pits, and (iii) to restore ecosystem functions for flood management. The objective is to improve ecosystem health and functions such as reducing the effects of erosion, landslides, and flash floods, and increasing water infiltration into the soil. These will help manage changes in rainfall brought about by climate change.

Services and materials will be procured through national competitive bidding together with the civil works for the water capture projects identified in activity 4.5 in Kampong Chhnang. The project would also identify women’s groups to undertake
the planting and maintenance, representing at least 40% of the paid workers. The project would also train and pay the women to plant, and maintain the grasses, shrubs and trees. At home, nursing of plants will be piloted for work from home initiatives.

The planting program will be supervised through the Commune Chiefs. A consultant will be recruited to design the contract, assist MPWT in bidding process, and supervise the work. The consultant will work closely with the detailed design team to identify locations and type of planting, and for procurement procedures. They will have expertise in ecosystem and natural resource management.

4.5 Completion and piloting of a plan for water capture and storage systems integrated in road construction features for the project province.

Most rural communities rely on wells, ponds, and canals for their water needs. The project area experiences both very wet and very dry periods throughout the year. Very little infrastructure has been built to conserve water and store it during the rainy season so that it can be available during extended dry periods. While water storage exists in some areas, it is often insufficient and water often runs out before the next rains. Rainwater harvesting to improve water supply for safe drinking water has been identified as an adaptation priority for the country (NAPA, 2006) and this project will contribute to the small-scale supply of water in the project area. At the same time, it will improve the road safety and stability where there are currently open borrow-pits close to the road structure.

Selected existing and new borrow-pits will be rehabilitated for improved water capture and storage based on the following criteria: (i) demand and use driven, (ii) safe distance from the roadway, (iii) safe slope in case of car accidents, for people and for livestock (1:3), (iv) increased water efficiency and storage volumes, (v) planting of wide canopy trees to increase shade and reduce evaporation, (vi) health and safety respected, (vii) fit for purpose, where borrow-pit materials are unfit for road construction, (viii) elevated safe areas can be created and planted for stability, (ix) water efficiency technologies applied, and (x) pit lining to reduce infiltration.

In addition, a number of small water capture activities have been identified in Kampong Chhnang Province: (i) repair of an abandoned railway water tank for low-cost water supply to Tuek Phos town, (ii) lake dredging for increased water supply during dry season, (iii) gate and dam repair, and (iv) small-scale water capture in Kbal Tuek Commune, Tuek Phos District. A hydraulic engineer will be engaged to undertake the detailed design for these activities. Furthermore, a climate change impact assessment on the local hydrology will be done by the consultants so that the design of the water capture activities are consistent with expected changes in water supply and consistent with integrated water resources management. Implementation of all activities will be coordinated with Ministry of Water Resources and Meteorology (MOWRAM).

<table>
<thead>
<tr>
<th>Province</th>
<th>District</th>
<th>Civil Works Contract Package A, B, C</th>
<th>Borrow-pits</th>
<th>Water Capture Interventions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Svay Rieng</td>
<td>Kampong Rou</td>
<td>B (314D)</td>
<td>270,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Svay Teab</td>
<td>B (314D)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Romeas Hek</td>
<td>A (NR13)</td>
<td>288,000</td>
<td></td>
</tr>
<tr>
<td>Province</td>
<td>District</td>
<td>Civil Works Contract Package A, B, C</td>
<td>Borrow-pits</td>
<td>Water Capture Interventions</td>
</tr>
<tr>
<td>----------</td>
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<td>--------------------------------------</td>
<td>-------------</td>
<td>----------------------------</td>
</tr>
<tr>
<td>Prey Veng</td>
<td>Kamchay Mear</td>
<td>A (NR13)</td>
<td>100,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Kampong Tralach</td>
<td>C (150B)</td>
<td>299,000</td>
<td>1,210,000</td>
</tr>
<tr>
<td>Kampong</td>
<td>Tuek Phos</td>
<td>C (NR53)</td>
<td>299,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sameakki Mean Chey</td>
<td>C (150B)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>957,000</td>
<td>1,210,000</td>
</tr>
</tbody>
</table>

NR = national road.

4.6 MPWT contributes to strengthening national emergency management efforts by piloting an emergency management system in Kampong Chhnang Province and operates it. A knowledge development component is integrated into Task 2.

In preparing this activity, consultations were undertaken with the National Committee for Disaster Management (NCDM), with the Provincial and District Governor, Deputy Governor and Tuek Phos District Chief, the Provincial Red Cross, Oxfam Climate Change Advisor, SmartMobile company, and INSTEDD (a non-profit systems provider), and the Department of Meteorology. The activities were also based on responses from community level surveys and a review of post disaster needs assessments conducted in the country.

Task 1. Establish an MPWT focal point for coordination with NCDM and develop a memorandum of understanding (MOU) between the MPWT and the NCDM to outline Standard Operating Procedures (SOP) for MPWT in the case of disasters and emergencies.

Task 2. Strengthen the MPWT database and data collection system to record and monitor infrastructure damages and losses from climate stressors. Use data for forward planning of maintenance and future infrastructure upgrades. This data is also collected post emergencies by many donors to target emergency recovery efforts. In the context of the project, it will also be used to monitor the benefits (through avoided losses) of climate change adaptation adjustments applied to the civil works and green measures put in place to manage flooding. This component will provide a learning mechanism to monitor successful engineering adjustments made to increase the climate resilience of the roads.

Task 3. Strengthen emergency communication system with local cell phone network providers and public address systems to disseminate early warnings for extreme events including storms, extended droughts, and floods, to communities as well as seasonal forecasts. This will likely involve partnership with MOWRAM, which monitors and issues early warnings for weather events and for floods, and, with major cell phone network providers in the country with broad coverage in Kampong Chhnang. Smart Mobile Company has currently agreed with the NCDM to provide free information dissemination to disaster coordinators across the country for two years. They have agreed to work with this project in a similar fashion and an MOU between the cellphone company and MOWRAM for early warnings by text messaging will need to be brokered by MPWT. Further detailed work and agreement on institutional arrangements is needed for this pilot activity. The consultants will design this activity and pilot its operations from a provisional sum in the consulting services package.
Task 4. Establish a framework agreement between MPWT and local contractors for emergency mobilization of equipment during extreme events in Kampong Chhnang. One of the major gaps for emergency response operators is a lack of access to equipment and transportation. A number of local contractors have heavy equipment and vehicles in the Province, which could be mobilized to assist in emergency response situations. Purchase of vehicles by the project for evacuations is not cost effective and would mostly be used for other purposes. They would also only contribute to the objectives of the project if there were an emergency. Instead, a Framework agreement will be established to mobilize local contractor’s equipment to support local response efforts. They will respond to needs identified by the Provincial and District Red Cross and Disaster Management Committees.

Task 5. Establish emergency response protocols and train communities on emergency response and climate change adaptation, including land-use management issues such as prevention of deforestation and forest degradation. Existing post disaster assessments identify a lack of community level response plans and this is supported further by interviews with Provincial Red Cross members and through community level surveys, which overall highlights a lack of general awareness as well as strategies for community responses (i.e. where to go, what to do, how to avoid health risks). Training for NCDM and Red Cross focal points is also needed.

Task 6. Establish local safe areas and supporting safety measures, including public address systems. Community members in project areas indicated preference to stay at home in case of disasters, as well as with their livestock. However, in some cases of prolonged floods, this is not always a safe option. In the case of livestock, losses are due to diseases and insufficient food. Communities should be encouraged to store fodder, particularly in years where unusual droughts or floods are expected. Safe and elevated areas can be equipped with water tanks to ensure safe water supplies for designated safe areas such as schools, clinics, and pagodas.

D. Cost Estimate

26. Since the output is financed by PPCR as a mixed loan and grant, the cost estimate covers the consulting services and equipment purchase for the entire output. It is envisaged that 43 person-months of international consultants and 84 person-months of national consultants will be needed to complete the activities of the output.

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Output 1: Civil works of road improvements in contract packages CW-A, CW-B, CW-C road adjustments, framework agreement and borrow-pits</td>
<td>7,680,000</td>
</tr>
<tr>
<td>B. Output 4: CW D: Civil works for climate resilience Water Capture and Storage, planting and equipment</td>
<td>2,770,000</td>
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<tr>
<td>C. Output 1: DDIS Consultants (CS1) proportion of climate resilience civil works of A and B supported by DDIS consulting services</td>
<td>1,270,000</td>
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<tr>
<td>D. Output 4: CS4: Consultants exclusively for climate resilience output</td>
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</tr>
<tr>
<td>1. Remuneration and Per Diem</td>
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</tr>
<tr>
<td>i. International Consultants</td>
<td>920,000</td>
</tr>
<tr>
<td>ii. National Consultants</td>
<td>350,000</td>
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<tr>
<td>2. International and Local Travel</td>
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</tr>
<tr>
<td>3. Provisional sum for development and operations of early warning system</td>
<td>258,000</td>
</tr>
<tr>
<td>4. Equipment (computers, GPS equipment, large scale printer)</td>
<td>100,000</td>
</tr>
</tbody>
</table>

Table 2: Climate Resilience Output Cost Estimate (PPCR-financed)
Table 3. Contracting Services 4 – Summary of Consultancy Services Requirements*  
(length of consultancy services is 38 months)

<table>
<thead>
<tr>
<th>Consultants team</th>
<th>Person-months</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>International</strong></td>
<td></td>
</tr>
<tr>
<td>Team Leader/Adaptation Specialist</td>
<td>12</td>
</tr>
<tr>
<td>Hydrologist/Impacts Modeler</td>
<td>6</td>
</tr>
<tr>
<td>Geographic Information System (GIS) Specialist</td>
<td>2</td>
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<tr>
<td>Emergency Management Specialist</td>
<td>6</td>
</tr>
<tr>
<td>Road Design Engineer</td>
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</tr>
<tr>
<td>Ecosystems Specialist</td>
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</tr>
<tr>
<td>Hydraulic engineer</td>
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</tr>
<tr>
<td>Climate Modeling Specialist</td>
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<tr>
<td><strong>Subtotal (International)</strong></td>
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</tr>
<tr>
<td><strong>National</strong></td>
<td></td>
</tr>
<tr>
<td>Adaptation Specialist/Institutional Strengthening and Knowledge Management Specialist</td>
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<tr>
<td>Hydrologist</td>
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</tr>
<tr>
<td>GIS Specialist</td>
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</tr>
<tr>
<td>Emergency Management Specialist</td>
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<tr>
<td>Road Design Engineer</td>
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</tr>
<tr>
<td>Land Use and Natural Resource Management Specialist</td>
<td>6</td>
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<td>Hydraulic Engineer</td>
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<td>Social Specialist</td>
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<tr>
<td>Translator</td>
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<tr>
<td>Data Collection Assistant</td>
<td>8</td>
</tr>
<tr>
<td><strong>Subtotal (National)</strong></td>
<td>84</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>127</td>
</tr>
</tbody>
</table>

* A summary of skills and qualifications for each expert is in Table 4. Source: Asian Development Bank.

E. Implementation Arrangements

27. MPWT will implement this output through project management unit 3 (PMU3). A supervising adaptation manager will be hired through a consulting package and will work in the Detailed Design and Implementation Supervision (DDIS) Team to develop the bidding documents for the defined civil works. The sustainability of the project will be secured by providing output related trainings across MPWT, by integrating climate change adaptation into engineering tools and guidelines and by producing vulnerability mapping to assist with planning.

28. There will be two dedicated climate resilience packages, one for civil works and the other for consulting services. Some of the activities have also been integrated into Output 1 contract
packages (civil works A, B, C). These are the improved borrow-pits and a Framework Agreement for emergency response by local contractors. The cost of borrow-pits is described in Table 1. Furthermore, the climate resilience engineering adjustments will be implemented under the aforementioned three civil works packages. The implementation of Output 4 will be led by a consulting team. A team leader will oversee the work of all experts hired under this consulting service. The team leader will work closely with PMU3 and the DDIS consultants for those activities financed under the PPCR. The civil works adjustments (Output 1) and detailed design and implementation of the improved borrow-pits will be led by the DDIS consultants, with inputs from the adaptation consultancy team. A national counterpart will be the deputy and will be engaged for the duration of the project. The deputy will lead the team during the absence of the team leader. They will lead the knowledge management and monitoring activities, coordination with other government departments and institutions and lead in the development of a training and learning program. The team leader will be responsible for coordination of all activities within the component and with other ADB- and PPCR-financed components, through PMU3.

29. Below is a description of the contracting packages for the proposed allocation of the PPCR funds (see Table 4).

i. **Output 1.** Civil works contracting packages A, B, C that improve provincial roads will have an allocation of $12.4 million from the PPCR to increase the resilience of the road to climate change impacts. Also, $1.378 million will be allocated through small works for improved borrow-pits, as described above under activity 4.5. Further, $0.8 million provisional sum will be allocated to the Civil Works Package C in Kampong Chhnang to support the Framework Agreement for emergency response support by local contractors.

ii. **Output 4.** One civil works contracting package D will include the construction of the small scale water capture, the purchase and implementation of the planting program and maintenance, the establishment of local safe areas in Kampong Chhnang, and procurement and installation of emergency communications equipment (i.e. public address systems and early warning systems). These civil works will be supervised by the consultants in collaboration with the DDIS. The value of the civil works package D is $2.65 million and, therefore, will use international competitive bidding procedures.

iii. **Output 4.** Under one consultancy services package, all the experts identified for the implementation of this output will be recruited. In addition to the implementation of Output 4, the experts will be responsible for the detailed design of the civil works package D (planting, water capture, and equipment) and for preparing the associated bidding documents under the leadership of the procurement expert in the DDIS. Furthermore, the consultants will develop the institutional arrangements and budget for the system for early warnings through various communication systems.
Table 4. Proposed Allocation of PPCR Funds

<table>
<thead>
<tr>
<th>Civil Works Output: Output 1</th>
<th>Climate Resilience Output: Output 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CW-A: Road Improvement</strong></td>
<td><strong>CW-B: Road Improvement</strong></td>
</tr>
<tr>
<td>Climate resilient roadworks</td>
<td>Climate resilient roadworks</td>
</tr>
<tr>
<td>Borrow-pits</td>
<td>Borrow-pits</td>
</tr>
<tr>
<td><strong>CW-C: Road Improvement</strong></td>
<td><strong>CW-D: Climate Resilience Civil Works</strong></td>
</tr>
<tr>
<td>Climate resilient roadworks</td>
<td>Planting</td>
</tr>
<tr>
<td>Borrow-pits</td>
<td>Water capture works</td>
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<tr>
<td>Framework Agreement with local contractors for floods</td>
<td>Equipment for EMS</td>
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<tr>
<td></td>
<td>Building safe areas</td>
</tr>
<tr>
<td><strong>CS-4: Climate Resilience Consulting</strong></td>
<td></td>
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<tr>
<td></td>
<td>Vulnerability mapping</td>
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<tr>
<td></td>
<td>Training</td>
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<td></td>
<td>Guidelines</td>
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<tr>
<td></td>
<td>Detail design for water capture</td>
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<tr>
<td></td>
<td>Detail design for planting</td>
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<tr>
<td></td>
<td>Design for EMS</td>
</tr>
</tbody>
</table>

CS = consulting services, CW = civil works, EMS = emergency management system, PPCR = pilot program for climate resilience.

F. Outline Terms of Reference for Consultants

30. Consulting services will be necessary to implement Output 4. The selected consulting firm/individual consultant’s team will execute, but not limited to, the tasks detailed in the terms of reference (TOR) below.

1. **Team leader/Adaptation Specialist (International) and Deputy Team Leader/Institutional Strengthening and Knowledge Management Specialist (National)**

   (i) **Objective/Purpose of the Assignment:** The objective of the assignment is to provide MPWT with: (i) vulnerability to climate change maps for the transport sector on a country-wide basis, (ii) a review and recommendation on adjustments to its engineering guidelines, and (iii) training and capacity building on climate change adaptation. The purpose of the maps is to inform planning and decision making by MPWT. The consultants should consider the lifetime of transport infrastructure including roads, bridges and drainage systems.

   (ii) **Scope of the Work:** The organization will work with MPWT to define the climate related concerns for infrastructure planning. An assessment and collection of existing data will be undertaken together with a team of National Consultants. Data gaps will be filled through collection of raw data and research, within the scope of the budget. Particular attention will be given to improving the understanding the hydrology, and the impact of climate change on local hydrology where information is lacking and vulnerability is apparent. The vulnerability index should be composed of a variety of indicators, including the natural, built, and social environments. The work will be done in a way that builds national capacity to maintain the work. In addition, a review of the Ministry’s engineering guidelines will be reviewed and recommendations made on how to integrate adaptation to climate change. Finally, on-going training will assist Ministry staff in utilizing the above as well as increase general understanding of climate change adaptation science, approaches, challenges and best-practices. Lessons learned will be collected throughout the project.

   (iii) **Detailed Tasks to be performed:**

   (a) confirm with the MPWT vulnerability indicators of interest to their
planning, including time span;
(b) identify and collect existing data sources;
(c) identify data gaps and prepare a plan (to be approved by MPWT) for filling in data gaps, including through field research and data purchase; identify survey needs;
(d) validate the data as needed;
(e) review existing climate change projections and impact assessments, which have been conducted through the Ministry of Environment;
(f) digitize and map data;
(g) obtain and overlay maps with transport network provided by MPWT mapping department;
(h) analyze maps and provide recommendations and assessment to the Government;
(i) hold a workshop and training to present and discuss findings, together with the Social and Environment Office at MPWT;
(j) finalize maps and hand all data and databases over to the Government; and
(k) contribute to training and capacity building at MPWT, also cooperating with a similar project at MRD.
(l) while the national expert assists the team leader in team leading tasks as well as those listed above, the following are those he/she should complete:
(m) prepare a knowledge collection and monitoring plan, including objectives, roles and responsibilities and communication and dissemination plan;
(n) collect and analyze information and prepare yearly and final report; and
(o) distribute information during training sessions, and to SPCR and PPCR.
(p) While all the above tasks are the responsibility of the international specialist, the national specialist should assist the international specialist in all tasks and in leading the team and should undertake the following tasks as well:
(q) conduct a needs assessment and assess the current baseline knowledge of MPWT staff;
(r) identify with MPWT at least twenty staff to be trained on an ongoing basis, ensuring representation by women, senior and junior staff;
(s) develop a capacity building and training program using multiple educational tools such as workshops, case studies, presentations, short and long-session, field visits, and university seminars with local and regional experts. Experts from the region can be invited to present experiences in the region;
(t) implement the training program at key times during the project, including at inception, as part of the development of vulnerability maps and review of engineering guidelines;
(u) provide translation into Khmer of key documents and presentations; and
(v) assess capacity improvements at the closing of the training program.

(iv) Final Output:
(a) vulnerability Maps in digital and hard copy and all associated data;
(b) report with recommendations and analysis for the MPWT, including risks and assumptions.
(c) Training plan, final materials and final report on all activities undertaken and an assessment of baseline and final capacity developed through the training program.

(v) **Skills required:** International expertise needs a post-graduate degree in any of these fields: hydrology, climate change modeling, disaster and risk management, ecosystems and land-use. The expert must demonstrate knowledge in transport and geographic information system skills, and previous experience preparing vulnerability mapping. The expert should have a minimum of 10 years experience in related work with at least 3 years experience in leading a consulting team. Also required is knowledge of Southeast Asia and understanding of its ecology and hydrology, and of Cambodia in particular, is an asset. Strong analytical and communication skills, experience with monitoring and evaluation and good knowledge of climate change vulnerability and adaptation. The national specialist needs a postgraduate degree in environmental sciences or studies, climate change or natural resource management. He/she must have 7 years experience and knowledge working on climate change resilience/adaptation implementation projects; experience in managing capacity building and planning related projects, knowledge of basic financial procedures, project planning and budget management. Excellent written and spoke communication skills necessary.

2. **Hydrologist/ Impact Modeler (International) and Hydrologist (National)**

(i) **Objective/Purpose of the Assignment:** The objective of the assignment is to develop a climate change impact modeling in Kampong Chhnang province.

(ii) **Scope of the Work:** The scope of this work is to develop climate change impact modeling in Kampong Chhnang, with hydrological data layers for vulnerability maps, and recommendations for flood management through a variety of measures available.

(iii) **Detailed Tasks to be performed:**
(a) study in detail the existing climate models as applicable to Cambodia;
(b) select most appropriate modeling technique for the use of developing the climate impact model for Kampong Chhnang;
(c) develop hydrological data layers for vulnerability maps; and
(d) recommends measures for flood management such as planting.
(e) While all the above tasks are the responsibility of the international specialist, the national specialist should assist the international specialist in all tasks.

(iv) **Final Output:** Computer based climate model for Kampong Chhnang province for the use by MPWT planners.

(v) **Skills required:** The international specialist must have a postgraduate degree related to hydrological modeling, hydrology or related fields. The specialist needs at least 10 years experience undertaking hydrologic modeling with climatology and climate change modeling. Knowledge of the hydrology of Southeast Asia and regional and national centers of excellence and sources of information in Cambodia.
The national specialist needs a postgraduate degree related to flood management and hydrology with some training in hydrologic modeling for land management and water capture systems. He/she should have at least 8 years experience undertaking hydrologic modeling. English skills essential.

3. Geographic Information System (GIS) Specialist (International) and GIS Specialist (National)

(i) Objective/Purpose of the Assignment: The objective of the assignment is to visually represent the results of the climate change impacts, vulnerability and adaptation assessment.

(ii) Scope of the Work: The specialists together will produce the final visualization of the vulnerability maps and advise together with the climate modeler, impact and vulnerability specialists.

(iii) Detailed Tasks to be performed:

(a) undertake data collection, analysis, storage and retrieval through a variety of techniques, including use of available GIS, ensuring the full involvement of local stakeholders from the outset;

(b) support the development of the adaptation plan and early warning system by using GIS to include physical development issues such as land tenure, informal development, development suitability, topography, drainage, access to land, and location choices for rural development based on available information;

(c) prepare vulnerability maps and work with team members to verify and assess the results; and

(d) document methodologies, practices, results, and lessons learned for communication to other stakeholders in order to increase the likelihood of replication of project results in other local areas.

(e) While all the above tasks are the responsibility of the international specialist, the national specialist should assist the international specialist in all tasks.

(iv) Final Output: Vulnerability maps consolidating data and information to inform country wide vulnerability to climate changes and disasters (as appropriate), and visual representation of hot spots and areas for implementation of adaptation strategies to inform MPWT budgeting and prioritizing process.

(v) Skills required: The international specialist should have a bachelor degree in engineering with 6 years practical experience in GIS and its application to planning, have a strong and demonstrated understanding of civil society involvement in local government and planning (skills related to group facilitation would be an asset); and have some work experience in a local government unit (whether full-time or through study placements) The national specialist should have a bachelor degree in engineering with training in GIS/Remote Sensing and data analysis for environmental management. 5 years experience producing multi-layer mapping using visual illustration tools, such as GIS is necessary. Experience producing vulnerability maps including defining its indicators. English skills essential.
4. **Emergency Management Specialist (International) and Emergency Management Specialist (National)**

(i) **Objective/Purpose of the Assignment:** The objective of the assignment is to establish a pilot emergency management/response system in Kampong Chhnang Province which has a pilot early warning system.

(ii) **Scope of the Work:** Change in the climate in most cases leads to disasters. In the case of Cambodia, this is mostly typhoons, heavy rainfall, floods, and induced earth slips. In any case, it is necessary to establish an early warning system to issue advance communications of warnings to the potentially affected residents, establishments, etc. and evacuate them. In this respect, this activity provides a pilot early warning system and a pilot emergency management system for Kampong Chhnang province. Multiple stakeholders are included in this activity, including the Cambodian Red Cross, NCDM, local mobile cell phone providers, MOWRAM, Provincial and District governments, local contractors and most importantly, local communities.

(iii) **Detailed Tasks to be performed:** There are 6 major tasks to be completed as below:

Task 1. An MPWT focal point for coordination with NCDR is established. The focal point will develop an MOU between the MPWT and the NCDM to outline SOP for MPWT in the case of disasters and emergencies.

Task 2. Strengthen the MPWT database and data collection system to record and monitor infrastructure damages and losses from climate stressors.

Task 3. Strengthen emergency communication system with local cell phone network providers to disseminate early warnings for extreme events including storms and lightening watches, extended droughts, and floods to communities, as well as seasonal forecasts. This includes registering users for receiving and responding to early warnings by cell phone text messages.

Task 4. Under civil works package C, establish Framework agreement with local contractors for emergency mobilization of equipment during extreme events in Kampong Chhnang.

Task 5. Establish emergency response protocols and train communities on emergency response and climate change adaptation, including land-use management issues such as deforestation. Training for NCDM and Red Cross focal points is also needed.

Task 6. Establishment of local safe areas and supporting safety measures, including public address system.

(a) coordinate with other consultants and MPWT to collect data from vulnerability mapping in order to locate safe areas, and access routes;
(b) develop a computer-based map of the above data to present the vulnerability of the study area, location of houses and establishments, vulnerable river structures, irrigation structures etc, and identify special groups of vulnerable
residents (like people with disabilities). Identify safe areas, and assist government officials in confirming land use for safe areas, including its management;

(c) work with local government units District offices and MPWT to use the above information to develop a framework agreement with local contractors for emergency mobilization of equipment. This should include a MOU with the Provincial Committee for Disaster Management and the Red Cross for mobilization of equipment for their needs during emergencies. Develop a real time emergency management system based on the golden 72-hour rule of response, and recovery phases; develop the entire structure of response team and responsibilities, with redundancies;

(d) based on the above identify evacuation paths and evacuation locations, with several redundancies, proposed locations of warnings systems, specifications, coverage, and operational procedures of early warnings;

(e) plan the system procedures for operation, training for all stakeholders for operation, maintenance, management, and improvement, and real case drills, that include residents as well; conduct several phases of drills; provide sufficient public information during drill phases and based on drills and training fine tune the system;

(f) develop plan and agreements for early warnings between the Department of Meteorology and of water resources for real-time early warning communication;

(g) after test runs of the systems, commission the systems;

(h) prepare necessary operation manuals for all stakeholders involved; prepare emergency procedure checklists and public information flyers (including emergency kit information, how to evacuate, etc) for all levels of stakeholders and disseminate through media and person-to-person public distribution. Such manuals and information materials should be in Khmer language;

(i) conduct targeted community level training of responses during specific climate related disasters, including lightening, heavy rains and, as much as possible, seasonal forecasts. Register users for receiving text messages early warnings and transfer this information to the mobile communication system;

(j) cooperate with Road Asset Management group at MPWT to monitor damages to road assets due to climate related events. Collect data from such system to report on lessons learned and results;

(k) prepare a financial management plan for operation and maintenance of the systems in a sustainable manner; and

(l) prepare MOU and financial plan between MOWRAM and mobile communication system etc for emergency communications.

(m) While all the above tasks are the responsibility of the international specialist, the national specialist should assist the international specialist in all tasks.

(iv) **Final Output:** A pilot emergency management program is in place, based on need and identified gaps, including with appropriate training and institutional arrangements finalized. Final report and necessary manuals for each personnel involved in the emergency management process should be developed. The early warning communication and response system should be installed and functioning.

(v) **Skills required:** A postgraduate degree in civil engineering with specialization in
urban development or transport planning. The international specialist with 10 years experience is expected to have developed previously emergency management systems in real-world cases and had them operational with assistance given to the respective government. He/she should be able to develop computer software system for early warning system and emergency management system that helps real time data retrieval of the disaster in progress, to trigger emergency management activities of multi-disciplinary nature. The national specialist should have a master’s degree related to risk, disaster management and planning or related fields, with 5 years experience in disaster related planning or response, with a sound knowledge in emergency management principles.

5. Road Design Engineer (International) and Road Design Engineer (National)

(i) Objective/Purpose of the Assignment: The objective of the assignment is to revise the current engineering manuals of MPWT such that climate change aspects are incorporated in them.

(ii) Scope of the Work: It is necessary to revise the current engineering manuals of MPWT such that climate change aspects are incorporated. Also, contributions to training should be provided here along with developing the road asset management database indicators.

(ii) Detailed Tasks to be performed:

(a) review and assess current engineering designs, standards and guidelines to withstand current and future climate change risks;

(b) drawing from international experiences, provide recommendations on adjustments that can be made to the above in order to better incorporate considerations of climate change risks and natural hazards in design manuals;

(c) review international experiences to indicate cost implications from existing case studies and models to follow, and

(d) contribute to training and capacity building activities.

(e) all these tasks will be the responsibility of the international specialist and the national specialist will assist the international specialist in all above tasks.

(iii) Final Output: Report with analysis, and brief and simplified recommendations on adaptation adjustments, including risks and assumptions. Adjustments and training for MPWT will be provided with the revised Bridge Design Standards, Road Design Standards: Drainage, Geometry and Pavement guidelines.

(iv) Skills required: The international expert should have a post graduate degree in road design, and highway pavement materials. 10 years experience in the development of engineering guidelines, particularly for road design, manuals and standards. Working experience in the Southeast Asian environmental conditions relevant to engineering specifications is necessary. For the national expert an 8 years experience developing and running road asset management systems, experience applying road works engineering guidelines in Cambodia. English skills essential.
6. **Ecosystems Specialist (International) and Land Management Specialist (National)**

(i) **Objective/Purpose of the Assignment:** As part of an adaptation strategy to reduce the vulnerability of roads in Cambodia to climate change, an ecosystem-based approach is being piloted in four provinces in Cambodia. The experts will prepare a climate resilience and ecosystem restoration plan and prepare bidding documents together with the Detailed Design Team.

(ii) **Scope of the Work:** Planting will be used to buffer against the uncertainties and risks associated to changing moisture levels, including floods and droughts. Plants include grasses, shrubs and trees. Planting will be used to restore greater ecosystem functions for slope-side stabilization, creating shading around water capture and storage pits, and flood management in selected areas. At the same time, species selection and location would need to be planted to avoid any damage to the roads. Consultations with the road engineers will, therefore, be necessary. This component is part of a gender-mainstreaming plan, where women’s groups will be trained and employed to grow, plant, and maintain plants.

(iii) **Detailed Tasks to be performed by the consultant:**

(a) confirm assessment of appropriateness of species given changing temperature, flood, and drought patterns;
(b) identify and confirm land area to be planted for three objectives: slope stabilization, shading, and flood management;
(c) prepare gender-mainstreaming plan to identify how women will be trained and engaged for nurseries, planting, and maintenance;
(d) identify scope and opportunity for home-based training and nurseries for women;
(e) prepare national bidding documents and contribute to shortlist selection;
(f) conduct orientation and training with selected firm or organization;
(g) supervise planting programs and monitor gender aspects, including equal pay for equal work, and monitor effects of planting on road protection; and
(h) conduct final community level survey to monitor effects of planting for local communities.

(i) All these tasks will be the responsibility of the international specialist and the national specialist will assist the international specialist in all above tasks.

(iv) **Final Output:** Detailed ecosystem restoration plan and public bidding documents, final report with results identified.

(v) **Skills required:** For the international specialist a degree in environmental science, ecology, natural resource management, biological sciences or other related field is required. Experience of at least 5 years in implementing and overseeing planting and reforestation programs, particularly in Southeast Asia. The national expert needs a degree in a related field of study with a minimum of 5 years experience. English skills essential.
7. Hydraulic Engineer (International) and Hydraulic Engineer (National)

(i) **Objective/Purpose of the Assignment:** The purpose of the assignment is to work with the DDIS team to develop a small scale water capture and storage plan for the project area and to oversee the construction of small scale water capture and storage systems. The activity will be implemented in the context of a larger road reconstruction project through civil works. The consultants will be required to complete the water capture and storage plans and design of individual water capture interventions, which have been identified. They will also contribute to the preparation of bidding documents for their construction, and non-government organization planning water capture in Kampong Chhnang Province.

(ii) **Scope of the Work:** Communities in the project area regularly run out of water during the dry season. Borrow-pits, which are left behind when materials have been extracted for materials for road construction, are often left unmanaged for use by farmers. The primary purposes are for livestock, fishponds, and irrigation. The majority of these pits is too close to the road and poses road safety problems. They are also inefficient in water storage.

The existing and new borrow-pits should be rehabilitated for improved water capture and storage based on the following criteria:
- demand and use driven
- safe distance from the roadway
- safe slope in case of car accidents, for people and for livestock (1:3 gradient)
- increases water efficiency and storage volumes
- planting of wide canopy trees to increase shade and reduce evaporation
- safe in terms of health
- fit for purpose
- where materials are unfit for road construction, elevated safe areas can be created and planted for stability.

In addition, a number of small scale water capture and storage interventions have been identified by local administrations including lake dredging, rehabilitation of a gate and dam, water tower rehabilitation and small scale water capture, and distribution in a local community near the Phnom Aoral mountains.

(iii) **Detailed Tasks to be performed:**

(a) conduct detailed field survey to identify local needs and priorities for water capture and storage. Consider climate and climate change trends to ensure sustainability of water sources. Apply agreed criteria for prioritization;

(b) work with Detailed Design Team to propose designs for individual water and capture systems, their location, best technology, and bill of quantities and costs;

(c) conduct all hydrological assessments necessary to ensure sustainable water consumption; and

(d) work with Team Leader to allocate budgets and designs into appropriate contract packages. The national specialist assists the international specialist in all the above tasks.

(iv) **Final Output:** Detailed water capture and storage plan and detail design.
Skills required: For the international specialist, a degree in civil engineering with major as hydraulics. At least 8 years experience in projects dealing with hydrological engineering interventions, and at least 4 years working in developing countries. Experience in small-scale water and capture storage facilities. For the national specialist minimum of 8 years experience in working in projects related to water and capture systems, such as water tanks and small dams; English skills essential.

8. Climate Modeling Specialist (International)

(i) Objective/Purpose of the Assignment: The objective here is to have climate change projections as input into all aspects of the output.

(ii) Scope of the Work: Communities in the project area regularly run out of water during the dry season. Borrow-pits, which are left behind when materials have been extracted for materials for road construction, are often left unmanaged for use by farmers. The primary purposes of the works are enhancement for livestock, fishponds, and irrigation. The majority of these pits is too close to the road and poses road safety issues. They are also inefficient in water storage.

(iii) Detailed Tasks to be performed:

(a) conduct detailed field survey to identify local needs and priorities for water capture and storage. Consider climate and climate change trends to ensure sustainability of water sources. Apply agree criteria for prioritization;
(b) work with DDIS Team to propose designs for individual water and capture systems, their location, best technology, and bill of quantities and costs;
(c) conduct all hydrological assessments necessary to ensure sustainable water consumption; and
(d) work with Team Leader to allocate budgets and designs into appropriate contract packages.

(iv) Final Output: Detailed water capture and storage plan and detailed design.

(v) Skills required: A degree in climatology with specialty in climate change and climate change modeling. At least 5 five years experience undertaking complex climate change modeling and exposure to implementing the results of modeling. Practical field based project implementation experience is necessary.

9. Social Sector Specialist (National)

(i) Objective/Purpose of the Assignment: To develop the socio-economic indicators for the entire output.

(ii) Scope of the Work: Climate resilience output requires monitoring during its implementation. Here such indicators will be developed. Baselines are those in the design and monitoring framework as well as in the Appendix of indicators of this output. however not limited to those.
(iii) **Detailed Tasks to be performed:**

(a) development of socio-economic vulnerability indicators;
(b) develop data for mapping
(c) contribution to all aspects of the project where social or gender issues are concerned;
(d) coordinate with all other experts and the DDIS consultants.

(iv) **Skills required:** A degree related to human vulnerability and 8 years experience in assessing socio-economic vulnerability and digitization of socio-economic data. English skills essential.

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10. **Translator (National)**

(j) **Objective/Purpose of the Assignment:** All translations of documents required for the entire output.

(ii) **Scope of the Work:** The works require translation of learning materials from English into Khmer, particularly for community level trainings.

(iii) **Detailed Tasks to be performed:**

(a) development of training materials translated from English to Khmer for community training workshops;
(b) assist the international and national experts during training as an interpreter; and
(c) organize all training materials in formats that can be reused by MPWT.

(iv) **Skills required:** A graduate in English as major. Language training in English and Khmer necessary. English communications skills essential.

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11. **Data Collection and Office Assistant (National)**

(i) **Objective/Purpose of the Assignment:** To support all data collection and office tasks related to the entire output.

(ii) **Scope of the Work:** This person has to support to all data and document collection, editing and proofreading documents, preparing and developing communications and invitations. Support to training activities. Can be part time.

(iii) **Detailed Tasks to be performed:**

(a) support all experts in collecting data and information;
(b) data input and making electronic database and files;
(c) proofreading and editing documents for all purposes;
(d) support other experts’ training activities; and
(e) arrange communications and logistics.

(iv) **Skills required:** Recent university graduate in environmental sciences/management or engineering. No previous experience necessary, but should possess strong communication skills and fluency in English.
Table 4: Summary Skills and Experience Requirements for the CS4 Consulting Team and Final Outputs

<table>
<thead>
<tr>
<th>Consultants team</th>
<th>Outputs</th>
<th>Academic Qualifications</th>
<th>Project Related Experience</th>
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<tbody>
<tr>
<td><strong>International</strong></td>
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<tr>
<td>Team Leader/Adaptation Specialist</td>
<td>Overall team management develops plan and criteria for vulnerability mapping, review of engineering guidelines, monitors progress against indicators, supervises field implementation, and coordinates with DDIS and MPWT.</td>
<td>Post graduate degree in environmental science or studies, climate change or related fields.</td>
<td>At least 10 years working on climate change resilience and adaptation in developing countries. Experience working in southeast Asia, preferably in Cambodia. Experience working with infrastructure projects and Ministries. Strong leadership, organizational and management skills. Project development and management experience.</td>
</tr>
<tr>
<td>Hydrologist/Impacts Modeler</td>
<td>Climate change impact modeling in Kampong Chhnang, hydrological data layers for vulnerability maps, recommendations for flood management through planting, training</td>
<td>Postgraduate degree related to hydrological modeling, hydrology or related fields.</td>
<td>At least 10 years experience undertaking hydrologic modeling with climatology and climate change modeling. Knowledge of the hydrology of southeast Asia and regional and national centers of excellence and sources of information in Cambodia.</td>
</tr>
<tr>
<td>GIS Specialist</td>
<td>Vulnerability maps</td>
<td>A bachelor degree in engineering.</td>
<td>6 years practical experience in GIS and its application to planning, have a strong and demonstrated understanding of civil society involvement in local government and planning (skills related to group facilitation would be an asset); and have some work experience in a local government unit (whether full-time or through study placements)</td>
</tr>
<tr>
<td>Disaster Management and Early Warning Specialist</td>
<td>Detailed pilot disaster management plan and operations, training, Recommendations for scale up and future work.</td>
<td>A postgraduate degree in civil engineering with specialization in urban development or transport planning.</td>
<td>10 years experience is expected to have developed previously emergency management systems in real-world cases and had them operational with assistance given to the respective government. He/she should be able to develop computer software system for early warning system and emergency management system that helps real time data retrieval of the disaster in progress, to trigger emergency management activities of</td>
</tr>
<tr>
<td>Consultants team</td>
<td>Outputs</td>
<td>Academic Qualifications</td>
<td>Project Related Experience</td>
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<tr>
<td>Road Design Engineer</td>
<td>Revised engineering manuals, contributions to training, road asset management database indicators.</td>
<td>Post graduate degree in road design, and highway pavement materials.</td>
<td>10 years experience in the development of engineering guidelines, particularly for road design, manuals and standards. Knowledge of the Southeast Asian environmental conditions relevant to engineering specifications is necessary.</td>
</tr>
<tr>
<td>Ecosystems Specialist</td>
<td>Detailed planting program, procurement packages and supervision of implementation, monitoring of gender components, training and knowledge generation.</td>
<td>For the international specialist a degree in environmental science, ecology, natural resource management, biological sciences or other related field is required.</td>
<td>Experience of at least 5 years in implementing and overseeing planting and reforestation programs, particularly in Southeast Asia.</td>
</tr>
<tr>
<td>Hydraulic Engineer</td>
<td>Detail design and contracting packages for water capture, including borrow pits, training and knowledge generation, lessons learned</td>
<td>A degree in civil engineering with hydraulics as the major.</td>
<td>At least 8 years experience in projects dealing with hydrological engineering interventions, and at least 4 years working in developing countries. Experience in small-scale water and capture storage facilities.</td>
</tr>
<tr>
<td>Climate Modeling Specialist</td>
<td>Climate change projections as input into all aspects of the project, training and knowledge, early warning systems, input into EMS</td>
<td>Degree in climatology with specialty in climate change and climate change modeling.</td>
<td>At least 5 years experience undertaking complex climate change modeling and exposure to implementing the results of modeling. Practical field based project implementation experience is necessary.</td>
</tr>
<tr>
<td>National Adaptation Specialist/Institutional Strengthening Expert and Knowledge Management</td>
<td>Assist team leader to lead the team, coordinating between Ministries and developing interagency agreements and frameworks, developing and implementing a detailed training program. Development of lessons learned document.</td>
<td>Postgraduate degree in environmental sciences or studies, climate change or natural resource management.</td>
<td>7 years experience and knowledge working on climate change resilience/adaptation implementation projects; experience in managing capacity building and planning related projects, knowledge of basic financial procedures, project planning and budget management. Excellent written and spoke communication skills necessary.</td>
</tr>
<tr>
<td>Hydrologist</td>
<td>Climate change impact modeling in Kampong Chhnang, hydrological data layers for vulnerability maps, recommendations for</td>
<td>Postgraduate degree related to flood management and hydrology with some training in hydrologic modeling for land</td>
<td>At least 8 years experience undertaking hydrologic modeling. English skills essential.</td>
</tr>
<tr>
<td>Consultants team</td>
<td>Outputs</td>
<td>Academic Qualifications</td>
<td>Project Related Experience</td>
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<tr>
<td>Flood management through planting, training, surveying and data collection</td>
<td>management and water capture systems.</td>
<td>5 years experience producing multi-layer mapping using visual illustration tools, such as GIS. Experience producing vulnerability maps including defining its indicators. English skills essential.</td>
<td></td>
</tr>
<tr>
<td>GIS Specialist</td>
<td>Vulnerability maps and collection of all relevant data and its digitization where needed or compilation where existing</td>
<td>A bachelor degree in engineering with training in GIS/Remote Sensing and data analysis for environmental management.</td>
<td></td>
</tr>
<tr>
<td>Emergency management specialist</td>
<td>Development of the emergency management pilot and supervision of its operations with a sustainability plan.</td>
<td>A master's degree related to risk, disaster management and planning or related fields.</td>
<td>The specialist should have a 5 years experience in disaster related planning or response, with a sound knowledge in emergency management principles. English skills essential.</td>
</tr>
<tr>
<td>Road Design Engineer</td>
<td>Road asset management system to monitor information on climate change resilience in project area, implementation plan and institutional structure in place. Collection and analysis of results during the project. Assistance to international expert.</td>
<td>Degree in highway engineering</td>
<td>8 years experience developing and running road asset management systems, experience applying roadworks engineering guidelines in Cambodia. English skills essential.</td>
</tr>
<tr>
<td>Land use and natural resource management specialist</td>
<td>Development of detailed planting and gender program, identification of local stakeholders and their roles and responsibilities, supervision of the implementation of the plan.</td>
<td>A degree in a related field of study of land use and natural resource management.</td>
<td>A minimum of 5 years experience in land use and natural resource management planning. English skills essential.</td>
</tr>
<tr>
<td>Hydraulic engineer</td>
<td>Detailed design and contracting packages for water capture, including borrow pits, training and knowledge generation, lessons learned</td>
<td>A degree in civil engineering.</td>
<td>A minimum of 8 years experience in working in projects related to water and capture systems, such as water tanks and small dams. English skills essential.</td>
</tr>
<tr>
<td>Social Specialist</td>
<td>Development of socio-economic vulnerability indicators and data for mapping, contribution to all aspects of the project where social or gender issues are concerned.</td>
<td>Degree related to human vulnerability, social and economic sciences.</td>
<td>8 years experience in assessing socio-economic vulnerability and digitization of socio-economic data. English skills essential.</td>
</tr>
<tr>
<td>Translator</td>
<td>Translation of lessons learned document into Khmer, written</td>
<td>Graduate in English as major. Language training</td>
<td>2 years experience in translation. Demonstrated ability for written and verbal</td>
</tr>
<tr>
<td>Consultants team</td>
<td>Outputs</td>
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<td>translation of training materials, particularly for community level trainings.</td>
<td>in English and Khmer necessary.</td>
<td>translation from English to Khmer, including on the spot. Some experience working with communities, in workshops and with publication ready documents.</td>
</tr>
<tr>
<td>Data collection and office assistant</td>
<td>Support to all in data and document collection, editing and proofreading documents, preparing and developing communications and invitations. Support to training activities. Can be part time.</td>
<td>Recent university graduate in environmental sciences/ management or engineering.</td>
<td>No previous working experience required but strong academic performance. Ability to meet deadlines and work under pressure. Must possess English skills.</td>
</tr>
</tbody>
</table>

DDIS = detail design implementation and supervision, EMS = emergency management system, GIS = geographic information system, MPWT = Ministry of Public Works and Transport.

Note: All experts will contribute to training and knowledge generation and management.

### Appendix: Monitoring of Climate Resilience Output through Specific Indicators

<table>
<thead>
<tr>
<th>Results</th>
<th>Indicators</th>
<th>Source of verification</th>
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</thead>
<tbody>
<tr>
<td>1. MPWT mainstreams climate change risks and resilience in provincial road planning and improvements by 2017</td>
<td>MPWT road transport policies adjusted to incorporate climate risks, and decision making appropriately reflects vulnerability (including gender dimension) studies</td>
<td>MPWT Annual Report; PPCR Progress Reports</td>
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<tr>
<td></td>
<td>MPWT budget allocations consider climate change vulnerabilities of priority roads</td>
<td>MPWT Annual Report; PPCR Progress Reports</td>
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<td>Road maintenance works in MPWT roads are aligned with climate patterns</td>
<td>MPWT Annual Report; PPCR Progress Reports</td>
</tr>
<tr>
<td>2. MPWT changes manuals to incorporate climate resilient design of roads by 2017</td>
<td>Road rehabilitation and new road construction will follow 100-year flood design</td>
<td>MPWT Design Manual; PPCR Progress Reports</td>
</tr>
<tr>
<td></td>
<td>Hazard maps for national and provincial roads of MPWT completed and used routinely in prioritizing road maintenance operations</td>
<td>MPWT Annual Report; PPCR Progress Reports</td>
</tr>
<tr>
<td>3. MPWT disseminates knowledge on climate resilience within Cambodia by 2017</td>
<td>At least 20 staff from MPWT participate in regional climate change adaptation forums and participate in PPCR knowledge dissemination (e.g., publications, studies, knowledge sharing platforms, learning briefs, communities of practice, etc.)</td>
<td>MPWT Annual Report; PPCR Progress Reports</td>
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<td></td>
<td>MPWT organizes climate resilience related conferences annually in collaboration with related stakeholders like the Ministry of Environment (MOE) and the Ministry of Rural Development (MRD)</td>
<td>Annual Reports of MPWT, MOE and MRD; Websites of MPWT, MOE, and MRD; PPCR Progress Reports</td>
</tr>
<tr>
<td></td>
<td>MPWT collaborates with Cambodian universities to integrate climate change in curriculum of environmental and transport engineering</td>
<td>Annual Reports and web sites of MPWT and universities; PPCR Progress Reports</td>
</tr>
<tr>
<td>4. Increased capacity of provincial roads in southeastern and mid-west Cambodia to withstand climate change impacts by 2017</td>
<td>157 km of provincial roads rehabilitated and 117 km of road enhanced to climate resilient codes and standards for ensuring all-year access</td>
<td>MPWT Annual Report; PPCR Progress Reports</td>
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<td>Green planning and planting completed along at least 100 km of roads</td>
<td>MPWT Annual Report; PPCR Progress Reports</td>
</tr>
<tr>
<td>5. Increased water capture facilities in provincial areas by 2017</td>
<td>Water capture interventions along with dredging irrigation lake in Kampong Chhnang province completed</td>
<td>MPWT Annual Report; PPCR Progress Reports</td>
</tr>
<tr>
<td>Results</td>
<td>Indicators</td>
<td>Source of verification</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
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</tbody>
</table>
| 6. Strengthened emergency management in Cambodia to cope with extreme climate induced calamities by 2017 | Early warning systems established in Kampong Chhnang province<br>  
   All residents are evacuated in a timely manner during a calamity in affected areas of in Kampong Chhnang province with emergency facilities<br>  
   All livestock is moved to safe areas during a calamity in affected areas of in Kampong Chhnang province with no shortage of feed | MPWT Annual Report; MPWT website; ADB Project Completion Report<br>  
   PPCR Progress Reports<br>  
   MPWT Annual Report; MPWT website; ADB Project Completion Report<br>  
   PPCR Progress Reports<br>  
   MPWT Annual Report; MPWT website; ADB Project Completion Report<br>  
   PPCR Progress Reports |