Ecological Mitigation for Drainage Improvement Works in Hong Kong

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Introduction

The effects of climate change are already being felt in Hong Kong with more frequent extreme rainfall and rising sea-level, making people vulnerable to the related risks. In the past 60 years, the mean sea level in Victoria Harbour rose at a rate of 30 mm per decade. Moreover, the annual total rainfall at Hong Kong Observatory rose at a rate of 31 mm per year and the annual number of heavy rain days (with hourly rainfall >30mm) increased at a rate of 0.3 days per decade. Extreme rainfall events have also become more frequent. The hourly rainfall record at the Hong Kong Observatory was broken several times in the last few decades (e.g. 145.5mm in 2008, 115.1mm in 2006, 109.9mm in 1992), whereas it used to take several decades to break the record in the past (e.g. 108.2mm in 1966, 100.7mm in 1926) (HKO, 2016).

Heavy downpours arising from the extreme rainfall may overload the capacity of drainage systems and cause flooding in the low-lying areas which may threaten citizen's lives and properties. Therefore, the Government identified flood prone black spots in rural areas of the territory and progressively upgrades the drainage system to adapt to looming climate change (DSD, 2016). Nevertheless, the drainage improvement works may involve modification of natural streams, which may have adverse effects on the ecological value and the natural habitats of these streams, if these projects are not governed by the Environmental Impact Assessment (EIA) process.

The Statutory EIA process in Hong Kong

In Hong Kong, drainage works, referring to channel/river training or diversion works with certain width or which discharge near the ecologically sensitive areas (e.g. <300m from conservation area or site of special scientific interest), are required to undergo the statutory EIA process and obtain an environmental permit (EP) before construction and operation, as mandated by the Environmental Impact Assessment Ordinance (EIAO). Through the EIA process, the potential ecological impacts and natural habitats that may be affected by the drainage projects shall be addressed with feasible mitigation measures, according to criteria as stipulated in the Technical Memorandum on the EIA Process.

In Table 1 below, twenty-two drainage improvement projects which have gone through the statutory EIA process are reviewed and the recommended ecological mitigation and enhancement measures are summarized, following the principles of avoidance, minimization, and compensation.

Table 1 Ecological mitigation measures for drainage improvement projects reviewed

Projects	Year obtained EP	Ecological mitigation measures								
		Avoidance		Minimization					Compensation	
		Alternative alignment	Alternative construction method	Divide works in segments	Schedule works in dry season	Standard good site practice	Transplanting rare/ protected flora	Translocating rare/ protected fauna	Compensatory planting	Wetland creation
1. Drainage Works at Mai Po	2014	×	✓	✓	×	✓	×	×	×	×
2. Drainage Improvement Works at Ngong Ping	2013	✓	✓	×	✓	✓	✓	✓	✓	×
3. Drainage Improvements in Southern Lantau	2012	✓	×	✓	✓	✓	×	✓	✓	✓
4. Regulation of Shenzhen River Stage IV	2011	✓	×	×	✓	✓	×	×	✓	×
5. Drainage Diversion Works for the Comprehensive Residential Development at Tai Po Tsai, Sai Kung	2011	×	×	×	✓	✓	×	×	✓	×
6. Drainage Improvement in Big Wave Bay	2010	✓	×	×	✓	✓	×	×	×	×
7. Hang Hau Tsuen Channel at Lau Fau Shan	2009	✓	×	✓	✓	✓	×	×	✓	×
8. Drainage Improvement in Sha Tin and Tai Po	2008	✓	✓	×	✓	✓	✓	×	✓	✓
9. Drainage Improvement in Tsuen Wan and Kwai Chung	2007	✓	×	×	✓	✓	×	×	✓	✓
10. San Tin Eastern Main Drainage Channel	2007	×	×	×	✓	✓	×	×	✓	✓
11. Kam Tin Secondary Drainage Channel KT13	2007	✓	×	✓	✓	✓	×	×	✓	×
12. Drainage Improvement in Northern New Territories - Package C	2006	×	×	✓	✓	✓	×	×	✓	×
13. Drainage Improvement Works in Upper Tai Po River	2005	✓	×	✓	✓	✓	×	✓	✓	×
14. Drainage Improvement in Sai Kung	2005	✓	×	×	✓	✓	✓	×	✓	×
15. Ngong Ping Stream Diversion	2003	✓	×	✓	✓	✓	×	✓	✓	×
16. Pok Wai Drainage Channel	2001	×	×	×	×	✓	×	×	×	×
17. Village Flood Protection for Mai Po Lo Wai and Mai Po San Tsuen	2001	×	×	×	✓	✓	×	×	×	×

18. Shenzhen River Regulation Project Stage III	2000	✓	×	×	×	✓	×	×	✓	✓
19. Yuen Long Bypass Floodway	2000	✓	×	×	×	×	×	×	✓	✓
20. Main Drainage Channels for Yuen Long and Kam Tin, Remainder Phase I	1998	×	×	×	×	✓	×	×	×	×
21. Improvement to Stream Course at Pui O	1998	✓	×	×	✓	×	×	×	×	×
22. Main Drainage Channels for Ngau Tam Mei, Phase 1	1998	×	×	×	×	✓	×	×	×	×
Total no. of respective ecological mitigation/ enhancement measures adopted	**n/a**	**14**	**3**	**7**	**16**	**20**	**3**	**4**	**15**	**6**

Findings and Discussions

The potential ecological impacts and ecological mitigation/enhancement measures for these twenty-two drainage projects are addressed in the EIA process. If not properly mitigated, most of the drainage projects would likely result in loss of stream, wetland or associated riparian habitats (from 0.1 ha to >30 ha) due to channel construction or straightening/widening of existing channels. In addition, some proposed construction works may affect wildlife relying on these habitats, particularly fishes and amphibians of conservation interest such as the globally endangered Romer's Treefrog (*Liuixalus romeri*) and the endemic Hong Kong Newt (*Paramesotriton hongkongensis*) .

During the EIA process, avoidance of impacts is preferred to minimization and then compensation, in line with the mitigation hierarchy. All of these twenty-two projects have considered mitigation in the form of avoidance and minimization first; for example, adjusting channel alignment to avoid loss of wetland habitat or habitat with species of conservation importance. In the drainage improvement works at Ngong Ping, the proposed alignment has been adjusted to avoid two orchid species *Bulbophyllum ambrosia* and *Coelogyne fimbriata*. Alternative construction methods are also considered in some drainage projects. Trenchless method pipe jacking was adopted in the drainage works at Mai Po and Ngong Ping for drainage installation to avoid aboveground works within wetland area and wooded area in Country Park respectively.

Most of the projects also minimize potential water quality and ecological impacts through scheduling works in the dry season with less stream flow and adopting standard good site practices such as enclosure of works areas from the existing stream, and collection of construction runoff. Some projects further divide the works into segments of a certain length and width to minimize the potential water quality impacts to the stream arising from the construction works and to keep the clear flow in the existing streams. For the species of conservation importance that would be affected by the works, these species will be transplanted or

translocated to the suitable receptor site with similar habitat characteristics (for 7 projects involving protected plants and amphibians). For instance, in the drainage works in Tai Po, the locally protected plants Hong Kong Pavetta (*Pavetta hongkongensis*) in the works site were transplanted to the newly created wetland and woodland compensation area. In the drainage improvement works of Lam Tsuen River, pre-construction capture surveys were conducted and endemic Hong Kong Newt and other fauna species in the affected channel section were relocated to upstream prior to work commencement.

Compensation measures for these projects include habitats creation (woodland and wetland for 15 and 6 projects respectively). The size of compensation area is comparable or greater than the respective habitat size lost in the works. Compensatory planting of native species in the number ratio from 1:1 to 1:3 is often adopted to compensate for the mature trees lost in the works, no matter whether the lost trees are exotic; while native species will bring more ecological benefit and its flowers/fruits are more attractive to wildlife. For wetland creation, using the Shenzhen River as example, >30 ha of marshy area and abandoned fish ponds along the river were reinstated and revegetated to compensate for the wetland loss of around 20 ha and provide the same ecological function for wildlife.

In Hong Kong, the construction and operation of these drainage projects approved under the EIAO are required to implement the Environmental Monitoring and Audit (EM&A) Program to check the implementation of the mitigation measures, evaluate their effectiveness and ensure that ecological impacts are tallied with those predicted in the EIA. The monitoring data have helped to evaluate whether the above mitigation measure are effective to mitigate ecological impacts and/or enhance the ecological values of these affected streams.

Based on the monitoring data, it is found that the species transplantation and translocation are feasible and effective in conserving rare and protected species. In drainage works in Tai Po, the transplanted individuals of Hong Kong Pavetta were monitored and their health status remains fair after the transplantation (AUES, 2016). In drainage improvement works of Lam Tsuen River, endemic Hong Kong Newt in the affected channel section were relocated upstream before works commenced. The monitoring data demonstrated that habitat quality was enhanced after the works and the number of Hong Kong Newt was nearly doubled in the improved channel section compared to the number before the works (AEC, 2015).

Besides the data from EM&A, another previous study has also demonstrated that the wetland compensation is effective and could enhance the ecological value of the site. Lam et al. (2004) demonstrated that bird species richness and density are higher in the reinstated fishponds for the Shenzhen River project and in the improved drainage channel in Yuen Long with mangrove planting along the stream embankment. These wetland habitats also support a large number of wetland dependent birds including the globally endangered Black-faced Spoonbill (*Platalea minor*).

In this review, we found evidence that biodiversity-friendly designs are incorporated into channel design for better ecological linkage after the EIAO came into the operation. Prior to the enactment of the EIAO, drainage design was mainly focused on the drainage capacity; thus the trapezoidal, concrete lined box channel with the straightforward way of drainage was usually adopted. With the EIAO, and through the EIA process, all the drainage channels purposely included natural substratum (e.g. boulders of different sizes), bends, shallow ponds and aquatic vegetation to attenuate flow and attract wildlife as to revitalize the concrete channel. Stream embankments comprising rock gabions also allow revegetation of stream banks and provide suitable habitats for wildlife. Moreover, fish ladders were constructed for drainages in Southern Lantau and Sai Kung with rich fish biodiversity, to facilitate fish movement along the drainage channel and the estuaries. Implementation of the above mitigation measures is ensured through enforcement of the EIAO while no non-compliance was detected.

Figure 2. Concrete lined drainage channel (left) Biodiversity-friendly drainage channel (right)

The Way Forward

Compared to the developing countries, Hong Kong has relatively robust infrastructure and is not particularly vulnerable to the risks of climate change, including flooding and rising sea level. With the continuous effort on drainage improvement, the number of flooding "blackspots" in rural areas has been reduced from about 80 in 1998 to only 8 in 2016 (DSD, 2016). Nevertheless, being a major climate change adaptation measure, it is anticipated that more drainage improvement projects will be carried out in the future. Taking biodiversity-friendly design and ecological mitigation measures into consideration, the potential adverse ecological impact from these drainage projects will be avoided, minimized and compensated through the EIA process, so as to conserve biodiversity while not compromising our ability to adapt to climate change.

Meanwhile, the Hong Kong Government will implement the city's first Biodiversity Strategy and Action Plan and strengthen biodiversity conservation, with EIA as one of the essential tools (Environmental Bureau, 2016). Conservation of biodiversity will in turn play an important role in mitigating the challenges climate change poses to our society as well as natural environment e.g. the eco-friendly drainage system and water bodies could moderate urban temperature, regulate water flow, provide natural habitats for wildlife and maintain habitat connectivity; vegetation in drainage channels could also absorb and store carbon from the atmosphere.

Hence, there are climate adaptation benefits to be gain from biodiversity conservation.

Through the review of twenty-two drainage projects which have gone through the EIA process, it is found that the Government has been creating attractive "Blue-Green" Infrastructure" in managing drainage and flooding, where landscape, biodiversity, connectivity and multifunctional benefits are optimized. To a certain extent, the statutory EIA process in Hong Kong has started contributing to the global efforts in addressing climate change and considering the biodiversity aspects in drainage projects. There is also a developing trend in Europe and North America in integrating climate change into the EIA process. It is expected that more practices will be in place in different countries and places (e.g. Canada, the UK, EU, the US, etc.) to use EIA to look into the climate change mitigation and adaptation requirements relating to development plans and projects.

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