WILD BUT NOT FREE: AN ECONOMIC VALUATION OF THE BENEFITS OF NATURE CONSERVATION IN HONG KONG

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Executive Summary

This paper estimates that the quantifiable conservation value of Hong Kong's natural resources—its marine ecosystem, its woodlands, its country parks—are worth a minimum of **HK$1.8 billion to 6.5 billion** annually.[1]

This does not mean that Hong Kong's natural resources could be replaced by 6.5 billion dollars deposited in a bank account. In fact, our attempt to assign monetary values to nature does not imply that conservation should be driven by economic incentives alone or even at all. Just because we can put a market value on something as intangible as an ecosystem's water cycling functions or a rare species does not mean that this dollar amount represents its total benefit. The view from Sharp's Peak or the existence of Romer's tree frog is priceless.

This report is intended to help policymakers and the public recognize the economic value of Hong Kong's natural resources. Valuing the benefits of conservation is an important intellectual exercise. We tend to value nature at zero dollars, forgetting the services and revenue nature provides. Recognizing the economic importance of nature is an important part of both understanding our environment and making conservation policy.

Our dollar estimate reflects both the **direct use** and **indirect use** values of Hong Kong's natural environment. Direct use values measure the economic value of consuming, trading or using products from nature. Examples of direct use values in Hong Kong include:

- ***The fishing industry****:* The value of Hong Kong's fishery is roughly equivalent to the market value of fish, both caught and uncaught, in Hong Kong waters. This ranges from HK$150-180 million annually, depending on whether one evaluates the status-quo situation or a restored ecosystem.
- ***Enjoyment of outdoor recreation****:* Hiking in Country Parks, trips to outdoor education centers and mountain biking are all direct use values. These activities generate economic revenue as a by-product of conservation. The annual value of outdoor recreation is estimated at HK$1.4 billion.
- ***Ecotourism****:* While the current value of ecotourism in Hong Kong is quite small, the potential for growth is substantial. Ecotourism could increase Hong Kong tourist receipts by HK$4.0 billion, or 7.2%. Such an increase would make ecotourism a sizable component of the Hong Kong economy.

Indirect use values refer to ecosystem services, or "those functions of the environment which provide direct value to the well-being of humans through the maintenance of a healthy natural environment."[2] This includes the role trees play in pollution absorption and the way in which wetlands help mitigate floods. In Hong Kong, examples of indirect use values include:

- ***Watershed protection:*** Hong Kong's reservoir catchments provide HK$880 million of water that would otherwise need to be imported from Guangdong.
- ***Flood mitigation:*** During storms, wetlands store flood water for later release, helping to limit flood intensity. Forests and grasslands also help limit flooding by controlling sediment deposition, which can lead to siltation and flooding downstream. While it is

[1]This is an annual value. At an discount rate of 4% (the same discount rate used for the Disney theme park), nature conservation has a total value of HK$45 billion-$162 billion in perpetuity. In comparison, the net present value of Disney theme park was valued at HK$148 billion over 40 years.

[2]Edward Barbier in *Handbook of Incentive Measures for Biodiversity Design and Implementation* (OECD: 1999), pp. 29-30.

difficult to put a dollar value on these services, Hong Kong's wetlands, forests and grasslands help prevent millions of dollars in flood damage costs.

- ***Foreign Direct Investment:*** To some degree, quality of the natural environment affects the willingness of people to live and invest in Hong Kong. Maintaining current levels of foreign direct investment—US$64 billion in 2000—is an important economic rationale for conservation.

The examples of flood mitigation and foreign direct investment show the difficulty of quantifying the economic benefits of conservation. HK$6.5 billion represents only the quantifiable benefits of conservation, not the total value of Hong Kong natural resources. Due to lack of data, many important direct and indirect use values have not been quantified in this report.

HK$6.5 billion also fails to take the **non-use values** of nature into account. For example, people may derive happiness from the existence of the Black-faced Spoonbill, even if they have never seen one. This kind of **existence value** can only be measured through Contingent Valuation surveys, in which participants are asked how much they would pay to save a particular ecosystem or species. No Contingent Valuation surveys have been done in Hong Kong, making existence values impossible to calculate.

As far as we know, this paper is the first attempt to put an economic value on nature conservation in Hong Kong. This report demonstrates the need for primary, local research to fill in data gaps. To cite two examples, a Contingent valuation survey and data on pollution uptake by Hong Kong urban trees would both be valuable. We hope this paper will spark debate and further exploration into Hong Kong's environmental economics.

Economic Breakdown of Benefit Estimates[3]

This paper estimates that the quantifiable conservation value of Hong Kong's natural resources is between **HK$1.8 billion and 6.5 billion** annually.[4]

Conservation benefit	**Methodology**	**Estimate of current value (HK$ million)**	**Estimate of future potential value (HK$million)**
DIRECT USE			
Marine ecosystem	Market value		
-status quo		+150	
-restored			+180
Ecotourism			
-potential increase in revenue	Revenue		+4001
-travel costs of hikers	Travel cost		+260
Education *-visits to outdoor education centers*	Travel cost	+40	
Scientific/Medicinal		--	
Amenity/Recreation			
-hiking in country parks	Travel cost	+310	
-outdoor conservation facilities	Travel cost	+10	
-marine leisure	Revenue	+580	
-wilderness courses	Revenue	+20	
-mountain biking	Revenue	+100	
-scuba diving	Revenue	+10	
-rock climbing	Revenue	+10	
-property landscape views	Hedonic pricing	--	
INDIRECT USE			
Watershed protection		+880	
Pollution absorption			
-mangroves & nutrients	Substitute cost method	+3	
-trees & air pollution	Substitute cost method	+40	
-vegetation & carbon sequestration		+20	
-potential carbon sequestration			+390
Flood prevention		--	
Pollination		--	
Pest control		--	
Foreign Direct Investment[5]		--	
NON-USE VALUES			
Existence values		--	
COSTS OF CONSERVATION	AFCD budget	-390	
TOTALS		**1,800**	**6,500**

[3]All numbers have been rounded to the nearest HK$10 million.

[4]This is an annual value. At an discount rate of 4% (the same discount rate used for the Disney theme park), nature conservation has a total value of HK$45 billion-$162 billion. In comparison, the Disney theme park was valued at HK$148 billion.

[5]Some fraction of US$64 billion.

1. Introduction : Why Valuing Nature is Useful

While conservation has moral, aesthetic and scientific importance, this paper does not delve into these areas. Instead, we present an overview of the economic benefits of nature conservation. This paper is, as far as we know, the first attempt to put an economic value on conservation in Hong Kong. In many cases, we've made broad assumptions because more specific data was not available. Almost every topic area deserves further study. We hope others will use this paper as a blueprint for further research and develop a more complex, nuanced understanding of the economic benefits of Hong Kong's natural resources.

To begin, Hong Kong has many natural resources worth preserving. With a total land area of just under 1,100 km^2, Hong Kong has a surprisingly rich flora and fauna and extensive undeveloped tracts. There are forest, wetland, freshwater, marine and intertidal habitats.[6] These support numerous plant and animal species including:

- 48 species of mammals
- 240 species of birds
- 206 species of butterflies
- 2,135 species of vascular plants[7] (360 classified as "rare")
- 75 species of reptiles
- 23 species of amphibians (Guangdong only has twice as many species although it is 100 times larger)

Though often taken for granted, Hong Kong's natural environment provides many 'free' services that form the foundation for both society and the economy.[8] We rely on the oceans for food, on forests for wood and new medicines, on air to breathe, on insects and other creatures to pollinate our crops, on birds and frogs to keep pests in check and on forests and rivers to supply clean water.[9]

> "*Nature's services have always been there, free for the taking, and our expectations – and economies – are based on the premise that they always will be. We are like young children who think that food comes from the refrigerator, and who do not yet understand that what now seems free is not.*"[10]

Such services have immense economic value but are largely unrecognized and uncounted until lost. By undervaluing natural services, economies unwittingly provide incentives to misuse and destroy the systems that produce those services.

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[6]Mangrove stands are another important Hong Kong habitat. While many mangrove systems still exist, large areas have been destroyed due to coastal development and reclamation. A three year study of the remaining mangrove stands in Hong Kong identified 43 mangrove stands covering 178 hectares (Tam N F Y and Wong Y S (1997). Ecological Study on Mangrove Stands in Hong Kong. Report for Agriculture & Fisheries Department. November 1997). This excluded the 85 hectares of mangroves at Mai Po Nature Reserve. The largest mangrove habitats are at Deep Bay and Mai Po Nature Reserve where the mangroves have deep, soft, muddy substrates. Smaller stands of mangroves with shallow, stony, sandy substrates exist in Sai Kung and other areas.

[7]This includes flowering plants, conifers and ferns.

[8]Abramovitz J N (1998). Putting a Value on Nature's Free Services. World Watch, Vol 11, No. 1. Jan/Feb 1998.

[9]Ibid

[10]Ibid

Scholars have suggested that the annual average value of the entire biosphere is US$33 trillion, nearly twice the global GNP of US$18 trillion a year.[11] On the face of it, this estimate is somewhat absurd because there is no finite compensation that individuals would accept to agree to the loss of the world's ecosystems because ecosystems are essential to human well-being. However, this study and the resulting international news headlines drew attention to the fact that we typically undervalue nature.

Economic valuation of the benefits of conservation is an attempt to assign quantitative values to the goods and services provided by environmental resources. Economic value is typically defined as what we are willing to pay for something minus what it costs to supply it.[12] When environmental resources provide the products and services at no cost, the economic value is what we are willing to pay for such products and services, whether or not payment is actually made.

Economic valuation is not a panacea for all decisions. This report is intended to help decision makers recognize the economic value of conservation as one factor in the decision-making process. Intuitively, planning guidelines take the intangible values of conservation into account. The decision to designate an area as Country Park, site of special scientific interest or even as a green belt is rarely subject to economic analysis. Rather, planners and decision-makers balance different values and make choices based on the best long-term interests of society.

This report does not advocate the use of cost benefit analysis (CBA) to determine conservation action and priorities. Just as we do not use CBA to determine whether it is worth saving lives, we should not use CBA to determine conservation policy.

Still, Hong Kong has an aggressive free market economy and many decisions come down to economics. This paper aims to make the value of nature more explicit because nature does have economic value even if it does not have a market price. Conservation is about protecting scarce ecological resources and making hard choices in a world where development pressures are increasing. Measuring conservation values by a common parameter – money – helps recognize the value of conservation.

2. Different values of nature

Humans need to be reminded that all life and economic activity depends on the biosphere. Our economy is a subset of the environment and not the other way around. The Biosphere 2 experiment, in which eight scientists were shut in a sealed glass dome in Arizona for two years, demonstrates the extent of human dependency on the life support systems of our planet. The dome contained man-made 'ecosystems' developed to sustain life and internal systems for all air, water and nutrient recycling. Many of the original species died and oxygen levels dipped to dangerous levels. The US$200 million (HK$1.5 billion) Biosphere 2 project could barely keep eight people alive for 24 months, while Biosphere 1—the earth—provides all these services for free.

The different values of nature and its services can be categorized as follows:

[11]Costanza R et al (1997). The Value of the World's Ecosystem Services and Natural Capital. Nature. Vol 387, pp. 253-260.

[12]Thus, the economic value of a loaf of bread is the retail price of that bread minus the costs of ingredients, baking and delivery.

- ***Direct use values:***

Our environment provides us with many products and services. When we consume, trade or use certain products, we tap the use value of that particular resource. Consumption of sharks' fin and the trade in ornamental fish are examples of direct use value. Use of areas for activities such as recreation, hiking, sight-seeing, and tourism also constitute direct use and are known as "amenity value."[13] Use values are generally related to the market prices of specific products.

- ***Indirect use values:***

Indirect use values usually relate to "ecosystem services" which are "all those functions of the environment which provide direct value to the well-being of humans through the maintenance of a healthy natural environment."[14] This includes the role our forested highlands play in water catchment and the importance of trees in purifying urban air. It might also include the importance of wetlands in flood mitigation or the pollutant removal value of mangrove stands. Usually, this value is estimated by calculating the actual cost of investing in the technology and infrastructure that would be necessary to fulfill similar functions.

- ***Option and quasi-option values:***

The option value is based on the notion that the future is uncertain. Some people may attach a value to the possibility of making choices in the future if their current preferences change. For instance, a person may not enjoy hiking in the countryside today but may value the ability to change her mind tomorrow. Similarly, the quasi-option value is based on the notion that our present knowledge is limited. In other words, people value the ability to react to new information in the future.

- ***Existence or bequest values:***

The simple knowledge that the Chinese White Dolphin or the Black-faced Spoonbill exist provides happiness or satisfaction to some people. This type of gratification relates to the existence value of a particular species or ecosystem. In other words, people appreciate the fact that certain things exist in the world, even if they never intend to use them. Bequest value is closely related to the possibility of maintaining something for future generations.[15]

For direct use values, such as the value of a fish harvest or timber supply, the market allows easy calculation of economic value. For some indirect services, such as watershed protection, it may be possible to estimate a monetary value. Other non-use values, such as the value of rare species or the aesthetic beauty of a landscape, are not subject to traditional economic methods of valuation. This has led to a new discipline of environmental economics that attempts to estimate the economic values of the more intangible aspects of nature.

3. Different methods of valuing nature

Since the market does not typically value environmental resources, new environmental economic methodologies have been developed to assign monetary values to these resources. Broadly, these economic methodologies can be classified into three categories: direct cost techniques, hedonic pricing techniques and contingent valuation techniques (see Appendix 1).

Both direct cost valuation and hedonic pricing use market prices to estimate the value people place on an apparently unpriced good or service. **Direct cost estimates** are often based on

[13]Barbier in *Handbook of Incentive Measures for Biodiversity Design and Implementation*. See footnote two.
[14]Ibid
[15]Ibid

defensive spending, the amount people spend to protect themselves, others or their property from environmental damage. For example, one of the direct costs of air pollution in Hong Kong is the cost of doctors visits due to increased respiratory problems.[16] A less obvious direct cost is travel cost, the amount of money people spend to visit an environmental amenity, such as a Country Park or a beautiful view.

Hedonic Pricing estimates the value of an unpriced good or service by separating that component from a larger expenditure. For example, apartments with views usually have a higher market price than apartments without views. The price differential can be considered the value of the view. The problem with both hedonic pricing and direct cost estimates is that they only provide a minimum value. Consumers may be willing to pay more for the unpriced good than the estimate indicates.[17] For example, people may be willing to pay more than their transportation costs to enjoy a (free) Country Park.

Contingent valuation (CV) uses surveys to determine how much people would be willing to pay to protect the environment or avoid environmental loss. Some surveys focus on willingness-to-pay (WTP) while others ask about willingness to accept compensation (WTA) for an environmental loss. Respondents say what they would be willing to pay or willing to accept if a market existed for the good in question (which could be Black Faced Spoonbills or more wilderness). Much care is taken to make the hypothetical (contingent) market as close as possible to a real market to ensure accuracy. CV surveys can provide an estimate of the full value people place on an unpriced good. It is also the only tool available to estimate non-use values, such as existence values. The problem is that there can be uncertainty about the honesty and accuracy of the responses.[18]

More specific methodologies include:

1. **Market price method (Direct cost estimate)** – estimates the economic value of ecosystem products or services that are bought and sold in commercial markets. It can be used to value changes in the quality or quantity of that good or service and is typically used for valuing fish harvests.

2. **Productivity method (Direct cost estimate)** – used to estimate the economic value of ecosystem products or services that contribute to the production of commercially marketed goods. For example, it can be used to estimate the benefits of a protected water catchment through the decreased costs of providing clean drinking water.

3. **Travel cost method (Direct cost estimate)** – based on the principle that the travel cost expenses that people incur to visit a site represent the "price" of access to the site. Thus people's willingness to visit the site can be estimated based on the number of visits they make at different travel costs. This is most typically used for estimating the recreational value of a natural area such as a country park.

[16]Much has been written about the economic cost of air pollution and, more generally, about the economic cost of environmental degradation. Although this paper does not explore this area, it can be expected that nature conservation would have a positive effect on human health and a depressive effect on health care costs.

[17]This is known as consumer surplus, defined as difference between what people are willing to pay and what is actually paid.

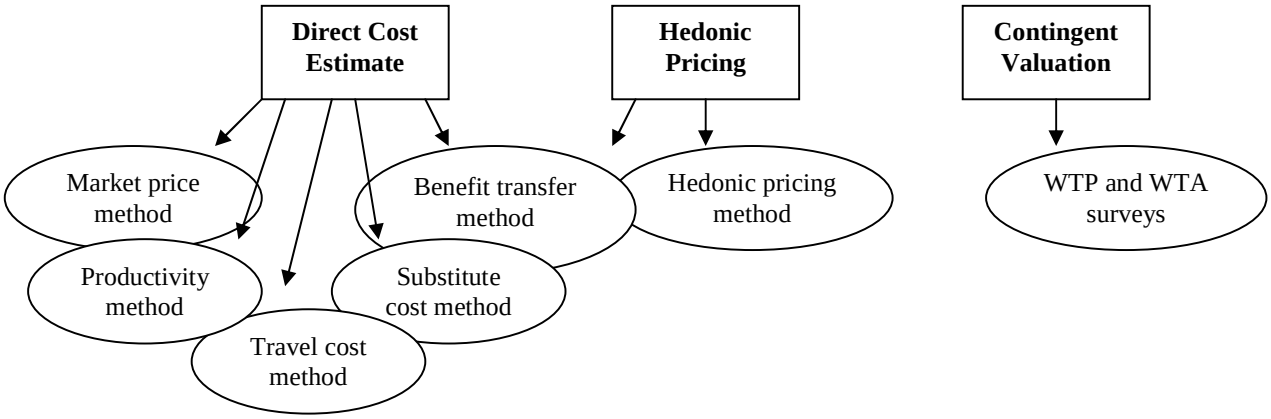
[18]Barron W, Perlack R and Boland J (1998). *Fundamentals of Economics for Environmental Managers* (London: Quorum Books, 1998).

4. **Hedonic pricing method (Hedonic pricing)** – based on the principle that the price of a marketed good is related to specific characteristics of the services it provides. It is most often used to value environmental amenities, such as aesthetic views, that affect the price of residential properties.

5. **Substitute cost method (Direct cost estimate)** – the value of ecosystem services is based on the cost of providing substitute services. It is based on the assumption that ecosystem services must be worth at least what people would have to pay to replace them. For example, this method can be used to value the water purification services of a wetland by measuring the cost of filtering and chemically treating water.

6. **Benefit transfer method** (**Direct cost estimate/Hedonic pricing)** – used to estimate economic values for ecosystem services by transferring available information from studies already completed in another location. It is used when it is too expensive or time consuming to conduct an original valuation study.

Figure 1: Flowchart of economic valuation techniques



For more details on these methodologies and their applications see www.ecosystemvaluation.org

4. Direct Use Values

4.1 Fishing industry

Fishing has traditionally been an important industry and way of life for the people of Hong Kong.[19] Prior to World War II, the fishing industry was extremely healthy and dominated by large, high-value species such as grouper.[20] However, fleet modernization in the 1960's led to overfishing and a decline in the health of fish stocks.[21] Today, most vessels fish offshore and the number of subsistence fishers is small. Most of the fish caught in Hong Kong today are low-value, small, short lived species that are heavily overexploited. Large, predatory, high value fish—previously abundant—have declined markedly. Some species, such as red grouper and giant croaker, are on the verge of local extinction.[22] Hong Kong, a city known for heavy seafood consumption, imports 95% of its annual seafood supply.[23]

In 1991, the then Agriculture and Fisheries Department (AFD), now the Agriculture, Fisheries and Conservation Department (AFCD), estimated the total Hong Kong fish catch at 20,664 tones for vessels less than 15 m in length. A 1996 study indicated that the 1996-97 total annual fish catch in Hong Kong waters was 14,747 tonnnes (7.8 tonnes per km^2), indicating a downward trend.[24] Of the 176 fishery areas examined in both surveys, 97 areas reported decreases of over 50% since 1989. This decline in stocks is a result not only of overfishing, but also of intensive coastal development and deterioration in water quality.

If the fishing industry is allowed to continue its current mode of operation, an ecological disaster and the total collapse of Hong Kong's fishery are likely. In fact, local inshore fisheries are already collapsing.[25] Despite well-documented evidence on the serious impact of trawling on the benthic organisms that provide shelter and food for fishes, there are no controls on bottom trawling fishing in Hong Kong, except in small protected areas.[26] Yet, with optimal management, catches of larger and slower growing species could be almost doubled. It is also estimated that increasing mesh size of fish nets could roughly double Hong Kong's long-term fish yield.[27]

In an unique study, the ecological and economic benefits of Hong Kong's marine ecosystem were evaluated by comparing a past scenario of a relatively unexploited ecosystem with three fishery management scenarios (run for 25 simulated years).[28] The three management scenarios were:

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[19] In part, Hong Kong's fishing industry is a product of high local demand. It is estimated that approximately 46 kg of fisheries products per capita per year are consumed locally, seven times the consumption rate of the US (ERM-Hong Kong Ltd (1998). Fisheries Resources and Fishery Operations in Hong Kong Waters. Report for AFD).

[20] Ibid

[21] Ibid

[22] Sadovy Y. and Cheung, W.L. (2002). The Case of the Disappearing Croaker, the Chinese bahaba, *Bahaba taipingensis*. Porcupine! Newsletter of the Department of Ecology and Biodiversity, The University of Hong Kong, 24 (2002), pp. 14-15.

[23] Warren-Rhodes K. and Koenig A. (2001). Ecosystem Appropriation by Hong Kong and Its Implications for Sustainable Development. Ecological Economics 39 (2001), p. 353.

[24] ERM-Hong Kong Ltd (1998). See footnote 19.

[25] William Cheung, Personal Communication, January 2002.

[26] Benthic organisms live on the bottom of a body of water.

[27] ERM-Hong Kong Ltd (1998). See footnote 19.

[28] Buchary, E.A., Cheung, W-L, Sumaila, U.R. and Pitcher, T.J. (2001). Exploring Policy Options for Hong Kong's Fisheries Using Ecosim. In Pitcher, T.J. and Trujillo, P. (eds) *The Use of Ecosystem Models to*

(1) *Status quo:* This scenario is a continuation of current heavy exploitation with only 1.4% of Hong Kong waters protected.
(2) *Slightly increased protection*: Based on the Agriculture, Fisheries and Conservation Department's (AFCD's) current proposals, this scenario designates 8.2% of Hong Kong waters as a no-trawl area and 1.2% as a no-take area.
(3) *Large no-take area:* Under this scenario, 45% of Hong Kong waters would be no-take areas.

Not surprisingly, the ecological modeling results showed that the large no-take scenario allowed the best recovery of both non-reef demersal and pelagic fish.[29]

For the economic analysis, three different valuation techniques were used. Two of the three valuation techniques take non-use values into account. However, for simplicity of organization, the entire study results are included in this direct use section of the paper.

Under the market valuation technique, a conventional cost-benefit analysis valued the fish and invertebrates caught and sold at constant 1997 prices. However, the market value of the fish catch does not capture the wider ecological and social benefits of a healthy marine ecosystem. Wider benefits include both non-use values, such as existence values, and use values that are not traded in the market. In an attempt to capture some of the non-market values of the fishery, an ecological-economic approach was also employed. In addition to the economic value of the fish catch, this technique valued marine organisms that remained uncaught and unsold. It was assumed that the biomass remaining in the ocean had a unit value equivalent to the unit market value. The ecological-social-economic approach took this theory a step further. To incorporate intergenerational equity concerns, a discount rate of zero was applied instead of a discount rate of 7% for the other valuation techniques. The results are shown in Table 1.

Table 1: **Average annual benefits from both market and non-market valuation (thousand HK$ per km^2) for three management scenarios simulated over 25 years to the present day**[30]

Valuation technique	Past ecosystem	Present day ecosystem		
		Status quo	Present initiative	Large no-take
Market	12	27	34	17
Ecological-Economic	115	74	76	90
Ecological-social-economic	231	148	151	180

Using the market valuation technique, the value of the past ecosystem is lower than the status quo because past fish catches were lower. Similarly, the pure market value of the large no-take scenario is lower than the status quo because the overall fish catch is lower.

However, the model shows that non-market values are critical. Under all three scenarios, non-market values dramatically increase the value of Hong Kong's marine ecosystem. By taking

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Investigate Ecosystem-based Management Strategies for Capture Fisheries. Fisheries Centre Research Report 9(2): (in press).

[29]Fish that spend most of their life swimming in the water column, as opposed to resting on the bottom, are known as pelagic species. Demersal fish live on or near the bottom of the water column and feed on benthic organisms.

[30]Buchary et al (2001). See footnote 28. The value of the past ecosystem model was also estimated by running a similar time-dependent analysis. It is considered to be the value of the restored ecosystem.

social and ecological factors into account, the model comes closer to realizing the full gains of a restored ecosystem.

Based on these figures, the total economic value of Hong Kong's marine ecosystem may range from HK$148 million per year for the current over-exploited status quo to HK$180 million per year for a restored marine ecosystem based on the large no-take scenario.

4.2 Ecotourism

Current Situation

Tourism is a key sector of Hong Kong's economy. It provides jobs for 330,000 people (12% of the workforce) and makes up about 7% of GDP.[31] In 2000, Hong Kong had 13 million visitors who generated receipts of approximately HK$61 billion.[32] Despite a current downturn in tourism, Hong Kong is on course to become the world's fifth most popular tourist destination by 2020, according to the World Tourism Organization.[33]

Following the slump in tourism after the handover and 1997 Asian financial crisis, tourism chiefs announced a number of new initiatives to maintain Hong Kong's attractiveness. While these focused primarily on conventional attractions, there were attempts to capitalize on Hong Kong's natural attractions. To promote nature-based tourism, the then Hong Kong Tourist Association (HKTA; now the Hong Kong Tourist Board, HKTB) published *Exploring Hong Kong's Countryside - A Visitor's Companion* in 1999. The book has sold over 20,000 copies to date, with English, Chinese and Japanese editions now available.[34]

Today, most of HKTB's overseas marketing campaigns and virtually all trade and consumer publications, including websites, feature Hong Kong's green attractions. Their latest series of advertisments and posters include images of unspoilt greenery under the headline "*Hong Kong is a natural wonder*." HKTB also has a special "Green Touring" section on their DiscoverHongKong.com website, which attracts some three million hits per month.[35] Through this website, special leaflets and Visitor Information & Services Centres, HKTB promotes a series of Guided Nature Walks and bird and dolphin-watching tours, all offered by independent guides and operators.

For the fiscal year 1999-2000, the HKTA spent HK$281.9 million on promotion, advertising and literature for marketing worldwide. It is difficult to put an accurate figure on HKTB's marketing of Hong Kong's scenic/natural wonders, because the promotion of these attractions is integrated into broader campaigns. However, it is estimated that heritage, culture and green elements constitute about 30% of a typical major campaign.[36] Marketing of green tourism particularly targets North America, Australia/New Zealand, Europe and Japan, markets where significant niches have been identified. Japan is an especially promising market, with nine travel agencies in Tokyo now offering hiking/walking tour packages to Hong Kong.[37]

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[31]Kwok, Fun Ki (2000). Ecotourism in Hong Kong: Its Current Status and Prospects. M.Sc. Dissertation (Environmental Management). University of Hong Kong, 2000.
[32]Hong Kong 2000. http://www.info.gov.hk/hk2000/eng/17/c17-02.htm
[33]Chow, Chung-yan. Future Bright for SAR Tourism. South China Morning Post. 21 October 2001, p. 5.
[34]In promoting ecotourism, Hong Kong tourist officials were responding to worldwide trends. The United Nations designated 2002 the "International Year of Ecotourism," an acknowledgement of the economic importance of the industry.
[35]S. Clennell, HKTB, Personal Communication, November 2001.
[36]Ibid
[37]Ibid

Estimating the number of tourists currently participating in nature-based activities is difficult due to the lack of comprehensive surveys or statistics. In a 2000 HKTB survey, 8% of visitors claimed to have visited one of the outlying islands, although there may be reasons other than natural attractions for the visit. There are no statistics estimating the current number of tourists who hike or who visit Country Parks.[38] The World Wide Fund for Nature Hong Kong (WWFHK) estimate that Mai Po receives about 4,065 visitors a year while Hong Kong Dolphinwatch estimates approximately 4,000 overseas visitors go dolphin-watching annually. An estimated 10,000 local tourists per year also join dolphin-watching tours.

Future Potential of Ecotourism

While Hong Kong is unlikely to ever attract large numbers of ecotourists, tourism experts believe that Hong Kong's green scene could encourage visitors to stay longer or to return. In HKTB's 2000 survey, 11% of all visitors indicated interest in "ecotourism" and 13% were interested in "hiking in the countryside."[39] A similar 1998 survey asked visitors what additional attractions they would like to see. Nature and heritage attractions featured strongly, with historical buildings, outlying islands, nature reserves and beaches & mountains numbering 3, 4, 7 and 8 on the list respectively.[40]

To date, Hong Kong's nature-based tourism industry has been underdeveloped due to lack of knowledge on the subject and lack of interest from the tourism industry.[41] However, the Hong Kong Government is beginning to develop ecotourism initiatives. In August 2001, the Government announced a HK$18 billion plan to boost tourism which included proposals to promote Sai Kung's role as Hong Kong's 'back garden' with more country parks, ecotourism and water sports.[42] A new HK $250 million International Wetland Park and Visitor Centre is also under development at Tin Shui Wai. This new eco-tourism attraction is aimed at diversifying the range of tourist attractions in Hong Kong. On completion in 2005, the Wetland Park will comprise a 64 hectare outdoor park and a visitor centre. The outdoor park will consist of constructed wetlands and habitats for waterbirds, with trails allowing visitors to get close to the migratory birds. Phase 1 of the park, opened in December 2000, attracted over 48,000 visitors in the first seven months, including over 5,200 Hong Kong students.[43] It is anticipated that the completed park will serve about 400,000 visitors a year. In HKTB's 2000 survey, 13% of visitors listed the wetland park as a future draw. AFCD estimates that 1% of the park's visitors will be from overseas, amounting to 4,000 overseas visitors per year.

Putting a dollar value on the potential of ecotourism is difficult because many of the activities will be free or low cost. However, it is possible to estimate the additional revenue that nature-based tourism could generate. Exit surveys show that, on average, visitors to Hong Kong stay for three days, but would tell a friend to stay for 4.9 days. Each tourist also spends, on average,

[38] For the purposes of this study, local tourists visiting country parks are included in the section on recreation and amenity.
[39] Hong Kong Tourism Board. A Statistical Review of Hong Kong Tourism 2000.
[40] Citizen's Party. http://www.citizensparty.org/economy/tourism3.html
[41] Ng C N and Li Y (1998). Ecotourism in Hong Kong: its potential and limitations. Paper presented at the Cuarta Feria Ecoturistica y de Produccion 15 – 23 Julio, 2000 Buena Noche de Hato Nuevo, Manoguayabo, Santo Domingo, D.N., Republica Dominicana http://www.kiskeya-alternative.org/publica/diversos/hong-kong.htm
[42] Tourism Hong Kong. South China Morning Post. 25 August 2001.
[43] AFCD (2001). Hong Kong Wetland Park Newsletter. Issue 1. September 2001.

HK$1,513 per day.[44] If 11% of tourists stay for an additional 1.9 days—based on the percentage of tourists indicating interest in ecotourism—this would generate an additional HK$4.1 billion in revenue. This is a high estimate because not all tourists indicating interest in ecotourism will stay for additional time. Still, it gives some indication of the potential size of the ecotourism market.

Using the travel cost method outlined in Appendix 2, it is also possible to estimate the travel costs of hikers. HKTB surveys show that 13% of tourists are interested in hiking. Not all 13% will actually go hiking, but this figure gives an indication of potential growth in hiking and other types of outdoor recreation. Assuming an additional 1.3 million tourists go hiking, they would generate HK$258.7 million in travel costs.[45]

4.3 Education

Environmental education is defined by the International Union for the Conservation of Nature & Natural Resources as *"A new educational approach that works for an integrated behaviour of individuals towards their environment, including initial cultural and natural components."* Environmental education encompasses education about the environment, for the environment and in the environment. While the former two can be taught in the classroom, education in the environment can only be taught outdoors. While there is no single subject called environmental education in the Hong Kong school curriculum, environmental issues appear in different subjects at different levels. To achieve the objectives of various syllabi, teachers must design learning activities in the open air to illustrate, clarify and develop observational skills, collect data and work with field instruments.[46]

Hong Kong is fortunate to have many opportunities for outdoors, nature-based education within a reasonably short distance from urban schools. There are a number of outdoor educational centers, including the Lions Nature Education Centre; country park visitor centers run by AFCD; Kadoorie Farm and Botanic Garden; a number of small organic farms; the internationally important wetland site at Mai Po Nature Reserve run by WWFHK and the new wetland park at Tin Shui Wai. These all organize school visits, providing an ideal open-air laboratory and an invaluable teaching resource.

For the purposes of this paper, the travel cost method (see Appendix 2) was used to estimate the educational value of such outdoors centers. Environmental education fosters ecological consciousness and respect for our natural environment, qualities that are priceless. The travel cost method obviously fails to capture such values and therefore represents an absolute minimum estimate of educational value. The travel costs estimates are presented in Table 2 below.

It has been assumed for the purposes of the table below that all visitors to country park education centers are there for educational purposes. For Mai Po and Kadoorie Farm, visitors other than students are included in the section on recreation. While this is a somewhat arbitrary assumption, it is logical that many bird-watchers or local tourists visit these places simply for rest and

[44]2000 statistics. S. Clennell, Personal Communication, November 2001.

[45]This estimate of travel cost makes the following assumptions: 1) 3% of the tourists who indicated interest in hiking already visit country parks/go hiking. 2) Average travel cost to country parks is HK$50 (assumes most tourists take taxis). 3) Average hourly wage for an overseas visitor is HK$150. This high wage rate assumes most tourists are professionals, a reasonable assumption considering that most of the tourists indicating interest in hiking are from Europe, Australia and North America and tend to have higher per capita incomes.

[46]World Wide Fund for Nature Hong Kong (1986). Mai Po – Its Educational Value with Relevance to the School Curriculum in Hong Kong. Booklet published by WWFHK.

relaxation. There is also a difference in travel cost because students will tend to travel by coach whereas other visitors tend to use public transport.

Based on the below travel cost estimates, the minimum educational value of outdoor education centers is HK$36.5 million per year.

Table 2: Number of school visits and visitors to various outdoor education centers in Hong Kong in 2000

Outdoor education center	Operator	No. students/visitors	Estimated Travel Cost per year (HK$million)[47]
Lions Nature Education Centre	AFCD	363,309	13.75
Aberdeen Country Park Visitor Centre	AFCD	76,162	2.6
Sai Kung Country Park Visitor Centre	AFCD	131,746	4.98
Shing Mun Country Park Visitor Centre	AFCD	27,961	.836
Plover Cove Country Park Visitor Centre	AFCD	37,276	1.8
Tai Mo Shan Country Park Visitor Centre	AFCD	72,388	2.5
Clear Water Bay Country Park Visitor Centre	AFCD	120,188	4.5
International Wetland Park and Visitor Centre (Phase 1)	AFCD	82,000*	3.1
Mai Po Nature Reserve	WWFHK	13,294	.64
Island House	WWFHK	2,400	.08
Kadoorie Farm	Kadoorie Farm	35,357°	1.7
TOTAL		**962,081**	**36.5**

* This figure is based on visitor numbers for Jan-July 2001, pro-rated for 12 months

° Figure for 1999, includes students from schools, kindergartens, tertiary institutes and child/youth care centers.

[47]The estimated travel cost for students is based on the methodology outlined in Appendix 2. j varies by location, o=.33, w=$40, t=$11. Following the precedent set by the 1986 Comprehensive Transport Study, we have valued student time at one-half the adult wage rate. Transport costs incurred in traveling to the education center (t) are based on the cost of hiring a coach (HK $550/each way for approximately 50 students). c=o, although the Education Department does pay some money to Mai Po to cover school entrance fees.

4.4 Landscape, Amenity and Recreation Value

The best way to measure the value of outdoor recreation is through contingent valuation surveys. Contingent valuation surveys measure consumer surplus, the amount users are willing to pay over and above the actual costs of travel and equipment. In the US, for example, researchers have used contingent valuation surveys to measure the economic benefits of mountain biking. A 1997 study found that mountain bikers were willing to pay US$197-205 (HK$1,521-1,599) per trip to Moab, Utah.[48] However, no Contingent Valuation surveys exist for outdoor sports or nature based recreation in Hong Kong. As a result, this paper uses travel cost and revenue generated as a rough way to gauge the economic value of outdoor recreation. If consumer surplus were taken into account, the real economic value of outdoor recreation would be far higher.

a. Hiking and recreation in Country Parks

Hong Kong has 23 Country Parks with over 487 kilometers of footpaths and 450 recreational sites.[49] They comprise scenic hills, woodlands, reservoirs and coastal areas and are visited by over 10 million people a year for recreational activities. A detailed survey conducted by AFCD found that the main reason for coming to a particular Country Park was the attractive scenery (23%) followed by convenient transport (20%). Barbecues were the most popular activity (39%) followed by picnics (14%), pleasure walks (12%) and hiking (8%).[50]

The travel cost method was adopted in order to estimate the recreational value associated with the Country Parks (see Appendix 2).[51] Unlike other countries, where travel distances to recreation areas are large and visitors are frequently required to stay overnight, Hong Kong's compactness and the efficiency/accessibility of the public transport system, mean that travel costs for Hong Kong recreational users are much lower than travel costs for recreation users in other countries. However, Hong Kong's small size allows for simplification of the estimates because overnight accommodation costs can generally be discounted. It is also worth noting that that the AFCD's estimate of 10 million annual visitors to Country Parks may be too low. Many Country Park users skirt around the boundaries of the park and are not counted in official statistics.[52]

The latest figures for transport costs for visitors to country parks were obtained from AFCD (see Table 3 below) which showed that most visitors spent less than HK$15 for a single journey, due to low public transport fares and proximity to urban areas. Figures from earlier surveys show that the transport time to Country Parks varied from less than half an hour to about 4.5 hours.[53] In

[48]Fix, P and Loomis, J (1997). The Economic Benefits of Mountain Biking at One of Its Meccas: An Application of the Travel Cost Method to Mountain Biking in Moab, Utah. Journal of Leisure Research 29, No. 3, pp. 342-52.
[49]AFCD. Annual Report 1999-2000.
[50]Agriculture & Fisheries Department (1984). Country Park Visitor Survey 1982-83. Summary Report. More recent detailed surveys are not available.
[51]Country Park visitors may view transportation time as an end unto itself. As a result, the value of time may be higher than the wage rate. Alternately, people may travel to Country Parks during the weekends and the true value of their time may be their willingness to pay for leisure time, possibly higher than the wage rate. We have chosen to use the wage rate to calculate travel cost, but this may be an underestimate.
[52]According to some estimates, as many as five million visitors stay outside Country Park boundaries. Many of these people believe that they have visited Country Parks, but are omitted from official statistics. R. Corlett, Personal Communication, 18 January 2002.
[53]FY Wong, Personal Communication, August 2001.

most cases, it was between 0.5 and 2 hours. A median value of 1.25 hours was adopted for this report.

In 1999/2000, there were 10,655,700 visitors to the Country Parks. Based on the formula shown in Appendix 2, total travel costs to Country Parks in 1999/2000 are estimated at HK$314 million per year.

Based on these estimated travel costs, the minimum recreational value of the Country Parks is HK$314 million per year.

Table 3: Total travel cost for Country Park visitors in 1999/2000 (HK$)[54]

Transport cost[55]	Median	% visitors	Total transport cost (t) (HK$million)	Total travel cost (TC) (HK$million)
Nil	0	16.5	0	.000041
$0.1 - $4.90	2.5	12.4	3.3	6.6
$5 - $9.90	7.5	14.7	11.7	23.5
$10 - $14.90	12.5	15.7	20.9	41.8
$15 - $19.90	17.5	11.5	21.4	42.9
$20 - $24.90	22.5	11	26.4	52.8
$25 - $29.90	27.5	5.1	15.0	29.8
$30 - $39.90	35	7.1	26.5	53.0
$40 – 49.90	45	2.4	11.5	23.0
$50 and over	55	3.5	20.5	41.0
Total		**99.9**	**157.2**	**314.3**

b. Recreational value of other conservation facilities

There are a number of non-government outdoor conservation facilities outside Country Parks that are also used for recreation. These include Mai Po Nature Reserve and Kadoorie Farm as well as a number of organic farms. While these are primarily educational facilities, it is assumed that many of the non-school visitors visit for leisure purposes. Therefore the travel cost of these visitors has been separated from those of school visits (given in Section 4.3). The same travel cost method used for Country Park visitors has been adopted for estimating the travel cost to these other facilities.

Table 4: Total travel costs for visitors to other conservation facilities

Destination	**No. visitors/y (excluding students and school visits)**	**Travel cost (rounded to nearest HK $100) HK$/y**
Mai Po Nature Reserve	64,234	3,340,600[56]
Kadoorie Farm	71,697	5,936,500[57]

[54] t = median transport cost from Table 3 above multiplied by total number of country park visitors in that category; j = a median value of 1.25 hours was adopted; w = an average hourly wage of HK$80 was adopted; o = 0.33; c = assumed to be zero

[55] FY Wong, Personal Communication, August 2001.

[56] Assumes j = 1 hour; t= 15 (based on MTR from Mong Kok to Kowloon Tong and KCR to Tai Po and minibus to Mai Po); w = 80 o = 0.33; c = 70, based on cost of permit

[57] Assumes j = 1 hour; t= 15 (based on MTR from Mong Kok to Tsuen Wan and bus to Kadoorie Farm; w = 80 o = 0.33; c = 0

c. *Hong Kong marine leisure*

Associated with wealth and relaxation, pleasure boating has long been a favorite leisure activity of Hong Kong residents. For Hong Kong city dwellers, escaping into the unspoiled outdoors is part of the attraction. The Royal Hong Kong Yacht Club highlights the natural appeal of pleasure boating on its website: "*From Middle Island, the Club's base on the south side of Hong Kong Island, head for a meal at the fish restaurants on Po Toi or take a trip to Sai Kung, Hebe Haven or Jade Bay. All these places have good, clean, clear water, and excellent swimming and fishing.*"[58]

One way to value Hong Kong's outdoors is by estimating the revenue generated by outdoor recreation. Marine leisure depends on the unspoiled nature of both Hong Kong's marine and terrestrial environments. The amount of money spent on fuel, boats, mooring fees, maintenance etc. is, to a large extent, a by-product of conservation.

While there are no official statistics on the size of the industry, a few hard statistics are available. There are 4,500 boats currently registered as pleasure boats in Hong Kong.[59] Boating experts value each of these boats, on average, at HK$600,000.[60] Thus, the value of the Hong Kong pleasure boat fleet is HK$270 million.

On a year-to-year basis, a rough estimate of the revenue generated by marine leisure might look like this:

Table 5: Estimated annual value of marine leisure

Revenue Item	Annual value (HK$million)
Capital cost of pleasure boats (amortized over 10 years, the average life span of a pleasure boat,[61] at an economic discount rate of 4%[62])	316
Mooring fees[63] ~1,300 boats in government private moorings @ HK$2,000/month. ~800 boats in marina berths @ HK$15,000/month. ~2,400 boats in yacht club moorings @ HK2,000/month	 31 144 58
Annual running costs – estimated at 10% of the capital cost of the boat[64]	27
TOTAL	**576**

d. Wilderness Courses

Outward Bound Hong Kong operates a number of courses featuring experiential learning in the outdoors. With the exception of a course operating in Nepal and one operating in Japan, these courses take place in Hong Kong's wilderness. Without conservation, Outward Bound would be unable to operate in Hong Kong.

[58]Royal Hong Kong Yacht Club. http://www.rhkyc.org.hk/marine.htm#Hiring
[59]Roger Tupper, Hong Kong Marine Department, Personal Communication, 27 September 2001.
[60]David Robinson, Editor of Fragrant Harbor, Personal Communication, 27 September 2001.
[61]David Bowdler, Aberdeen Marina Club, Personal Communication, 15 October 2001.
[62]This is the economic discount rate adopted by the Hong Kong government for the Disney theme park.
[63]Information from the Hong Kong Marine Department and David Bowdler. Personal communication.
[64]David Bowdler, as quoted in Howe K. Super-Yacht Syndrome: Part II. www.totallyhk.com

In 2000, Outward Bound generated HK$21 million in course fees.[65] Given the nature of Outward Bound's business, this money is a direct by-product of conservation in Hong Kong.

e. Revenue Generated by Outdoor Sports

Nature conservation makes possible a variety of sports that utilize the outdoors. Without nature conservation, these types of recreation would be impossible. As a result, the revenue generated by outdoor sports can be considered a by-product of conservation. This report estimates the revenue generated by three sports: mountain biking, scuba diving and rock climbing. Clearly, this is not a comprehensive estimate of the revenue generated by outdoor recreation in Hong Kong. Many other sports—recreational fishing, to take one example—also generate revenue and benefit from nature conservation.

Mountain Biking

Mountain Biking is a growing sport in Hong Kong. According to the best estimates of the Hong Kong Mountain Biking Association, there are 2,000 mountain bikers in Hong Kong with 1,000 people regularly using five legally designated mountain biking trails. Mountain biking is also a very expensive sport. Mountain bikes cost around HK$3,500 and many bikers also buy a second bike, shoes, helmets, water bottles and clothing.[66]

There are no statistics on the value of the mountain biking industry, but a source at one of the four biggest bike retailers in Hong Kong estimates his revenue at HK$15-20 million per year.[67] There are also six smaller bike shops, each with an estimated revenue of HK$6 million. The Hong Kong Mountain Biking Association believes that HK$100 million is a low estimate of the total annual revenue generated by the biking industry.[68]

Of course, not all of this value is directly attributable to conservation. Bikes are much cheaper in Hong Kong than in North America or Europe, so many tourists buy bikes to take home. Yet a substantial portion of the $100 million is due to conservation. If there were no mountain biking trails, the bicycle retail industry would dramatically shrink.

Scuba Diving

Hong Kong has a surprisingly diverse marine ecosystem with more coral species than the Caribbean and a wide variety of reef fish and other animals.[69] While much of Hong Kong's marine waters are too silty for good diving, the Eastern Waters, which contain most of the hard coral colonies, offer many good diving sites. The number of local active scuba divers (those that dive at least once a year in Hong Kong or overseas) is estimated at approximately 30,000.[70] It is estimated that they spend approximately HK$10 million annually on gear and training. This does not include any travel time or costs to reach the dive sites, which are usually in remote areas.

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[65] Hong Kong Outward Bound. Annual Report 2000. http://www.outwardbound.hk.org
[66] Richard Barton-Smith, Personal Communication, 11 October 2001.
[67] Hong Kong's biggest bike retailers include Flying Ball Bike Shop and Bicycle World.
[68] Richard Barton-Smith, Personal Communication, 11 October 2001.
[69] The sites with best coverage include Hoi Ha Wan Marine Park, Lai Chi Wo, Wong Chuk Kok Hoi, A Ma Wan in Ping Chau, Bluff Island, Pak Lap Tsai, Kat O, Yung Kok and Double Island. AFCD coral reef check. October 2001.
[70] LC Ng, Scuba Network, Personal Communication, October 2001

Rock Climbing

Hong Kong has a number of clubs devoted to rock climbing, including the Hong Kong Mountaineering Union and the Hong Kong Ngok Fung Rock Climbing Society. There are roughly 2,000 rock climbing routes and 700-800 active climbers in Hong Kong. According to best estimates, each climber spends roughly HK$8,000/year on equipment, including ropes, shoes and harnesses. Based on a median value of 750 climbers, rock climbing generates an estimated HK$6 million in annual revenue.[71]

4.5 Direct Use Values Not Quantified

Scientific and Medicinal Value

Hong Kong has over 1,000 herbs that are known to have medicinal properties.[72] These range from commonly found herbs to rare and indigenous plants. However the direct use value is limited to those small quantities of herbs gathered and sold in markets. Most of the herbs sold in traditional Chinese medicine emporiums are either cultivated in China or imported from overseas. Therefore, the main value in Chinese herbal plants is in the potential commercialization of rare plants found only in Hong Kong. Given the small land area in which such plants are found (compared to areas such as Amazonia) and the fact that the medicinal value of these plants is already well researched and documented, the likelihood of such commercialization is low.

Value of Properties Overlooking Aesthetic Views

In Hong Kong, there is typically a premium on properties with aesthetic views—sea, harbor or mountain views. The hedonic pricing method is most often used to value environmental amenities that affect the price of residential properties on the basis that the price of a marketed good is related to certain characteristics of the services it provides. To determine the extent to which property prices are affected by aesthetics of the view, the market price of residential flats in the same building that differ only in their views were compared. This would eliminate any differences due to size, age, district, proximity to urban area and other factors affecting market price. Based on developer's price lists for a limited number of properties, it was found that landscape vies can increase property value by up to 20% compared to flats with less aesthetic views (see Table 6 below). However, it was impossible to estimate the total added value of landscape views in the property market because there was no data on the total number of properties in Hong Kong with aesthetic views.

[71] Stuart Sharpless, Personal Communication, 24 October 2001
[72] The 5 volumes of *Chinese Medicinal Herbs of Hong Kong* list at least 1,000 medicinal plants.

Table 6: Difference in property prices between flats with views and without views (averaged over all floors) in selected buildings

District	Development	Average price of flat with view (HK$/sq ft)	Average price of flat with no view (HK$/sq ft)	Difference (%)
Aberdeen	South Horizon	4,333	3,550	22
Tsing Yi	Grand Horizon Block 1	3,392	3,117	9
	Grand Horizon Block 6	3,562	3,261	9
Tsing Yi	Villa Esplanada	3,715	3,538	5

5. Valuing the Indirect Use Values

5.1 Watershed protection

The value of a forested watershed comes from its capacity to absorb and cleanse water, recycle excess nutrients, hold soil in place and prevent flooding. A watershed also contributes to the regulation of the local climate. After forest cover is removed, an area may become hotter and drier because water is no longer recycled by plants.[73]

One way to estimate the economic value of a 'free' service like watershed protection is to estimate what it would cost society if that service had to be replaced. New York City relies on the natural filtering capacity of its rural watersheds to cleanse the water that serves 10 million people a day. In 1996, experts estimated that it would cost US$7 billion (HK$54.6 billion) to build water treatment facilities to meet the city's future needs. Instead, the city chose to spend one-tenth of that helping upstream counties protect the watersheds around its drinking water reservoirs.[74]

Hong Kong's water gathering grounds comprise nearly one-third of the land area of Hong Kong. The surface runoff over this area is collected and delivered to 17 impounding reservoirs.[75] All of the reservoir catchments in Hong Kong are protected because they fall within Country Park boundaries. Indeed, when the Country Park boundaries were established in 1974, many of the boundary lines followed water catchments. Since the establishment of the first reservoirs in the 19th and early 20th century, there was been extensive tree planting to help improve the ability of the catchment to capture rainfall. Not all the surface runoff over the catchment area can be collected because the steep terrain of the catchment areas often results in overflow of surface water collection systems during periods of heavy rainfall.[76] The mean annual gross yield that can be collected from local catchments in one year is about 295 million m^3.[77]

However, local water resources cannot meet all of Hong Kong's demand, which was 924 million m^3 in 2000. Fulfilling Hong Kong's water needs locally would require an additional 800-1200

[73] Abromovitz JA (1998). See footnote 8.
[74] Ibid
[75] The largest reservoirs—High Island, Plover Cove, Shek Pik and Tai Lam Chung—have a total capacity of 555 million m^3. The total storage capacity for all reservoirs is 586 million m^3 (Water Supply Department, www.info.gov.hk/wsd).
[76] Ku C C (2000). Water Resources Operational Strategies in Hong Kong. Water Supplies Department.
[77] It should be noted that some of the reservoirs are also used for balancing (and purifying to some extent) the raw water from Guangdong before it is pumped to the various Water Treatment Plants. Water Supply Department (WSD), Personal Communication, 27 August 2001

km^2 of catchment area, equivalent to about 75-100% of Hong Kong's land area.[78] Instead, Hong Kong has been importing raw water from China since the 1960s. Today, Hong Kong receives 80% of its raw water from Dongjiang, a river north of Shenzhen

Table 7: Freshwater supply and demand statistics for Hong Kong[79]

Water supply and demand parameters	Quantity (million m^3)
Total reservoir storage capacity	586
Local catchment yield in year 2000	260.76
Mean annual gross yield from local catchments	295
Water supplied from Guangdong in year 2000	840
Water consumption in year 2000	924.13

In 2000, Guangdong supplied 840 million cubic meters through a system with a design capacity of 1,100 million cubic meters a year. Guangdong is thought to be the long-term solution to Hong Kong's growing water demand. While there is complacency about the security of Hong Kong's water supply, it should be noted that many cities in Guangdong are already classed as water short cities. It was also not long ago that Hong Kong suffered severe water shortages and rationing. For a period in 1977, supply was limited to 10 hours a day. There were also similar restrictions in 1981 and 1982. To address water scarcity, Hong Kong even built a full-scale desalination plant, fully commissioned in 1976.[80]

All of the reservoir catchments in Hong Kong are protected by virtue of being country park boundaries. Indeed when the country park boundaries were established in 1974, many of the boundary lines followed water catchments. However, since the establishment of the first reservoirs in the 19th and early 20th centuries there has been extensive tree planting to help improve the ability of the catchment to capture rainfall.

At a minimum, the value of Hong Kong's local water catchments may be estimated as the avoided cost of purchasing the equivalent raw water from Guangdong minus the costs of maintaining the reservoirs.

In 1999, a total of 737.95 million m^3 was supplied by Guangdong at a cost of HK$2,223 million. Although raw water is purchased under a bulk purchase agreement, a pro-rata cost of HK$3 per m^3 has been assumed for the purpose of this report.[81]

Table 8: Estimated value of locally supplied raw water based on substitute value of Guangdong water

Maximum quantity of water supplied from local catchments in one year	295 million m^3
Cost of supplying equivalent volume of water from Guangdong @ HK$3 per cubic meter	HK$885 million
Minus annual cost of reservoir maintenance	HK$4 million[82]
Total	HK $881 million

[78] Warren-Rhodes K and Koenig A (2001). See footnote 23.
[79] Water Supply Department (WSD). www.info.gov.hk/wsd
[80] The plant was later demolished due to high energy costs.
[81] There may be economies of scale in that the marginal cost of supplying additional water is very low, although treatment and pumping costs would be approximately proportional to the volume of water supplied.
[82] WSD, Personal Communication. WSD could only provide statistics from 1.4.01-23.8.01 due to changes in accounting practice. These five months were pro-rated to an annual figure and rounded up to the next million.

If the amount of water now supplied by local reservoirs was purchased from Guangdong, this would equate to an increase of HK$881 million in annual water costs. It should be noted that this is a minimum value since it does not account for the biodiversity or other value of the water gathering grounds.

This figure also assumes that additional water is available from Guangdong and that water can be supplied at a sufficiently high quality. Currently, the water supplied from local reservoirs is of high quality and requires standard filtration treatment at Hong Kong's nineteen Water Treatment Works. Guangdong's raw water undergoes the same treatment, although it has become necessary to add additional chlorine over the last few years. If the quality of Guangdong's raw water deteriorates beyond a certain point and contains unacceptable levels of organic chemicals like PAHs and PCBs, expensive and additional treatment levels will be needed. The public has already expressed considerable concern regarding the worsening quality of the Dongjiang raw water, due to rapid urbanization and industrialization of the catchment. Should the quality of Guangdong's raw water deteriorate further, there will be additional costs associated with water treatment.

In addition, Guangdong's demand for fresh water will increase with increasing population growth and urbanization. Hong Kong will have to compete for water supply with other cities in the Pearl River Delta.

5.2 Pollution Absorption and Buffering

a. Mangroves as filters of sewage effluent

Wetlands play an important role as a filter of nutrients, heavy metals and organic pollutants. Mangrove plants are particularly important in trapping significant amounts of pollution. The plants are perennial, have extensive root systems and are specially adapted to shifting aerobic and anaerobic conditions, as well as alternating wet and dry conditions.[83] These features allow mangrove communities to withstand and retain wastewater-borne nutrients and pollutants. Mangrove plants are intertidal and dominate natural estuarine shorelines in Hong Kong.

Studies elsewhere in the world have shown that mangrove plants can immobilize 150-250 kg of nitrogen per hectare and 10-20 kg of phosphorous per hectare on an annual basis by incorporating these substances into plant tissues.[84] This may only be a temporary storage mechanism since the plants would need to be harvested to remove the nutrients from the ecoystem permanently. However, the mangrove sediments and its indigenous microbial populations could ultimately immobilize both nitrogen and phosphorous.[85]

Some international studies have attempted to quantify the denitrification effects of mangrove sediments. In Fiji, nitrate levels in sewage discharged from a sewage treatment plant decreased 30% after passing through an estuary of mangroves. This translates into an estimated reduction rate of 26.2-87.6 mg N per m^2 per day.[86] By comparison, the mean rate of denitrification in an unpolluted mangrove system in tropical Australia was 0.18 mg N per m^2 per day.[87]

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[83]Chen et al (1995). Effect of Synthetic Wastewater on Young Kandelia Candel Plants Growing Under Greenhouse Conditions. Hydrobiologia (295), pp. 263-273.
[84]Clough et al (1983) in Chen et al (1995). See footnote 83.
[85] Tam N F Y and Wong Y S (1995). Mangrove Soils as Sinks for Wastewater-borne Pollutants. Hydrobiologia 295, pp. 231-241
[86]Robertson A I and Phillips M J (1995). Mangroves as Filters of Shrimp Pond Effluent: Predictions and Biogeochemical Research Needs. Hydrobiologia (295), pp. 311-321.
[87]Ibid

In a study to examine the benefits of mangroves filtering the effluent from coastal shrimp ponds in Thailand, it was estimated that an area of two to three hectares of mangroves would be able to remove nitrogen and phosphorus from a one hectare shrimp pond discharging 565 kg N and 70 kg P per hectare per year.[88] This assumes that all the uptake of nutrients is through the plants and not through the sediments and may well underestimate the total potential uptake.

In Hong Kong, one local study examined the ability of different mangrove soils to purify nutrients and heavy metals from high strength wastewater.[89] The muddy, clayey mangrove soils, typical of Deep Bay and North West New Territories, were found to retain 58% of the ammonia-nitrogen concentration and over 90% of phosphate content from wastewater added to the mangrove soil system. The mangroves were also able to completely immobilize toxic heavy metals such as copper, zinc and cadmium.

Table 9: Figures on mangrove/wetland pollution absorption capacity from international literature

Mangrove or wetland N absorption capacity mg N/m^2/day	Mangrove or wetland P absorption capacity Mg P/m^2/day	Reference
41.1-68.5	2.7-5.5	Clough
26.2-87.6		Nedwell
0.18		Alongi
51.6-77.4	6.4-9.6	Roberson and Philips
58% reduction in NH_3	90% reduction in PO_4	Tam and Wong

There is currently one operational constructed wetland in Hong Kong at Kadoorie Farm, and two others under construction at the Tin Shui Wai International Wetland Park and at Lok Ma Chau. Unlike natural systems, constructed wetland systems enable the artificial modification of flowrates, the distribution of water through the system and water levels for optimum removal of pollutants, particularly organic matter. These systems can therefore remove a higher percentage of pollutants.

Taking minimum and maximum values of nitrogen and phosphorus removal from a natural mangrove system as 0.18-87.6 mg N/m^2/day and 2.7-9.9 mg P/m^2/day respectively, the quantities of nutrients removed by a certain area of mangroves in Hong Kong may be estimated.

The Government does not maintain separate cost figures for nutrient removal at its sewage treatment plants because this is an integral part of the activated sludge treatment method typically used to treat sewage. Nutrient removal is performed to varying degrees at each of the five large sewage treatment plants. The operation and maintenance costs of treating sewage at these plants during 2000 was HK$2.20 per m^3. This is a minimum cost since it does not include the amortized costs of sewage treatment plant construction. Based on removal rates at Shatin sewage treatment works, it is estimated that the cost of removing 1 kg of total N is approximately HK$83.[90] The removal rate of phosphorous is not known.

[88] Ibid

[89] Tam and Wong (1995). See footnote 85.

[90] Based on a Dry Weather Flow (DWF) of 150,000 m^3/d, average O&M costs of HK$2.20/$m^3$ and a removal rate of total N of 3,990 kg/d.

Table 10: Quantities of nutrients removed by mangrove systems in polluted areas and equivalent cost of removal by mechanical means

	Deep Bay	Tolo Harbor
Area of mangrove (ha)	106	12
Quantity of N removal possible (kg/day)	0.19-92.8	0.02-10.5
Equivalent cost of N removal by mechanical means	$7702/d $2.8 million/y	$871/d $0.3M/y

Whether the maximum removal quantity is realized depends on the quantity of nutrients in the water flowing through the mangroves. Given the tidal nature of the rivers flowing through the mangroves it is not possible to use river water quality statistics to estimate the daily load of nutrients discharging into Deep Bay and Tolo Harbor. However, based on these figures, it is estimated that it would cost HK$3 million to remove the equivalent amount of nitrates by mechanical sewage treatment plants.

b. Trees as absorbers of air pollution

Trees play a critical role in reducing air pollution in urban environments. Trees can absorb gaseous pollutants such as carbon monoxide, ozone, sulphur dioxide and nitrogen dioxide through the leaf stomates during daylight hours when plant leaves are taking up carbon dioxide.[91] Particles can also be dry deposited on plant surfaces through sedimentation, although sometimes particles are resuspended later. The interception and retention of particles by plants is highly variable – smaller leaves and/or leaves with a rougher surface are more efficient in collecting particles than larger and/or smoother leaves. Particle resuspension varies from 91% for oak leaves to 10% for pines.[92]

There has been little research on the removal of atmospheric pollution by urban trees internationally and none in Hong Kong. Some estimates for the pollutant removal efficiency of trees in the US are given in the table below.

[91]Nowak D J (1994). Air Pollution Removal by Chicago's Urban Forest. In *Chicago's Urban Forest Ecosystem: Results of the Chicago Urban Forest Climate Project* USDA Forest Service Gen Tech Rep NE-186.

[92]Witherspoon and Taylor (1969) in Nowak (1994). See footnote 91.

Table 11: Pollutant removal estimates for trees

Pollutant	Removal efficiency (kg/ha/day)
Particulates	3.1[93]
Particulates	1.5-4.4[94]
Carbon monoxide	1.5-4.7[95]
Nitrogen oxides	1.3-4.1[96]
Nitrogen dioxide	0.04-0.18[97]
Sulphur dioxide	22.7-74.4[98]
Sulphur dioxide	0.15-0.59[99]
Ozone	34.7-111.5[100]

The higher figures were obtained in laboratory studies.[101] As a result, the pollution concentrations used were often quite high. Because the removal rates are dependent on the pollution concentration used, these removal rates may be higher than would be expected in typical US urban conditions. While Hong Kong's pollution levels are generally higher than US values, especially for particulates and nitrogen oxides,[102] the fact that most of the forest cover is on the urban fringes or in rural areas means that the lower absorption values are probably more applicable.

A Chicago study found that 49 hectares of canopy cover can absorb up to 2.5 kg of carbon monoxide, 55 kg of sulfur dioxide, 10 kg of nitrogen dioxide, and 77 kg of particulates per day. Trees in a 212 hectare area of Lincoln Park had an annual air pollution mitigation value equivalent to around US$25,000 of traditional air pollution controls.[103]

The American Forestry Association estimates that the average economic contribution of a single tree is US$73 in energy conservation, US$75 for erosion control, US$75 for wildlife shelter, and US$50 for air pollution benefits.[104] Over its lifetime, an average tree provides more than US$57,000 in environmental and economic benefits. Other studies show that the carbon dioxide emitted into the atmosphere by burning fossil fuels (cars and power plants are the worst offenders) are absorbed by a single mature tree at the rate of 22 kg a year. This same tree releases enough oxygen to support two human beings.

[93]Desanto et al (1976b) in Nowak (1994). See footnote 91.
[94]DeSanto et al (1976a) in Nowak (1994). See footnote 91.
[95]Ibid
[96]Ibid
[97]Heggestad (1972) in Nowak (1994). See footnote 91. Lower figure based on pollutant concentration of 0.005ppm, higher figure based on 0.02ppm.
[98]DeSanto et al (1976a) in Nowak (1994). See footnote 91.
[99]Murphy et al (1977) in Nowak (1994). See footnote 91. Lower figure based on pollutant concentration of 0.008ppm, higher figure based on 0.015ppm.
[100]DeSanto et al (1976a) in Nowak (1994). See footnote 91.
[101]These were calculated using average removal rates in µg /m^2 of leaf area/hr.
[102]For example the highest pollutant concentration of nitrogen dioxide used in the field of 0.02ppm, compares with a standard in Hong Kong of 80 ug/m3 (0.042 ppm) and annual average concentration at roadside monitoring stations of 100 ug/m3 (0.052 ppm).
[103]Cited in Nowak D and McPherson E.G. (1993). United States Forests Service Northeastern Forest Experiment Station, 1993. http://www.tpl.org/tier3_cdl.cfm?content_item_id=1103&folder_id=726
[104]McAliney, Mike (ed.) *Arguments for Land Conservation: Documentation and Information Sources for Land Resources Protection* (Sacramento, California: Trust for Public Land, December 1993). http://www.tpl.org/tier3_cdl.cfm?content_item_id=1103&folder_id=726

In 2000, woodlands and plantations in Hong Kong covered an area of approximately 20,000 hectares.[105] Hong Kong's natural forest consists of tropical evergreen broadleaf monsoon forest. Plantation forest, approximately 5% of land area, mainly includes brisbane box (Lophostermon confertus), slash pine (Pinus elliottii), acacia (Acacia confusa), swamp mahogany (Eucalyptus robusta) and paper bark (Melaleuca quinquenervia), while the most widely planted native is Schima superba.

A very simplistic calculation based on the highest and lowest removal efficiencies given in Table 15. gives a range of daily values for pollutant removal. Given that Hong Kong's forest is mainly evergreen, this may be extrapolated to a yearly removal figure. Note that removal rates will vary significantly with pollutant concentration, meteorological factors, distance of trees from source of pollution etc. These figures provide ballpark estimates only.

Table 12: Estimates of minimum and maximum pollutant removal rates by tree cover in Hong Kong

Pollutant	Minimum daily removal rate (kg/d)	Maximum daily removal rate (kg/d)	Minimum annual removal rate (t/y)	Maximum annual removal rate (t/y)
Particulates	30,000	88,000	10,950	32,120
Carbon monoxide	30,000	94,000	10,950	34,310
Nitrogen dioxide	800	8,200	292	29,930
Sulphur dioxide	3,000	1,488,000	1095	543,120
Ozone	694,000	2,230,000	253,310	813,950

An air quality modeling exercise using the Environmental Protection Department's PATH model[106] was conducted to see whether the presence or absence of Hong Kong's forests make any significant difference to ambient air quality. In the PATH model trees are assumed to be both a source of biogenic emissions (mainly Volatile Organic Compounds) and also act as a surface for dry deposition of gases, although no account is made of absorption. In the absence of any figures for Hong Kong, US figures for deposition are used in the model. Two model runs were conducted: a base case, and a case where it was assumed there was no deposition on vegetation. The difference was assumed to be representative of the amount of dry deposition on vegetation.

The results in Table 13 below show that while vegetation can account for a significant fraction of the dry deposition of different pollutants (up to 42%) this does not translate to a significant difference in the annual average pollutant concentration. The main reason is that dry deposition overall accounts for a very small fraction of the pollutants in the atmosphere. However, more work is needed to verify the ability of trees and vegetation to act as a sink for pollutants in Hong Kong.

[105]CIA factbook. http://www.cia.gov/cia/publications/factbook/geos/hk.html

[106]This is a 3-D model incorporating meteorological, emission and chemical transformation processes. To predict annual average concentrations of air pollution a number of meteorological scenarios representative of a 'typical' year were simulated and weighted.

Table 13: Results of PATH modeling. Shows quantities of pollutants dry deposited on vegetation and the effect on annual average concentration.

Pollutant	DRY DEPOSITION (TONNES)			ANNUAL AVERAGE (μg/m^3)		
	Base case	No deposition	Vegetation only	Base case	No deposition	Difference
Ozone	4586	2987	1599 (35%)	54.30	55.03	0.73 (1.34%)
Nitrogen dioxide	356	205	151 (42%)	20.00	20.16	0.16 (0.80%)
Sulphur Dioxide	1964	1669	295 (15%)	15.96	16.20	0.24 (1.50%)
Respirable Suspended Particulates	-	-	-	49.31	50.22	0.91 (1.85%)

While the reduction in overall annual average concentrations is still quite small (less than 2% in all cases), it is worth noting that there are few individual air abatement measures that will make an appreciable difference in overall air quality. This is why Government relies on a basket of measures to reduce air pollution.

The Government has pledged HK$1.4 billion for air pollution abatement measures including grants to owners of taxis, light buses and other pre-Euro standard diesel vehicles to switch over to LPG and install particulate traps and catalytic converters. This does not include the costs of land premium foregone at the LPG filling stations or the cost of Government time spent implementing and enforcing these measures. These measures will result in an estimated 80% reduction in total particulates and a 30% reduction in nitrogen dioxide emissions by 2005.[107] This is equivalent to a reduction of 1,724 tonnes of pariculates and a reduction of 2,981 tonnes of nitrogen dioxide.[108]

Deposition on vegetation causes a reduction in pollutant levels equal to 5% of the nitrogen dioxide reduction of the above abatement measures. If we assume that half of the HK$1.4 billion is used for NO_2 reduction (though it is impossible to separate), then the deposition rate on vegetation is arguably worth at least HK$35.5 million.

c. Carbon Sequestration by Vegetation

Hong Kong's terrestrial vegetation acts as a carbon sink, an area that takes up carbon rather than releasing it. Vegetation sequesters carbon for decades as part of trees, plants, detritus and soil. The Kyoto Protocol recognized that, by sequestering carbon, carbon sinks help mitigate global warming.[109] Scientists estimate that natural vegetation sequesters between 10 tones of carbon/ha (for wooded grassland and bush) and 125 tonnes of carbon/ha (for secondary closed forest).[110] However, given the degradation of Hong Kong's soils, 125 tonnes of carbon/ha may be too high.

[107] Tung Chee Hwa (1999). 1999 Policy Address.

[108] Environment & Food Bureau (1999). Expected Effects of Vehicle Emission Reduction Measures as outlined in the reply to a Legislative Council question. Annex. 27 October 1999.

[109] Significant controversy surrounds the extent to which carbon sinks can be used as credits to meet greenhouse gas targets. The 6th Conference of Parties, held in November 2000 in the Netherlands, featured intense discussion about carbon sinks.

[110] Emerton L (1998). Dijibouti Biodiversity: Economic Assessment, October 1998, p. 26. http://biodiveristyeconomics.org/pdf/topics-504-01.pdf

Woodlands and forests cover approximately 20,000 hectares of Hong Kong.[111] Most of Hong Kong is wooded grassland rather than secondary closed forest, so lower rates of carbon sequestration are more applicable. Using an average sequestration rate of 15 tonnes of carbon/ha, Hong Kong's terrestrial vegetation sequesters 300,000 tonnes of carbon per year.

Carbon sequestration has market value because of emission trading programs. In carbon trading schemes, offset projects, including carbon sequestration projects like forest expansion, count as emissions trading credits. These credits can be bought and sold and have a market value.[112] According to some estimates, the global market for carbon dioxide is around US$100 billion per year.[113] Estimates of the economic value of carbon sequestration range from US$1-100 per tonne.[114] In a 1997 study, the World Bank chose a "shadow price" of US$5-40 per tonne for carbon.

Choosing a conservative figure, Hong Kong's carbon sequestration is worth US$10 (HK$78) per tonne. If Hong Kong sequesters 300,000 tonnes of carbon per year, the overall value of carbon sequestration is HK$23.4 million/per year.

There is also potential for increased carbon sequestration. Hong Kong is naturally a forest climate. The dominance of grassland and shrubs is due to the prevalence of hillfires, not ecology. Complete fire control, as currently practiced on Hong Kong Island, would allow current grassland and shrubland to be replaced by forest. A transition from grasslands to forest would increase forest cover by 70,000 ha, increasing carbon sequestration rates significantly.[115] Once again valuing carbon sequestration at US$10 per tonne, potential carbon sequestration is worth an additional HK$385.6 million.[116]

5.3 Indirect Use Values Not Quantified

a. Flood prevention

In many parts of Hong Kong, flooding occurs because of the interaction of tidal and fluvial events – tidal extremes tend to dominate in lower catchments and fluvial events in upper catchments.[117] Of the 25 principal drainage basins in Hong Kong, the Kam Tin and Shenzhen (which includes the River Indus) basins have 45% of the total floodplain and 40% of the recorded

[111]This is equivalent to 20% of Hong Kong's land area. CIA factbook. http://www.cia.gov/cia/publications/factbook/geos/hk.html

[112]Carbon trading is rapidly becoming a reality. In late 2001, the Chicago Climate Exchange (CCE) launched the first voluntary carbon-trading scheme in the United States. Participants from seven US states (Indiana, Illinois, Wisconsin, Michigan, Iowa, Minnesota and Ohio) were issued tradable emissions permits and committed to reducing carbon emissions 5% by 2005. In the third phase of the program, starting in 2004, the scheme will be expanded to include international participants. For more information, please see *Background Paper: Emissions Trading in China—Opportunities and Constraints*. Civic Exchange, October 2001. http://www.civic-exchange.org

[113]Ibid

[114]Emerton L (1998). See footnote 110.

[115]Richard Corlett, Personal Communication, 18 January 2002. This assumes all non-developed land would revert to forest.

[116]This assumes that 70,000 ha of forest sequester 75 tonnes per ha. This would potentially create 5.25 million additional tonnes of sequestered carbon, worth HK$409 million. This is an additional HK$385.6 million over the baseline case.

[117]Mott Connell (1990). Territorial Land Drainage & Flood Control Strategy, Study Phase I & II.

flooding blackspots.[118] The majority of Government's storm drainage expenditure has been in these two areas.

The main cause of flooding is natural floodplain inundation, but this is exacerbated by land use changes, obstruction of natural drainage paths, inadequate drainage provisions, and lack of maintenance of river channels. Land use changes affect flooding by reducing the active floodplain storage, constraining floodplain flow, redirecting the natural drainage, temporarily obstructing drainage during construction, contributing to soil erosion and reducing former drainage gradients following land reclamation. Landfilling for open storage has caused local problems through obstruction and redirection of natural drainage paths.

The method used by Government to evaluate the benefits of flood mitigation measures, is to determine the potential damages which would have occurred in the absence of mitigation at different frequencies of occurrence of flooding, i.e. 2, 5, 10, 25 and 50 year flood return periods. From these figures, the mean annual damages are evaluated and then discounted over the life of flood mitigation measures and compared to the costs of mitigation (see Appendix 3). However, relating some of these damage costs to loss of wetlands is no easy task.[119]

While the loss of wetlands and natural floodplain in the Kam Tin basin has obviously contributed to increased flood damage, no studies have quantified the extent to which landuse changes have exacerbated the situation.[120]

It is generally accepted that wetlands reduce streamflow peaks and increase low flows. The function of wetlands is attributed to their ability to store floodwater during storm events for later release. However, depending on the extent of the wetland, its geographic location, storm intensities and durations and seasons of the year, the influence of wetlands on streamflow may vary greatly with the region as well as with specific wetland type.[121] While studies in Illinois, US have found that both peakflow and floodflow volumes decrease as the percentage of wetland areas increase in a watershed (see Appendix 3 for details), it is difficult to translate these figures to Hong Kong given its particular topography and climate.

In addition to the flood mitigation benefits of wetlands, forests and grasslands also contribute to flood prevention by controlling sediment deposition, which can lead to siltation and flooding downstream. One study calculated the sediment yield reductions that can be achieved by afforestation and improved grassland management in several water catchments in Hong Kong and assessed their cost effectiveness.[122] The combined efficiency of afforestation and improved grasslands management can reduce sediment yields by an average of 45% in the catchments studied.

The study conducted a cost benefit analysis on the value of afforestation and improved grassland management in preventing sedimentation. While it was found that the costs of afforestation

[118]Ibid

[119]Damage costs may be increasing simply due to increased population density in the area, rather than landuse changes per se, although population increases tend to go hand in hand with infilling of wetlands and natural floodplain.

[120]The situation is complicated by the fact that development of fishponds, a major type of wetland, may actually reduce the active floodplain storage. (Mott Connell (1990). See footnote 117).

[121]Ibid

[122]Hyder Consulting Ltd (1997). Territorial Land Drainage & Flood Control Strategy Study Phase III TELADFLOCOSS III. Task 8: Erosion Control and Maintenance Provisions May 1997. Report for Drainage Services Department.

outweighed the benefits in terms of reduced sediment dredging, there was insufficient data to calculate the costs and benefits of improved grassland management.

In another study, afforestation and improved grassland management were looked at as a means to reduce river flows and water levels resulting from a combined 50-year maximum flow and tidal water level. The combined effect is a stream flow reduction of 8-40% for various catchments and resulting reduction of water level of 10-50 cm (see Appendix 3).

More studies are needed to quantify the flood mitigation benefits of wetlands and improved grassland management in Hong Kong.

b. Pollination

There are economic and non-economic values to maintaining diversity in the world's pollinators. Pollinators—bees, butterflies, beetles, moths, ants and flies, as well as birds, bats and geckos—provide enormous value to agriculture and the functioning of natural ecosystems. 80% of the world's 1,330 cultivated crop species are pollinated by wild and semi-wild pollinators.[123] One third of US agricultural output is from insect-pollinated plants. Without pollinators, crops would yield less and wild plants would produce few seeds. In the US, scientists estimate that consumers realize US$1.6-5.7 billion in annual social gains or surplus income that would be lost if honey bee pollination was reduced.[124]

The non-economic value of pollinators is wide-ranging. On an evolutionary time scale, diversity of pollinators helps foster diversity in angiosperms. Pollinators also serve a key role in ecosystems by re-distributing energy-rich foodstuffs and scattering nitrogen-rich waste.[125]

Many plants have developed interdependencies with particular species of pollinators. In Malaysia, the bat *Eonycteris spelea* is thought to be the exclusive pollinator of the durian.[126] The bat's primary food supply is a coastal mangrove that flowers continuously throughout the year. The bats fly tens of kilometers from their roost site to the mangrove stands, pollinating durian trees along the way. However, the mangrove stands are threatened and the bats are unlikely to survive without them.

While Hong Kong does not have any significant agricultural industry, pollinators often travel significant distances. However, only our two fruitbats will commute far enough to be potential pollinators of crops outside Hong Kong and most regional crops are either self-fertililizing or bee-pollinated.[127] Similarly, Hong Kong's most common bees probably have a normal foraging radius of only a kilometer or so from the nest.[128]

[123] Abramovitz J A (1998). See footnote 8.
[124] Southwick and Southwick (1992) cited in Gary Paul Nabhan and Stephen L. Buchman. Services Provided by Pollinators. In Gretchen C. Daily ed. *Nature's Services: Societal Dependence on Natural Ecosystems* (Washington D.C.: Island Press, 1997).
[125] Ibid
[126] Ibid
[127] It is also not clear that there are any bat pollinated plants in Guangdong. Richard Corlett, Personal Communication, November 2001.
[128] Ibid

c. Pest control services

Pests and disease also serve as biological controls that do not have the damaging side effects of chemical pesticides. Bats and birds eat large quantities of leaf-eating insects that can slow the growth of trees or crops.

d. Foreign Direct Investment (FDI)

Hong Kong is a hub of foreign direct investment (FDI) in Asia. According to International Monetary Fund (IMF) accounting standards, Hong Kong received US$64 billion in FDI in 2000.[129] Sustaining a high level of FDI rests on the willingness of foreign firms to invest. More and more, expatriates are indicating that quality of the environment—including conservation measures—influences their desire to live in Hong Kong and do business here.

In one survey of American businesses in Hong Kong 87% respondents agreed that the quality of the environment was either an important or the most important factor for continued investment in Hong Kong.[130] A September 2001 British Chamber of Commerce survey specifically asked about conservation in Hong Kong. 86% of respondents said they were not satisfied with local conservation measures. This dissatisfaction with conservation measures stems from a wider concern about Hong Kong's environment. 79% of British Chamber of Commerce respondents said they were not satisfied with the quality of the environment and 96% were not satisfied with air quality.[131] Respondents to a similar 2001 survey by the Swiss Business Council gave Hong Kong's natural environment a score of 3.83 out of 10.[132]

Conservation is not just a Western expatriate issue. Much of Hong Kong's FDI comes from the Mainland and, more and more, Mainland elites are indicating that the environment matters. Hong Kong people are also increasingly concerned with environmental quality. It is impossible to say to what degree investment is linked to conservation, but conservation is clearly tied to quality of life, an important factor for foreign companies and, increasingly, for local people. 35% of British Chamber of Commerce respondents were critical of quality of life in Hong Kong. In the long run, firms are comprised of individuals. If people do not want to live in Hong Kong, FDI will suffer. Economics and conservation are intimately intertwined.

[129]Using IMF standards is controversial. Many argue that the actual figure is far lower and that US$64 billion only represents capital flow through Hong Kong. (Sabapathy K (2001) Direct Foreign Investment Rises to US $64 billion. ABC Online, 19 June 2001).
http://www.abc.net.au/ra/asiapac/archive/2001/jun/raap-19jun2001-4.htm).
[130]American Chamber of Commerce. 2000 Confidence Survey.
http://www.amcham.org.hk/hongkong/business_outlook_survey.html
[131]British Chamber of Commerce. British Chamber of Commerce Poll of Business Commerce, 21 September 2001.
[132]In contrast, the political environment scored 6.43 and infrastructure scored 7.86. Swiss Business Council in Hong Kong. Results of Business Confidence Survey, October 2001.

6. Valuing the Non-use Values

6.1 Existence Values

Non-use values can be considerably higher than use values. Contingent Valuation surveys, which ask individuals about their priorities, preferences, and 'willingness to pay' in regard to specific issues have been used to estimate both use and non-use values for various environmental commodities. In the US, this has been an increasingly popular method to calculate non-use values, particularly as damages for loss of non-use values can be recovered through law suits.[133]

It should be noted that willingness to pay estimates obtained through Contingent Valuation studies cannot be compared with willingness to pay responses obtained through the conventional attitudinal surveys typically conducted in Hong Kong. Simply asking a respondent how much they would be willing to pay for something in a simple attitude survey is subject to so many biases and caveats as to make the result almost meaningless. A Contingent Valuation survey, on the other hand, is a carefully worded and structured instrument designed to remove bias and ensure a meaningful answer. A proper Contingent Valuation survey costs over US$30,000 and can take six months to conduct.[134]

Most contingent valuation studies have been conduced in the United States, Europe and Australia. In addition, most have been single-species valuation studies. These studies tend to focus on emblematic species, such as the gray whale in the United States or the wolf in Sweden.

Table 14: Single species valuation studies[135]

Author	**Study**	**Mean WTP estimates (per household/year)**
Boman and Bostedt (1995)	Conservation of the wolf in Sweden	700 SEK-900 SEK (~US $3.70-4.86)
Loomis and Larson (1994)	Conservation of the gray whale (US)	US$16-18
Bower and Stoll (1988)	Conservation of the whooping crane (US)	US$21-141

Other Contingent Valuations studies use the natural habitat as the unit of valuation. For example, in the New England region of the US it was found that there was an average willingness to pay of US$74-115 (HK$577-897) per year for five years for wetland protection or conservation.[136] A survey done in Australia, using a similar survey instrument to allow for direct comparison, found an average willingness to pay of US$96 (HK$748), which is broadly comparable.[137] The difference in figures may be related to differences between the economies of the two countries.

In considering reasons for funding wetland conservation, it was noteworthy that 50% of respondents in the New England study and 43% of the respondents in the Australian study cited

[133]Stevens et al (1995) in Streever et al (1998).
[134]Barbier E B, Acreman M and Knowler D (1997). *Economic Valuation of Wetlands: A Guide for Policy Makers and Planners* (Switzerland: Ramsar Convention Bureau). www.ramsar.org
[135]Nunes, Paulo A.L.D., Jereon C.J.M. van den Bergh (2001). Economic Valuation of Biodiversity: Sense or Nonsense? Ecological Economics (39), pp. 203-222.
[136]Stevens et al. (1995).
[137]Streever W J, Callaghan-Perry M, Searles A, Stevens T and Svoboda P (1998). Public Attitudes and Values for Wetland Conservation in New South Wales, Australia. Journal of Environmental Management (54), pp. 1-14.

the need to preserve this resource for future generations. The intrinsic value of wetlands was the second most important reason given followed by personal or human benefit.

Table 15: Other natural habitat valuation studies[138]

Author	Study	Mean WTP estimates (per household/year)
Nunes (1999)	Protection of wilderness areas, Portugal	US$40-51
Richer (1995)	Desert protection in the US	US$101
Brouwer (1995)	Protection of peat meadow land, The Netherlands	Dfl. 28-77 (~US$11.42-31.4)

A few contingent valuation surveys have been done in Asia. In Taiwan, researchers found an average willingness to pay (WTP) of NT$212 (US$6.23) at the Shanping Natural Education area.[139] Over the course of under a year (July 1997-June 1998), there were 19,214 visits, leading to a use value of US$119,703 (HK$933,683) A similar study in Malaysia examined willingness to pay for mangrove protection in Johor State.[140] Totalling the results for 12,650 households in the area, the survey found a WTP of US$40,000/year. The designers of the Malaysian survey chose to present information on biodiversity and the importance of mangroves in the questionnaire. As a result, 62% of respondents said that the questionnaire changed their preferences towards mangrove protection.

A third Asian survey measured how much visitors would be willing to pay to visit Khao Yai National Park in Thailand. The survey showed that WTP was 22 baht while the current entrance fee is only 5 baht.[141] Taken as a group, these surveys show that Asian citizens are willing to pay for conservation.

Table 16: WTP in Asia

Author	Study	Mean WTP estimates (per household/year)
Wang (1999)	Value of Shanping Natural Education Area, Taiwan	NT $212 (~US$6.23)
Baun (1999)	Mangrove protection, Malaysia	US$3.16 per household/year
Panayotou and Deshazo (1995)	WTP for Kaho Yai National Park, Thailand	22 baht (compared to entrance fee of 5 baht)

There is a clear need for a WTP survey in Hong Kong. Policymakers would benefit from a better understanding of the extent to which local people value the environment. For example, a WTP survey would give a better indication of the true value of Country Parks. The travel cost method used here suffers from imprecise data about the number of visitors and the low cost of public transportation in Hong Kong. Both of these factors lead to an artificially low valuation of Country Parks. A more precise valuation of the value of Country Parks—as well as the value of

[138]Nunes et al (2001). See footnote 135.

[139] Wang, Dar-Hsiung, Wang, Pei-Jung and Lin, Cheng-Jung (1999). Economic Evaluation of Recreation Benefits a the Shanping Natural Education Area. Taiwan Journal of Forest Science. December 1999. http://ww.tfri.gov.tw/publish/144-9e.htm

[140]Bann Camille (1999). A Contingent Valuation of the Mangroves of Benut, Johor State, Malaysia. Johor State Forestry Department, June 1999. Note: The survey designers threw out 49% of survey results because they felt that these respondents were not reporting honest WTP, but recording protest votes.

[141]Cited in Isangkura, Adis. Environmental Valuation: An Entrance Fee System for National Parks in Thailand. http:www/eepsea.org/publications/research1/ACFFO.html

other natural resources—would allow for efficient policy formulation that responds to these values.[142]

7. Conservation Costs

In 2000-2001, AFCD spent HK$394.6 million on nature conservation and country parks.[143] This $394.6 million represents the cost of conservation in Hong Kong and must be subtracted from the overall economic value of conservation.

8. Conclusion

This paper estimates that the quantifiable conservation value of Hong Kong's natural resources—its marine ecosystem, its woodlands, its country parks—are worth as an absolute minimum between **HK 1.8 billion and 6.5 billion** annually.

This does not mean that Hong Kong's natural resources could be replaced by 6.5 billion dollars deposited in a bank account. In fact, our attempt to assign monetary values to nature does not imply that conservation should be driven by economic values alone or even at all. Just because we can put a market value on something as intangible as an ecosystem's water cycling functions, or a rare species, does not mean that this dollar amount represents its total value. Unique landscapes, endangered animals and irreplaceable ecosystems are priceless.

In addition to the moral and aesthetic reasons for nature preservation, nature conservation yields economic benefit. This paper shows that Hong Kong decision-makers need to stop valuing nature at zero dollars. Nature provides both direct use benefits, including fishing and ecotourism, and indirect use benefits, including pollution absorption, watershed protection and flood mitigation. In some cases, as with foreign direct investment and ecotourism, nature conservation could significantly affect Hong Kong's GDP.

This paper also highlights the need for further research. This report relies on secondary sources and there is clearly a need for primary local research. To cite two examples, a Hong Kong Contingent Valuation survey and improved data on pollution uptake by Hong Kong urban trees would both be valuable. Researchers should also consider expanding their scope of research to include the entire Pearl River Delta region. Hong Kong is part of a larger, regional ecosystem and scientific work needs to be done with a regional scope as well as a local one. In Hong Kong, environmental economics is still a young field and there is much work to be done. It is hoped that this paper will stimulate further exploration.

[142]WTP surveys can also serve as a public education tool by raising awareness of environmental issues.
[143]This is an AFCD estimate. It compares to HK$394.4 million spent in 1999-2000. HK$394.6 million may also be an underestimate. Other departments besides AFCD may indirectly spend money on nature conservation.

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LC Ng, Scuba Network
David Nowak, United States Forestry Service
Keith Noyes
David Robinson, Fragrant Harbour
Stuart Sharpless
Ellen Shek, World Wide Fund for Nature
Brian Shutes
Lynne Smith, Binnie Black & Veatch
Richard Barton Smith, Hong Kong Mountain Biking Association
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Appendix 1: Economic Valuation Techniques[144]

Direct Cost Estimates

Definition:	Estimation of actual expenditures required to mitigate at least in part the effects of or to prevent some form of environmental damage
Advantages:	1) Provides market-based estimates 2) Relatively reliable 3) Sometimes easy to estimate
Disadvantages:	Gives only a minimum indication of the value

Hedonic Pricing

Definition:	Examination of market transactions for indications of the willingness to pay for (or be compensated) for differences in environmental conditions
Advantages:	Provides a market-based estimate of how much people are willing to pay for an environmental benefit
Disadvantages:	1) Fails to take consumer surplus into account 2) Estimates may be q questionable due to problems with insufficient disaggregation of data and confounding factors

Contingent Valuation

Definition:	Estimation of willingness to pay (or be compensated for) differences in some feature of environmental quality
Advantages:	Potentially provides an estimate of the full value of an environmental Benefit
Disadvantages:	Potential for uncertainty about the honesty and accuracy of the responses

[144] Adapted from Barron W, Perlack R and Boland J (1998). See footnote 18.

Appendix 2: Travel Cost Method

Many studies have been conducted in North America and Europe on the economic benefits derived by visitors to National Parks and other recreational sites. The methods generally adopted by Government agencies in the US and UK are based on travel costs, an indirect method of valuation that uses travel expenditure in getting to the site as a surrogate for the price paid by that visitor for use of the site.

The basic definition of travel cost adopted[145] is

$TC = 2 [t + (j * w * o)] + c$

Where TC = travel cost
t = transport costs incurred in travelling to the conservation facility
j = journey time to the conservation facility
w = average household hourly wage
o = opportunity cost of time parameter = 0.33
c = amount respondent spent while in the conservation facility (excluding travel costs)

The opportunity cost (value) of time spent visiting conservation facilities has been estimated by using 33% of the individual wage rate as a proxy.[146]

A value of HK $80 for w, based on the average hourly wage for clerical workers, was adopted for all travel cost calculations used in this study, except for the potential travel costs of overseas hikers and students. For overseas visitors, w was HK$150 based on the assumption that most overseas visitors are professionals. For students, w was $40, one-half of the adult wage rate.

[145] Adapted from Liston-Heyes and Heyes (1999) where transport costs are substituted for petrol costs divided by the size of the respondents party. This is due to the fact that a relatively small proportion of visitors use cars to visit Country Parks in Hong Kong.

[146] 33% is often chosen as a good rule of thumb, especially in North American studies. The US Department of Transport recommends 43%. See Liston-Heyes C and Heyes A (1999). Recreational benefits from the Dartmoor National Park. Journal of Environmental Management (55), pp. 69-80.

Appendix 3: Flood prevention

Flood Damage Costs

Historic flooding records in Hong Kong are poor, with few available records prior to the May 82 flood. Flooding associated with Typhoon Brenda (July 88) and Typhoon Warren (May 89) was well documented. It appears that while the frequency of flood events is no worse than before, the impact is greater due to land use change and increased population density.

Flood damage costs associated with inundation of agricultural land, damage to household contents and property, and increased traffic costs associated with traffic delays due to flooding were calculated for the three flooding events in the Kam Tin Basin. The table indicates that flood damage from the three events totaled HK$41.6M (1989 prices).

Table 1: Historic flood damages, Kam Tin Basin (1989 prices)[147]

Area affected (ha)	1982	1988	1989
Cultivated	470	76	101
Fishponds	125	41	64
Other	455	60	113
Total	1050	177	278
Damages (HK$M)			
Property	2.7	2.3	2.8
Agriculture	15.2	2.2	6.2
Traffic	2.8	2.8	4.6
TOTAL	20.7	7.3	13.6

Government studies have calculated flood damage costs for different flooding events and the damage that would be mitigated by flood protection. Table 2 shows that annual average damages of HK$10.3 million. For a 50-year return period, this translates into present value benefits for flood protection of HK$181 million (at a 5% discount rate over 50 years).

Table 2: Flood damage – frequencies (Kam Tin HK$M)[148]

Return period	Damage mitigated	Mean annual benefits	Present values @5%	Present values @10%
2	10	2.5	46	25
5	16.6	6.5	119	64
10	18.5	8.3	151	82
20	21.5	9.3	170	92
50	23.6	9.9	181	98
100	25.3	10.2	186	101
200	27.7	10.3	188	102

Benefits of tree cover in flood mitigation

Hillfires are probably the most important cause of erosion in Hong Kong.[149] Between 1976-1992, 5.3 million seedlings were planted in the Country Parks. Over 3.4 million trees were burned in the same period. Assuming a 60% survival rate of planted trees, burning would have outstripped planting. Outside country parks the Territory Development Department (TDD) planted over 8.6 million seedlings between

[147]Mott Connell (1990). See footnote 117.
[148]Ibid
[149]Hyder Consulting Ltd (1997). See footnote 122.

1996 and this year.[150] Given the large number of hillfires outside country parks it is likely that many of these seedlings would also have been burnt. Although grasslands generally provide good protection against erosion, most grasslands in Hong Kong provide meager protection to the soil due to frequent burning and high erosion rates. It is estimated that any grassland area in Hong Kong is burnt once every two years[151]. While this figure may be something of an overestimate, grasslands in Hong Kong certainly experience frequent and unnecessary hillfires.

Table 3: Number of hillfires in Hong Kong over last 5 years

Year	No. hillfires in country parks[152]	Area affected (ha)	No. hillfires outside country parks[153]
1996/97	89	956	2664
1997/98	54	250	1773
1998/99	180	1575	2094
1999/2000	105	629	3079
2000/2001	58	158	1469

One government study calculated the annual average sediment yields originating from natural erosion in a number of different catchments. The changes in notional erosion rates resulting from landuse changes were then used to recalculate erosion rates.

Table 4: Reduction in sediment erosion rates due to afforestation and better grassland management[154]

Mitigation measure	Erosion rate before mitigation ($t/km^2/y$)	Erosion rate after mitigation ($t/km^2/y$)	Area affected by mitigation in various catchments (km^2)	Total sediment reduction (t/y)	Percentage Sediment reduction yield (%)
Afforestation	2000	350	7.34 (less than 2.5% of catchments)	3020	9 (average) 58.8 (highest)
Better grassland management	750	375	124		35.6
Combined afforestation and grassland management					44.6 (33-72% range)

Table 4 shows that afforestation can reduce sediment yields in some catchments by nearly 60%, although the average was 9%. However, it requires 25 years to reach this reduction level. For grasslands, the results are more immediate and results in sediment reduction yields of 36%. The combined efficiency of afforestation and improved grasslands management can reduce sediment yields by an average of 45% in the catchments studied.

In an earlier study, afforestation was looked at as a means to reduce river flows and water levels resulting from a combined 50 year maximum flow and tidal water level.[155] The calculations were based on the assumption that 50% of the non-forested upper catchments would be afforested. The results showed that afforestation could reduce flow by an average percentage of 20.3% with a range of 3-45.6% for 5 river

[150]Territory Development Department (TDD), Personal Communication, October 2001.
[151]Hyder Consulting Limited (1997). See footnote 122.
[152]AFCD, Personal Communication, September 2001.
[153]Fire Services Department , Personal Communication, October 2001. No data is kept on area affected.
[154]Hyder Consulting Ltd (1997). See footnote 122.
[155]Mott Connell (1990). See footnote 117.

basins (Tin Shui Wai, Yuen Long, San Tin, R Indus and R Ganges). The reduction of water level averaged 0.28 m (with a range of 0.04-0.58 m).

With improved grassland management, flow reductions of between 6-20% can be expected. The combined effect is a stream flow reduction of 8-40% for various catchments and resulting reduction of water level of 10-50 cm.

The study conducted a cost benefit analysis on the value of afforestation and improved grassland management in preventing sedimentation. The costs were based on afforestation costs of HK$26/$m^2$, or HK$26M/km^2 which were annualized over 50 years. There were no equivalent costs for improved grassland management. The costs saved by not dredging were based on the amount of reduction in sediment calculated per catchment.

Table 5: Quantification of potential costs and benefits of afforestation and improved grassland management in reducing the need for sediment dredging (1997 costs)[156]

	Afforestation	Improved grassland management
A. Area to be reforested/managed within the catchments studied (km^2)	7.34	124
COSTS		
B. Afforestation costs (HK$/$km^2$)	26,000,000	Not known
C. Annualized costs over 50 years (10% discount rate) (HK$/$km^2$/yr)	2,622,339	Not known
D. Total cost (HK$/yr) (A*C)	19,247,968	Not known
BENEFITS		
E. Costs of dredging sediment (HK$/ton)	66.67	66.67
F. Total sediment reduction after reforestation/grassland management (tons/yr)	3020	12001
G. Total sediment costs avoided (HK$/y) (E*F)	201,343	800,106
BENEFIT/COST RATIO (G/D)	0.01	Not applicable

[156]Hyder Consulting Ltd (1997). See footnote 122.