ELSEVIER

Ecological Economics 39 (2001) 347–359

ECOLOGICAL ECONOMICS

www.elsevier.com/locate/ecolecon

ANALYSIS

Ecosystem appropriation by Hong Kong and its implications for sustainable development

Kimberley Warren-Rhodes [a,b,*], Albert Koenig [b]

[a] *NASA-Ames Research Center, MS 245-3. Moffett Field, CA 94035, USA*
[b] *The University of Hong Kong, Department of Civil Engineering, Pokfulam Road, Hong Kong SAR, Hong Kong*

Received 29 September 2000; received in revised form 2 April 2001; accepted 4 April 2001

Abstract

The Hong Kong Special Administrative Region is a highly developed modern city where technical and economic advances have made it possible to support 7 million people on 120 km^2 of built-up land, resulting in 58 000 people per km^2, one of the highest population densities in the world. This population depends on a continual supply of materials, energy and information to function, and these resources are mainly supplied from outside Hong Kong's own geographical boundaries. The ecological footprint (EF) of Hong Kong due to its direct and indirect consumption of renewable resources and waste generation is presented. Additionally, the paper traces the spatial patterns of Hong Kong's EF and examines the implications of this ecosystem appropriation. The study finds an EF for Hong Kong of about 6 ha per capita, with the largest appropriation occurring for marine ecosystems. If the impacts of fish farming are included, Hong Kong appropriates a marine area nearly 2000 times its own built-up city area. Current resource consumption and waste generation patterns in Guangdong, China — where much of Hong Kong's terrestrial ecosystem appropriation occurs — are also discussed.

Keywords: Ecological footprint; Ecosystem appropriation; Hong Kong, China; Guangzhou; Pollution

1. Introduction

The Hong Kong Special Administrative Region (SAR) is a dense, highly developed metropolitan area in southern China. Hong Kong supports 7 million people on as little as 120 km^2 of built-up land (excluding open space and vacant development property) with one of the highest population densities in the world (58 000 people per km^2 built-up land).

Like other cities, Hong Kong requires productive ecosystems for food, water and other basic necessities (Newcombe et al., 1978; Boyden et al., 1981). While Hong Kong supplies some of these requirements, it depends heavily upon ecosystems outside its own borders for resources and waste

* Corresponding author. Tel.: +1-650-6040489; Fax: +1-650-6046779.
E-mail address: kwarren-rhodes@mail.arc.nasa.gov (K. Warren-Rhodes).

0921-8009/01/$ - see front matter
PII: S0921-8009(01)00194-X

assimilation. The concept of an ecological footprint (EF), as articulated by Rees and Wackernagel (1994), Wackernagel and Rees (1996), Folke et al. (1997), provides a quantitative (albeit static) measure of this use, or appropriation, of external ecosystems and their resources. An EF reflects not only the direct impacts of food and material consumption, but also the indirect, or 'hidden,' ecosystem support required to sustain a city's population (Folke et al., 1997). By making this support explicit, an EF enables policy-makers and consumers to visualize, measure and compare their city's environmental impact and appropriation of other areas' resources and ecosystems. Such comparisons have been carried out for a number of countries and regions (Wackernagel et al., 1999a,b), most recently in the World Wide Fund for Nature's (WWF) Living Planet Report (World Wide Fund for Nature, 2000).

In this paper, we estimate Hong Kong's direct and indirect ecosystem appropriation and environmental impacts from resource use and waste discharges. The paper's main objective is to present a new dimension in EF methodology: identifying the spatial patterns of environmental demands through ecosystem appropriation. In order to do so, the paper first estimates the area of agricultural land, marine ecosystems, and forests appropriated (the 'EF') by Hong Kong for annual wood, fiber, paper, water and food consumption, and assimilation of CO_2 emissions. We then analyze the location from which some parts of the EF (e.g. certain food items and drinking water) are appropriated or to which certain pollutants (e.g. nitrogen) are discharged. Finally, we compare the EFs and consumption patterns of Hong Kong with its neighbor, Guangdong Province, China.

2. Estimates of ecosystem appropriation by Hong Kong

Hong Kong depends almost exclusively on imported goods from around the globe to feed, clothe and house its population. Our calculations show each Hong Kong citizen appropriates about 3.7 hectares (ha) of terrestrial and marine ecosystems for renewable resource consumption annually, depending on an area over 2200 times its built-up land to support themselves (Table 1). When the assimilation of CO_2 emissions from fossil fuel use is taken into account, Hong Kong's footprint increases to about 6 ha per capita (5–7 ha per capita, depending on the sequestration conversions applied). The supply of seafood to Hong Kong requires the largest ecosystem appropriation (65% of the total, excluding energy use), with an EF of nearly 160 000 km^2 of sea required. This marine area equates to about 90 times Hong Kong's total sea area or 145 times total land area (1700 and 1100 km^2, respectively), or nearly 1450 times its true city area (i.e. built-up land). Agricultural land (i.e. arable land and pasture) and forest appropriated for food and wood, and paper consumption, contribute 29 and 6% of Hong Kong's total EF (excluding energy use), respectively (Fig. 1).

The EF calculated for a city can vary depending on the accuracy of the underlying statistical data, scope of analysis, and productivity yields applied. For the estimates shown in Table 1, a variety of data sources were consulted and compared.[1] Because our main goal was not to repeat other workers' EF calculations for Hong Kong

[1] Data on food consumption and agricultural productivity yields were taken from the Food and Agriculture Organization (FAO) statistical databases (http://www.fao.org/FAOSTAT) as well as those employed in the WWF Living Planet Report (World Wide Fund for Nature, 2000). Population data, waste generation rates, and production and trade figures were obtained from statistical yearbooks and website databases (http://www.info.gov.hk) published annually by various Hong Kong government organizations, including the Hong Kong Census and Statistics Department (HKCSD), Environmental Protection Department (EPD) and Agriculture, Fisheries and Conservation Department (AFCD), or from the departments directly. All data for Guangzhou were supplied by the Guangzhou Environmental Protection Bureau (EPB) or various statistical yearbooks. Because data availability varied, the results may reflect different years, as indicated throughout the paper. We calculated and compared the food, seafood and fiber components of the EF based on data sets for apparent consumption from (i) FAOSTAT and (ii) detailed trade statistics from HKCSD and AFCD. We also varied the global and local yields given in FAOSTAT with those cited in the WWF Living Planet Report (World Wide Fund for Nature, 2000) for comparison purposes. For details, see the notes accompanying the tables.