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# Environmental Resilience and the Metabolism of Peripheral Settlement in an American Metropolitan Area

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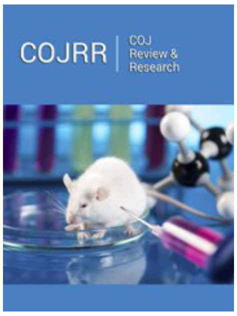


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## Introduction

In the current Anthropocene Era environmental, resilience can be defined as the capacity for urban settlement to withstand and/or recover from negative settlement environmental impacts [1]. This in turn relates to the metabolism of the settlement, particularly with regard to various embodied flows of water, energy and material stocks measured in metric tons per year or similar and directly attributable to the settlement. In this research, stock-flow models were devised using available data characterizing the metabolism of various domains of human co-existence [2]. These included peripheral settlement in metropolitan regions, such as the Dedham, Westwood and Norwood area of Boston in the United States. Flows were then represented emanating from sources in the geosphere, biosphere and hydrosphere of natural circumstances through the production of materials and other physical settlement resources and on to uses and then waste disposal, including recycling [3]. From this 'cradle-to-end use' description major vulnerabilities to resilience became readily apparent, including excessive paving, material consumption and waste. Amelioration of the vulnerabilities could then be identified and remodeled with regard to improvements through technological and urban design interventions.

The Dedham, Westwood and Norwood area under study was defined by three zip codes and census tracts. It is located on Route 128 encircling the periphery of Boston as part of the World War II Federal Highway Program [4]. It has an area of some 83,000 square kilometers and a population of some 28,000 households. It also embraces sensitive natural environmental areas within the Neponset River Watershed and is otherwise comprised of patches of mainly single-family residential development and pockets of commercial and industrial use, usually adjacent to Route 128.

With regard to water consumption, 21 percent is derived from surface water and 79 percent from ground water sources underlaying the area. Distribution among users was 40 percent for commercial, including some municipal and related uses, although a further 18 percent was from street cleaning and use by the municipal Fire Departments. Some 14 percent of consumption accrued to residential use, mainly through household appliances and another 15 or so percent went to industrial use. Energy use involves 43 percent in petroleum, 37 percent from natural gas and only about 9 percent from renewables. The remaining 12 percent was imported from out of state. Consumption by residential activity was 32 percent with 29 percent from commercial use and about the same proportion again for transportation and 11 percent in industrial use. Perhaps understandably within this mixed climate, residential heating was the single biggest area of consumption and, of course, fully 59 percent of the transportation energy used was directly from petroleum. At 67 percent, the majority of material flows were drawn from the geosphere in oil-based material, metal and other mined materials, with 23 percent from the biosphere primarily in lumber, particularly for typical stick-built housing, and 10 percent was drawn from the hydrosphere. In terms of use, fully 42 percent was in the composition of roads, streets, parking lots and other paved areas. This is a very high proportion though perhaps understandable given the inherently automobile dependent form of settlement. A further 35 percent went into residential construction and 21 percent in commercial and other uses. With regard to the waste stream, some 36 percent was recycled, 25 percent was composted and almost 40 percent was disposed of without any form of recycling including land filling.

In the recycled version of the water flow model, 57 percent of the original wastewater was returned, reducing the extraction of both surface and ground water, even though Boston is not a water stressed area. This did, however, suggest a reduction in necessary infrastructure. Improved conditions for energy consumption could be achieved in several ways. This included use of electrical vehicles, with much of electrical power coming from hydro sources. It also included substantial gains from heating and cooling using geothermal resources and solar panels, as well as increased residential densities using buildings on sites already served by paved surfaces. Plans were also imagined where excessive paved areas were converted to greenways integrated back into adjacent or neighboring forested preserve areas. Modeling indicated that these measures could reduce energy consumption by as much as 50 to 60 percent. Overall, through the stock-flow re-writing, so to speak, of existing development, targets of opportunity for better environmental performance in peripheral settlement could be identified. Currently, further work is being dedicated to improving both the input and output functions of the current models, as well as improving the aging capabilities of especially the material flows over time. Also on the agenda is a better and more nuanced description of life-cycle aspects of constructed environments, as well as more complete documentation of modeling and data processes.

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