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Resource Management in the Urban Sphere: Ambon's Urban Environment

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A preliminary foray into recent research on physical environmental conditions in Kota Ambon, reveals disturbing trends of ecosystem degradation and decline in quality of life for urban residents. Rapid population growth and urbanization activities have taken a massive toll on Ambon's coastal environment, and in turn, environmental degradation is progressively undermining the quality of life of Ambon's urban residents.

1 Introduction

Ambon, as much of Maluku, was once blessed with a diversity, abundance and beauty of natural resources: clear blue waters, abundant marine life, beautiful beaches, breathtaking coral reefs, pearls, and tropical forests. The coastal city of Ambon once possessed great charms: in fact "Ambon Manise" "Beautiful Ambon" is the nickname attached to the city to describe its surrounding natural beauty. As the dominant geographical feature, Ambon Bay provides the focal point for Ambon and its activities. The noted nineteenth century biologist Alfred Russel Wallace (1869) wrote glowingly of his first encounter with this bay and its surrounds:

> ...the clearness of the water afforded me one of the most astonishing and beautiful sights I have ever beheld. The bottom was absolutely hidden by continuous series of corals, sponges, actiniae and other marine productions, of magnificent dimensions, varied forms and brilliant colours ... For once the reality exceeded the most glowing accounts I had ever read of the wonders of a coral sea. There is perhaps no spot in the world richer in marine productions, corals, shells and fishes than the harbour of Amboyna.

At the time of Russel's visit, Ambon had been an established center of trade and commerce for over two hundred years with a population of approximately 8,500 people. It was an appealing settlement, with clear waters, beautiful reefs, forested coastline, abundant rivers and sandy beaches. Although the city was experiencing economic decline in the aftermath of the failed VOC clove monopoly, it remained a bustling center of local trade. Passing through in the late 1880s, Forbes (1888) commented:

> Amboina is one of the most salubrious of towns. It is situated on a long, river-like arm of the sea and encircled by verdure-clad slopes to which shady, arbour-like roads lead from the centre of the town. Along the shore are stores, factories and the dwellings of the (traders), and beyond these ...European dwellings, Fort Victoria, and the elegant mansions of ...Chinese and Arabs. ...[T]he marketplace ...is exceedingly picturesque. The booths form a square in whose centre a great tree spreads its giant arms.

Forbes also remarked on the abundance of sago houses and sago plants, and the absolute reliance of local people on sago as a daily food staple. She also marveled at the variety of fish in Ambon's market and the abundance of native birds, deer and cuscus around the city (p. 89).

Today one finds a landscape greatly transformed. Ambon Bay is severely degraded—its polluted waters laden with silt, algae and solid waste; its now-remnant reefs badly damaged; its sea-grass beds degraded and its once-abundant fish populations on the decline. In adjacent land areas, extensive de-vegetation and coastal construction have taken a heavy toll on wetlands (especially areas of mangrove), caused beach loss, and accelerated processes of erosion and stream sedimentation in all watersheds above Ambon Bay.

Amidst this setting reside an estimated 350,000 citizens of Kotamadya Ambon, most of whom are poor and whose quality of life is diminished by frequent flooding, earthquakes and landslides, polluted air and water, crowding and lack of sanitation. Government statistics show that annually tens of thousands of residents suffer from maladies linked to inadequate living environments, including respiratory ailments, skin diseases,

diarrhea and other gastrointestinal ailments, and parasites. Despite ongoing efforts by government and local people themselves to manage the urban environment, Ambon's problems continue to worsen.

Although limited historical information about Ambon's urban environmental conditions exists, narrative evidence and recent scientific research suggest that most of this degradation is fairly recent in origin. For example, a local university source (Anon 1997) described changes in Ambon's environment since 1966:

> The shoreline around Ambon is much different than it was 30 years ago. Places where school children and families used to go are no longer beautiful or good for recreation. The beaches that were once sandy are now silted over, or else so polluted with trash and sewage that no one wants to go there. The water that was once bright blue-green is now cloudy gray, turning red after a storm. You can't see the corals anymore. There also used to be many trees along the shoreline, including mangroves and swamp trees full of birds. Now its difficult to find a beautiful place on Ambon Bay. The panorama are obscured with houses, factories, abandoned boats and lots of rubbish. . . . Besides the issue of lost beauty, the destruction of the environment also means lowered productivity of fisheries and lost tourism opportunities. Fisheries in Ambon Bay have been on the decline for years now. 25 years ago it was easy for local fishermen to catch fish in the Bay. Now the fish are fewer and fewer.

Because insufficient historical data exists, it is nearly impossible to draw direct comparisons between current urban conditions and those of the past century. However, there is emerging a solid and growing body of literature concerning the ecology and management of Ambon Bay which includes considerations of past environments and present trends. Recent oceanographic, biological and geological research findings suggest that since the 1970s the rate and extent of environmental degradation has been accelerating. The literature also suggests that while Ambon's environmental problems stem from multiple sources—including urbanization,

agriculture and shipping—it is urban-related activities which presently contribute the majority of impacts.

This literature also indicates that serious damage has already been caused. Indeed, the current regional spatial plan for Maluku (*Pemerintah Propinsi Daerah Tingkat I Maluku 1992* III, 43) acknowledges:

> Ambon has developed very quickly . . . meanwhile the supportive capacity of the land area affected is relatively lacking. The entire area of Ambon's two bays (Ambon Bay and Baguala Bay) have been designated a critical area. These areas face environmental problems that have already achieved a critical level. (Human) activities have degraded water quality, increased erosion and sedimentation and exacerbated flood conditions in Kotamadya Ambon, and caused degradation of the highly productive Ambon Bay. (author's translation)

Yet, typically, this document contains no provisions for creating and implementing remedial steps, including disseminating basic environmental information to local people and urban managers. While provincial authorities recognize that serious environmental problems have arisen, government is poorly equipped to deal with them. In general, Ambon's urban planners and managers have tended to operate along sectoral lines and/or within the scope of single projects, and always within limited means. Stemming the current rate of degradation will require an integrated approach which addresses the full range of sources and actors involved, as well as a fuller understanding of the biophysical setting itself—and the present changes being brought to bear upon it.

This paper addresses the latter concern—focusing on environmental changes that have occurred as a result of the urbanization of Ambon—drawing from recent scientific and other literature. An overview of the city's biogeophysical environment, past and present, is followed by a summary of recent research pertaining to Ambon's coastal urban environment. This literature survey is by no means exhaustive. Nor is any attempt made to analyze the full array of social, cultural, economic and political factors which together shape the urban environment and its activities. Rather the primary aim is to provide a broad brush picture of

the condition of Ambon's urban environment and to begin to illustrate some of the complex interdependencies between the various factors involved in urbanization. To the best of this writer's knowledge, none of the research outlined in this summary was conducted under the aegis of urbanization studies; nor has this literature been previously compiled as a piece. The hope is that such a compilation will serve as a starting point for those who wish to pursue urban management from an integrated coastal and environmental perspective.

2 Ambon's Biophysical Environment

The city of Ambon is located on the small island of the same name (Figure 1). Ambon island measures 761 square kilometers, of which about 310 square kilometers—or roughly 41 percent—is presently designated as the metropolitan district (Kotamadya) of Ambon. Given its size and the fact that virtually all its land areas drain to the ocean, the island may be thought of as coastal zone in its entirety. The coastal zone is a particularly useful concept in thinking about the urbanization of Ambon because of the critical importance of ocean resources to its inhabitants. The coastal zone is an area of intense activity—an area of interaction between biological, geological, hydrological, social, cultural and economic processes. It is made up of interlinked systems—terrestrial, marine and riverine—and thus changes in any part of a system may have far reaching impacts throughout the chain.

Positioned near the equator at 3 degrees 42 minutes south latitude, Ambon has a hot, humid monsoon climate with high rainfall. Like many other coastal tropical environments, Ambon possesses unique and often fragile ecosystems, generally erodible and often unstable soils, and distinct hydrological and meteorological characteristics.

2.1 The Natural Environment

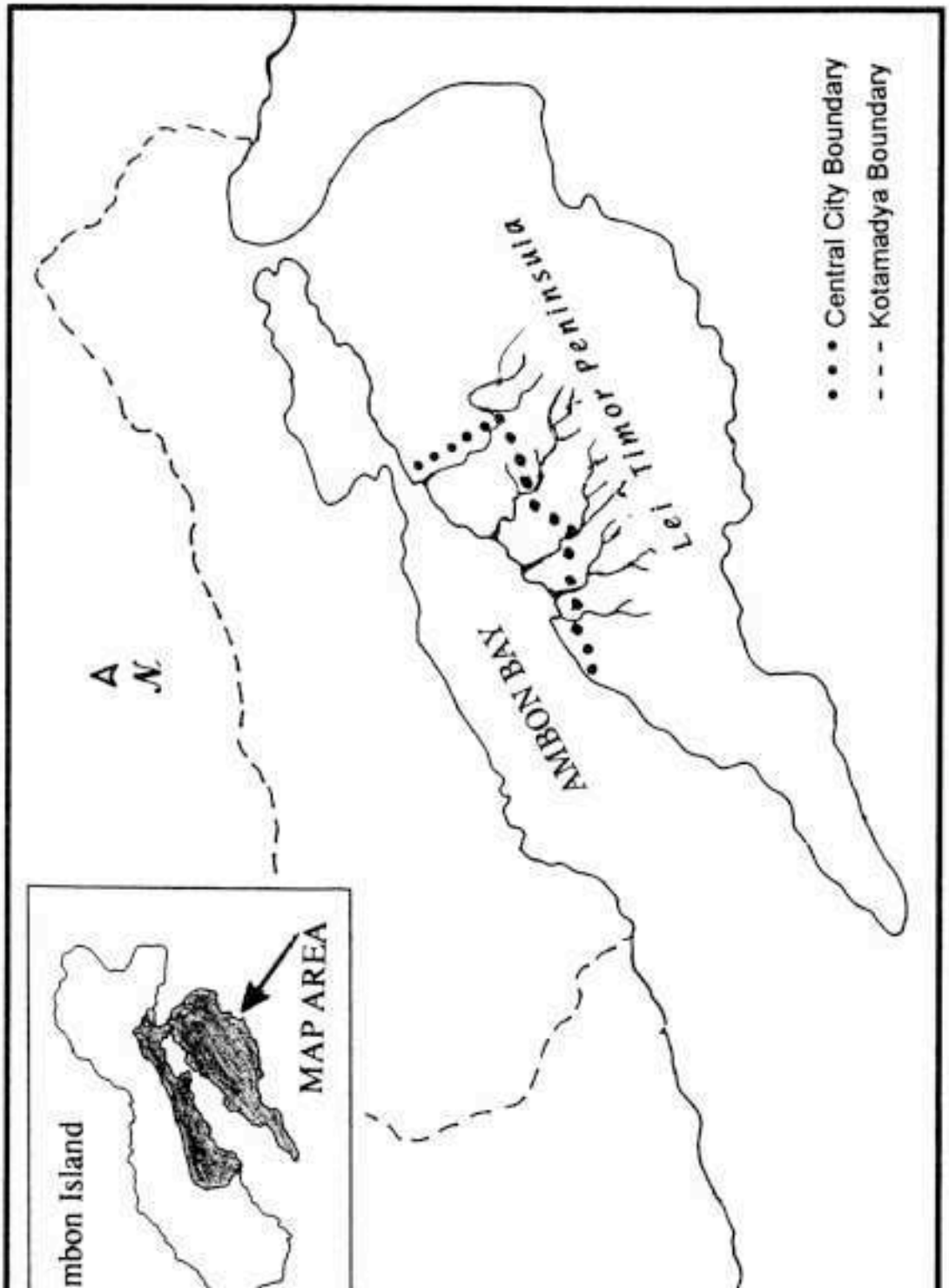
To a large extent the geology and topography of Ambon influences local environmental conditions and patterns of human settlement. Ambon lies in an area of intense tectonic activity and is geologically young, having been recently uplifted, and is still experiencing relatively rapid rates of erosion. Ambon Island was formed by the collision of two separate

islands, resulting in two linked peninsulas (Lei Hitu and Lei Timor) with a deep, narrow bay (a tectonic valley) between them. The geology underlying the urban area is complex, but briefly put, the oldest rocks of the peninsula are Jurassic and Triassic sedimentary rock (sandstones, shales, limestones and conglomerate) mixed with later (Mesozoic) intrusive ultrabasic rocks. Above these are found volcanic rocks and/or layers of coral limestone (raised coral reefs) about 100 meters in depth. Continuing activity imparts a vulnerability to Ambon, as the city is subject to numerous seismic hazards including eruptions, earthquakes, tsunamis and landslips.

The urban center of Ambon is built mainly upon narrow coastal floodplain and adjacent hilly bench areas along Ambon Bay, approximately midway along the Lei Timor Peninsula. Spontaneous settlement at its periphery and along upper watershed areas has enlarged the urban area considerably. Serious erosion is now widespread in the areas behind the city. The soils of the upper hilly bench areas of Ambon where about 55 to 75 percent of Ambon's residents reside are generally erodible and unstable, particularly when denuded (RePPProT 1989, Ongkosongo 1991). Frequent seismic activity also causes landslips in the watersheds behind the city. The lowland areas of the central city are built upon alluvial fan deposits (sand, pebbles, and clays) (Tjokrosapoetro et al. 1994) and fill. These areas are subject to flood, while the plasticity of the underlying sediments increases susceptibility of buildings to earthquake damage.

According to Rahmat (1997) the geology of the island creates difficulties for groundwater collection and conservation. The upper layered rocks of the peninsula have low permeability, resulting in extremely slow rates of groundwater recharge, and high losses to surface streams as water moves laterally through layers. Thus, the rate of groundwater withdrawal by humans may easily surpass the rate of recharge, resulting in a deficit. Historically the majority of Ambon's inhabitants have obtained drinking water from surface sources (rivers) and from shallow wells which tap a thin freshwater lens along the shoreline. In the latter instance the majority of wells occur in a zone of mixing, where shallow layers of freshwater intermingle with sea water. Withdrawal of water from these areas over time has resulted in the increasing salinization of coastal lands and local water sources.

Figure 1: Kotamadya Ambon



Rivers are a main feature of Ambon City. Five rivers transect the central urban area and flow into Ambon Bay. All of these have common topographic and geologic characteristics, that is, they start in the upper ridges and flow from steep mountainsides, to hilly plateaus, and finally through alluvial lowlands to Ambon Bay. These streams in natural state are short and narrow, beginning in steep upper reaches with wide deltas below. As in many other tropical environments, the rivers are typically flashy; that is, flows tend to fluctuate quickly between scant flows and fast moving, full-to-capacity flows. With annual rainfall in excess of 3000 millimeters per year, the steep upper gradients fill quickly in tropical storms and large volumes of sediment—as much as 539.3 tons per hectare annually—wash down the slopes and quickly overload river mouths and enter the Bay (Louhenapessy 1996). When these estuarine systems are additionally burdened by urban activities such as shoreline filling, land clearing and solid waste dumping, the result is increased flooding.

According to Wahono and Lok (1990) the "original" (pre-human occupation) condition of this site was coastal wetlands populated with mangrove and other hydrophitic plants; lower slopes with mixed riparian and other vegetation (heavy cover of trees, shrubs, grasses and herbs); and dryland forest in the upper regions. Today virtually the entire urban area has been denuded, from the shoreline to the mountains, with scattered remnants of forest remaining in upper slopes and along riparian areas. The city's most precious commodity is space, as evidenced by a lack of trees and by dense settlements of the poor packed along riverbanks, on steep slopes and along the shoreline of the central urban area. Only very limited tree planting and gardening occurs in the city, and a survey of vegetation revealed mostly introduced species. Above the city, forested watersheds are designated by law as preservation areas and efforts to regenerate forest areas at the fringes of the metropolitan area have been made. Nonetheless, rates of incursion and forest loss continue to outstrip those of regrowth as pressures on land increase.

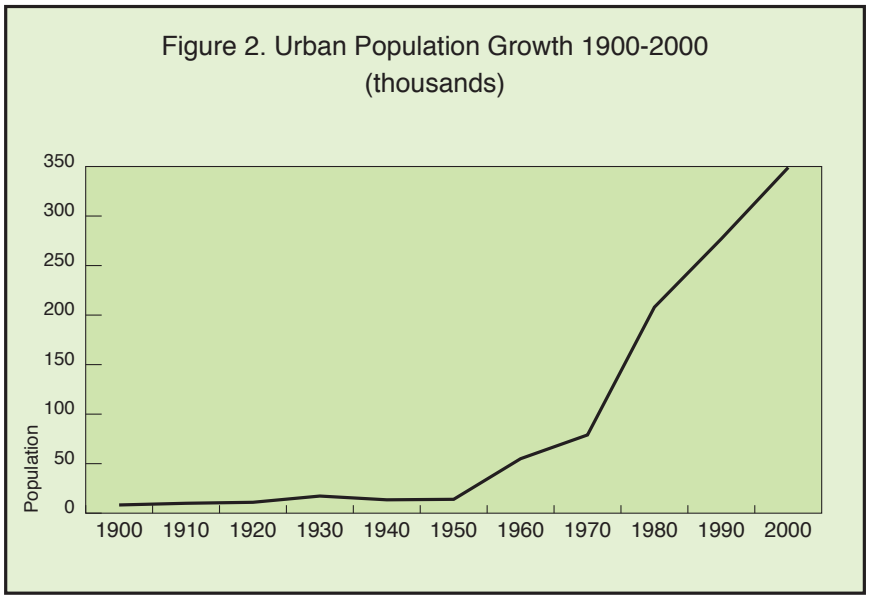
Maluku is known to have some of the most extensive reefs and highest coral diversity in Indonesia. Ambon Bay possesses coral reefs and other important marine ecosystems, most of which are very sensitive to environmental changes, and all of which have been altered by human activities. Fringing coral reefs support a high diversity of animals and

plants and protect coastlines from wave erosion and tsunamis. Seagrass beds and algae (seaweed) beds are highly productive ecosystems which function as nursery grounds for many juvenile fish and invertebrates, and which provide feeding grounds for green sea turtles (*Chelonia mydas*), the endangered dugong (*Dugong dugon*) and numerous species of fish. Mangroves (mostly species of *Sonneratia* and *Rhizophera*) also provide important nursery grounds and habitats for many marine organisms including shrimp and fish, protect coastlines against erosion, and have the capacity to prevent salt intrusion as well as filter pollutants from waters entering the bay.

In the urban area, terrestrial plants and wildlife are dominated by introduced species. Most native plants have been replaced by vegetables, fruits and ornamentals imported from other regions. Local wildlife is dominated by European sparrow, dogs, cats, chickens and pigs. Indigenous terrestrial wildlife found in the urban area are primarily birds (parrots, doves, and finches) and small mammals (rats, mice, and shrews). Cuscus, an indigenous arboreal marsupial found occasionally in forested areas above the city, has become an endangered species due to extensive hunting and deforestation (Monk et al. 1997).

2.2 The Socio-Economic Environment

As the provincial capital of Maluku, Ambon has a long and fascinating history (see Knaap 1991, Knaap 1987, Jacobs 1981, Rumphius 1910). Established more than 400 years ago as a Christian fort and trading post by the Portuguese, it was later taken over in 1605 by the Dutch and transferred to the control of the Verenigde Oost-Indische Compagnie (VOC); who transformed the town into the administrative and strategic center of its spice monopoly. For the next two centuries, Ambon served as an integral and vital world trade port and regional locus of military and economic control. By the beginning of the twentieth century, however, Ambon had become an economic backwater due to the VOC's loss of control over spice production. During this period, Ambon's population grew slowly and the city occupied a space of less than five square kilometers. When 25,000 Japanese troops occupied Ambon island in 1942 Kota Ambon's population numbered approximately 17,500 people (Chauvel 1980). Post-war Ambon's population grew intermittently with the ur-



Note: Ambon Metropolitan Area was expanded from 4.2 km^2 to 300 km^2 in 1980.
Sources: deGraf 1972; Chauvel 1980, Tamaela 1972; Kantor Statistik Propinsi Maluku 1996; Repelita VI Maluku; Direktorat Tata Kota dan Daerah, Ambon 1966

ban population reaching about 50,000 by 1961 (See Gray et al. 1995 for a summary of factors influencing Maluku's population during this period).

Major geographical and demographic changes in the urban domain occurred subsequent to Indonesian nationhood and shifts in national and international economies. For the past three decades Ambon's urban population has been growing quickly (Figure 2). A major driving force for urbanization was the rapid expansion of the Indonesian bureaucracy, which more than quadrupled in size between 1975 and 1990, becoming the largest sector of employment in Ambon. This transformation in the structure of employment created a new middle class, mostly Christian Ambonese, with relatively strong political power. Changes in international markets and trade, and Indonesia's export-led development policies of the 1980s and 1990s brought increased shipping and trade activities to port cities (Douglass 1989). During this period the govern-

ment focused increasingly upon international and regional linkages as a means to promote economic growth, with the result that products and income from natural resource exploitation and estate crops flowed through Ambon. Besides housing the offices of provincial and local government and the armed forces, Ambon has become a regional center for banking, shipping, fishing and pearl farming companies, mining companies and the lumber industry. In-migration has been spurred by government policy giving free rein to merchants and street vendors and by increased mobility afforded by gains in transportation, communication and other infrastructure (Cohen & Murphy 1999, Douglass 1984). To this day Ambon maintains a reputation as an open frontier, a place where it is easy to make a living. Migrants from neighboring provinces, especially those from southern Sulawesi, have played a key role in building Ambon's local economy. Hardy pioneers in retail trade, Bugis and Makassarese migrated to Ambon to find occupation as merchants. Butonese also found entry as *becak* drivers, laborers and vendors. By the early 1990s, a majority of transport and retail trade industry was controlled by these ethnic groups.

Today, the situation remains one of highly concentrated development on Ambon, with over 80 percent of the island's inhabitants residing within the designated metropolitan area—which itself comprises 310 km^2, or about 40 percent, of the island's total area. Most residents are poor. Average per-capita income for the year 1995 was estimated at 2,260,000 rupiah or about U.S.$900 (Kantor Statistik Kotamadya Ambon 1995). With a youthful population approaching 350,000 people, Ambon remains the largest and fastest growing urban center in the region.

3 The Legacy of Urbanization: Research on Ambon's Urban Environment

This section pulls together key research on Ambon's urban environment. Several generalizations can be made about this literature. First, it is recent in origin, with most works emerging since 1980. Only within the last two decades have researchers begun to delve into such important local environmental issues as the fate of Ambon Bay's ecosystems and the biological health of Ambon's rivers. Second, most environmental research has taken the form of single-projects, with little follow-up research

or linking between studies. Third, documentation and dissemination of research findings have as a rule been very limited. Many studies remain unpublished and/or unavailable to the public, to be found only in the private libraries of project managers, university faculty members, or NGO offices. Finally, although this summary is by no means comprehensive of existing literature, nonetheless this preliminary survey reveals disturbing trends in the areas of air quality, water quality, hydrogeological processes, and ecosystem health, which continue to affect human health and quality of life. Each of these will be considered in turn.

3.1 Air Quality

Very little research has been conducted on air quality in Kota Ambon, but Municipal statistics state (and physicians polled by this author unanimously agreed) that severe respiratory ailments are the top medical problem treated at hospitals and clinics, comprising nearly 30 percent of all patient ailments (Kantor Statistik Kotamadya Ambon, 1996). Heavy levels of smoke, dust, fumes and particulate matter prevail in both public and private spheres. In Ambon City there is an annual 'smog season' created when smoke from the seasonal burning of forests in Maluku, Irian Jaya and Sulawesi combines with the ambient day-to-day pollution from urban activities. A gray haze regularly blankets the island for two to three months of the year.

Major urban nonpoint sources of air pollutants include automobiles, the domestic cook stove and household waste burning. Domestic cooking, including the boiling of drinking water, is frequently done in poorly ventilated areas using poor quality fuel. About 75 percent of households use kerosene stoves with the remaining 25 percent relying upon wood as a fuel source. Additionally, about 30 percent of garbage is not collected, and many residents resort to burning household wastes (which contain a high percentage of plastics)—contributing smoke and airborne particulate matter. In public areas, such as indoor and outdoor markets, the air is frequently polluted with high levels of auto exhaust, smoke from restaurant stoves and rubbish fires, and the ubiquitous cigarette smoke. The two main point sources of urban air pollution are Ambon's oil-burning electrical generation plants and its main waste disposal site. The city landfill, located above the north end of the urban center, is on fire, generating

a constant stream of black smoke which settles over the city each morning.

3.2 Noise

Noise, a little-addressed form of pollution, is also a growing environmental problem in Ambon (Deane 1979). In nearly all areas of the city, noise remains unregulated. High levels of noise may be present at all hours of the day and night. Much noise comes from traffic, animals, retail shops, radios and public address systems.

3.3 Water Quality: Groundwater and Surface Waters

Fresh water for drinking and other domestic uses is derived from both groundwater sources and surface water sources. According to official sources, most residents obtain water for household consumption from municipal sources. A small municipal water distribution system presently delivers piped water to approximately 20 percent of the population, with an estimated additional 50–60 percent of residents obtaining water distributed by truck delivery or hand-carried from public water sources and stored in tanks. The remaining 20 to 30 percent of residents obtain household water from non-municipal sources such as shallow household wells and rivers.

The official figures tell only part of the story, however. Piped water is only available during designated periods—typically one to four hours per day, three days per week. Even more importantly, many households rely on multiple sources of water as a cost-saving device, using water purchased from municipal sources for drinking, while relying upon 'free' surface sources (wells and river water) for other uses. In fact, Ambon's rivers and the multitude of wells along the river courses constitute an important resource for residents. River water is used by many households for bathing, dishwashing, laundry, and housecleaning, and the river provides public space for socializing and for children's playgrounds. Rivers also provide space for toilets as there is no public sewer system. The few septic systems presently in use are little more than conduits into rivers and the Bay, due to the fact that most have been installed in sand, and well below the water table. As a result, the majority of the population

discharges sewage directly into waterways, such that Ambon's rivers and ocean receive all domestic sewage from the city. The pollutant load far exceeds the maximum level where the rivers can perform self-purification, and the oxygen-depleted, nutrient laden waters cannot support fish or other aquatic life. Surface waters also constitute a potentially large source of exposure to waterborne pollutants, toxins, and disease. While citizens of Ambon are aware that all drinking water regardless of source must be boiled, many do not understand the implications of using unboiled and/or polluted water for purposes such as bathing and washing dishes, nor of allowing children to play in such waters. The relatively high incidence of skin ailments, diarrhea, malaria and parasites among the urban population (Kantor Statistik Kotamadya Ambon, 1991, 1996) is evidence of a high level of exposure to pollutants and/or pathogens.

Government testing of groundwater sources occurs irregularly and test results are unavailable to the public. However a 1997 study by Yachiyo Engineering Co., Ltd. of Ambon's urban rivers and water supply found severe contamination with fecal coliform and other bacteria, as well as heavy metals in all samples, and pronounced all rivers "essentially the same as open sewers". The same study found that 70 percent of samples of tap water piped to households or delivered by truck from public water sources also exhibited some contamination.

Besides addressing the existing inadequacies of the water supply system, government faces the task of increasing municipal water supply for a rapidly expanding urban population. There is already evidence that the groundwater supply tapped for public drinking water is becoming steadily contaminated by residential dwellings which are encroaching on protected catchment areas. A current government proposal entails the construction of large reservoirs in these upper catchment areas to provide additional drinking water.

3.4 Ambon Bay and Coastal Resources

Development of Ambon's port areas has brought changes in the shape of the bay as well as changes in environmental conditions. Ambon Bay is a heavily-used passage for marine transportation and fishing vessels. Besides the regular ferries crossing the Bay, there are typically twenty to thirty ships and hundreds of small boats using Ambon Bay on a daily ba-

sis. Urban activities have brought pollution, changed bottom characteristics, modified currents and water temperature and damaged submerged reefs and vegetation in the Bay. Ambon Bay also serves as an important harvest area and a nursery grounds for the fisheries industry (Day et al. 1993). Most locally consumed fish is harvested in or around the Bay, and historically Ambon's inner bay has served an important source of baitfish for the fishing industry. In recent years there have also been attempts to develop Ambon Bay as a tourism area (Dinas Pariwisata Daerah Maluku 1995, Pemerintah Propinsi Daerah Tingkat I Maluku 1994, Malindar 1997). Much important research on Ambon Bay is compiled within four volumes of conference proceedings published by the LIPI Marine Resources Unit in Ambon (Soemodihardjo et al. 1987, Praseno et al. 1990, Ongkosongo 1991, Wenno et al. 1997). These volumes provide detailed research findings on important aspects of the Bay's ecology, biology, geology, chemistry, hydrography and oceanography. A number of the papers published within these works are cited below. Because much recent evidence points to a decline in fisheries, uncontrolled land development and increasing levels of pollutants, Ambon Bay has been designated as a Critical Area. However, this designation has not prompted appropriate actions on the part of urban planners

Degradation of water quality has occurred in Ambon Bay to the extent that swimming, bathing, and consumption of seafood may pose serious health threats. Major contaminants include sediments, pathogens (bacteria and diseases), solid wastes, pesticides, hydrocarbons and heavy metals. Many of these pollutants derive from urban sources transported by rivers and urban runoff although some, such as pesticides, originate mainly from agricultural sources. Presently, the largest threats to human health are thought to be bacteria and other pathogens found in the Bay's waters (Suprapto 1985); nonetheless there is evidence that the accumulation of heavy metals, pesticides and hydrocarbons are also of immediate concern.

One study of pesticides in Ambon Bay in 1981 found moderately high concentrations of DDT, Aldrin and Lindane in bottom sediments, and high levels of DDE (which is a breakdown product of DDT) and the organochlorine pesticide Endosulfan in Bay waters (cited in Ongkosongo 1991 pp. 22–25). While the study noted that none of these substances

posed an immediate threat to humans, over time these chemicals are known to concentrate in the tissue of marine biota. Another study conducted in 1985 reported similar levels of pesticides for both seawater and sediments (cited in Persulessy and Manik, 1997). Persulessy and Manik also collected data on heavy metals in seawater and sediments for the years 1987, 1988 and 1995. The authors do not much discuss the findings of this research but their data indicate fairly constant levels of heavy metals and pesticides at the sampled sites throughout the period 1981–1990. Although levels found in these studies fall below standards established by Australian and U.S. Health and Environmental agencies for human exposure, other studies indicate that such pollutants, especially pesticides, may inhibit phytoplankton growth (Thayib and Razak 1988). Phytoplankton are positioned at the bottom of the food pyramid and any disruption to this group immediately affects other communities. Further, findings on heavy metals in sediments appear to be highly site specific, as evidenced by a 1985 study by Manik reporting very high levels of the heavy metals lead, cadmium, copper and zinc in Bay sediments at three sites directly adjacent to Ambon's harbor, market and main fish storage plant.

Studies of sedimentation in various locations around Ambon Bay indicate very high values, averaging 23.81 millimeters per year (Wouthuyzen et al. 1997, p. 245, quoting Hermanto 1987). Steep topography in Ambon's five river drainages and relatively high number of rainfall days create a naturally high rate of stream sedimentation which is exacerbated by loss of vegetation and construction in upper watersheds and shoreline areas, and by stream channelization. Meanwhile, natural coastal filtering processes have been lost through filling of wetlands and removal of mangroves and other vegetation. The increased amount of sediment has resulted in three serious effects. First, sediments choke stream mouths, causing frequent flooding in high-density areas of the city; second, large amounts of sediment are regularly deposited on the ocean floor, smothering marine life and inhibiting solar insolation critical to the development of coral reefs; third, currents tend to recirculate the bottom sediments, depositing thick layers of silt on recreational beach areas.

An often commented-upon feature of Ambon Bay is a thin film of oil which blankets its waters and imparts a sheen. Its shimmering enhancement of sunsets which delights tourists is roughly analogous to

the colorful effect rendered by particulate air pollutants in smoggy cities. The persistent film of petroleum derives from a variety of sources, including automobiles and industry, motorboats and ships in the harbor, and numerous abandoned hulks on the shorelines of Ambon. Nearby petroleum storage areas and ferry operations doubtless contribute to this situation as well.

Like smog, the oil may be beautiful but deadly. Hydrocarbon concentrations in seawater for the years 1988, 1990 and 1995 were measured in the Persulessy and Manik study cited above. The study found low to moderate concentrations present, depending upon location. No investigation of the impact of petroleum compounds on corals or marine life of Ambon Bay has been conducted, but there is some speculation in the literature that even low concentrations of hydrocarbons may cause significant impacts on benthic organisms (Halstead 1972).

Ambon Bay is heavily polluted by sewage and domestic waste (Manuputty 1997, Dangeubun 1997, Tarigan and Ongkosongo 1991). There is severe beach litter, which consists predominantly of decaying organic wastes and plastics, as well as ever-present flotsam upon the waters of the Bay. No studies have been conducted on the impact of domestic waste on marine organisms in the Bay, although observations of corals and other marine life smothered or killed by trash have been made (Randall & Eldredge 1983, Sahetapy 1991). Fishing boats and speedboats ferrying customers across Ambon bay frequently have their propellers fouled by floating debris. Other concerns associated with domestic wastes include eutrophication, toxicity, and dangerous concentrations of bacteria and other pathogens.

Eutrophication is a condition of rapid plant growth and depleted oxygen due to high levels of nutrients, most commonly nitrogen and phosphorous associated with urban and agricultural wastes. Impacts from eutrophication include the smothering of coral reefs, death of fishes and invertebrates and threats to human health due to accumulation of poisonous algae within food fishes and shellfish. Eutrophication induces various types of algae blooms, one of which is commonly known as a red tide. Red tides are associated with Paralytic Shellfish Poisoning (PSP) a condition where filter feeders concentrate high levels of the toxin from the dinoflagellate *Pyrodinium bahamense* var. *compressum* and are subse-

quently eaten by humans. Wouthuyzen et al. (1997) describe an incident in June 1994 in which three people died of PSP and 33 others were hospitalized after they consumed *kerang*, a species of shellfish, gathered from Ambon Bay. Additional narrative evidence obtained from fisherfolk suggests that red tides may occur in Ambon Bay as often as once each 2–3 years.

The ongoing contamination of water and sediments is particularly disturbing given that an overwhelming majority of the population regularly consumes fish caught in the waters around Ambon. A staple food and principal source of protein for Ambon's population, fish is typically consumed by households at least twice each day. Given the large part that fish plays in local diet, contamination by bacteria, pathogens, heavy metals, and toxins may pose a significant health risk to the population.

Unfortunately very little data on bio-accumulation of heavy metals or other pollutants in fish and shellfish of Ambon have been collected and extant studies do not seem to agree on present levels of exposure (see for example Tarigan 1987 and Edward 1990). A 1994 study found high concentrations of *E. coli* in shellfish along Ambon's shoreline (Indah and Chasanah 1997). Overall levels of bacteria reported in the study were nearly eight times the maximum presently allowable in shellfish in the USA (EPA 1997). Warning against using Bay water as a source of domestic or commercial wash water, the study's authors also noted that shellfish are likely to be accumulating resistant human viruses and pathogens such as typhus, cholera and hepatitis. Persulessy and Manik (1997 p. 66) present data from 1988 which shows high levels of mercury in shellfish. Two other studies conducted between 1990 and 1995 concluded that significant impacts on indicator organisms (whelks) have probably resulted from highly toxic Tributyltin (TBT) residuals from anti-fouling paints in Ambon Bay (Evans et al. 1995, Pattisina 1994). These paints which are found on foreign fishing vessels are known to leach the TBT, a potent biocide, into seawater. Toxicity is high: less than 1 part per million of the metal is known to be hazardous to human health. The study by Evans et al. also described a correlation between parasitization of the coral reef fish *Abedefduf saxatilis* and pollution from urban waste, indicating a possible indicator of pollution stress.

3.5 Special Ecosystems

As mentioned above, Ambon Bay has three important coastal ecosystems: coral communities (fringing reef), seagrass beds and mangroves. Historical data on the composition and condition of these systems is limited, although early taxonomic work on coral reefs was conducted by the Siboga Expedition of 1899 (Randall and Eldredge 1983); the Snellius Expedition of 1929–30 (van Riel 1937); the Rumphius Expedition of 1973 (Oseanologi di Indonesia 1974); and the Snellius Expedition II of 1984–85 (Best et al. 1989) (for a list of early marine research in Eastern Indonesia refer to Romimohtarto et al. 1985). Intensive research on biology and ecology of Ambon's reefs and fisheries has been conducted since the 1980s, and most researchers seem to agree that the evidence points to significant disturbances in Ambon's coral communities (Sutarna 1989, Ongkosongo 1991 pp. 1–20). Demand for building materials, physical damage from boat hulls and anchors, siltation, fishing with chemicals and urban pollutants are the main causes of degradation of coral reef systems (Sahetapy 1991, p. 10). Studies of coral reefs indicate that of 9 locations adjacent to Ambon City where substantial coral communities were previously known to exist, only one is in very good condition, seven are in fair condition and two are in poor condition (Sutarna 1989, Sutarna and Leatemia 1991).

Research on Ambon's wetlands and seagrass communities is also limited. Clearly, however, extensive modifications of the shoreline have occurred to the point where virtually the entirety of Ambon's waterfront has been transformed. Areas of mangroves, trees and other wetland vegetation, which previously provided functions of filtering sediments and toxins and slowing the rate of water discharging into the Bay, have been mostly removed (Pramudji 1987, Yachiyo Engineering 1997). As noted above, wetlands, sea grass beds and mangroves are very important habitats for many juvenile and adult fish (Pulumahuny 1991). Portions of Ambon's Inner Bay are known to be a nursery ground for several types of commercially important fish such as ikan Puri (*Stolephorus* spp.); ikan Make/Lemuru (*Sardinella* spp,) ikan Momar (*Decapterus* spp., ikan Komu (*Rastreliger kanagurta*) and ikan Beronang (*Siganus* spp.) as well as shrimps and other invertebrates (Wenno 1986, Heryanto 1987, Abrahamsz 1992).

Many of these areas have over time been cleared and/or drained. With vegetation loss, and subsequent discharges of silt, trash, pesticides and other pollutants into nearby estuarine area, the capacity of both mangrove and seagrass ecosystems to perform these functions is greatly diminished (Yulianto 1991). Specific studies on the effects of pollutants and urban activities on seagrasses and mangroves have yet to be conducted for Ambon Bay.

3.6 Fisheries

Considerable fisheries research has been done on the biology and/or culture of commercial species including ikan Cakalang (*Katsuwonus pelamis*), ikan Komu (*Rastreliger kanagurta*), ikan Lema (*Rastreliger* spp.), ikan Kerapu (*Epinephelus* spp.), ikan Beronang (*Siganus* spp.) and others (Papalia 1991, Susetiono 1987). While detailed population studies of commercial fish species in Ambon Bay have yet to be conducted, production records for baitfish show steady declines since 1976 and both researchers and fisherfolk alike tend to agree that the fishing grounds inside the Bay are degraded (Nontji 1997, Wenno 1991a, Hukom 1991). This may be the combined result of heavy fishing pressure, pollution, loss of nursery grounds, and changes in currents and water chemistry (Wenno 1991b, Ongkosongo 1991, p. v.).

3.7 Beach Erosion

It is estimated that most of the shoreline areas of Ambon city have undergone rapid and extensive erosion since the 1940s, at rates between 0.20 meters and 0.5 meters per year (Hermanto and Suwartana 1986). According to Ongkosongo (1991, pp. 6–17) most of this erosion was probably caused by the mining of coral and beach materials, the removal of vegetation from the shoreline, and shoreline construction activities.

In response to the retreating shoreline, the government began in the 1970s to fill extensive areas of coastline and build seawalls. By 1990 at least 17 km or nearly 34 percent of Ambon's beachfront was hardened with seawalls, revetments or bulkheads. While these structures prevented the loss of existing buildings, they also interfered with currents and natural sand movement. These changes in turn induced accelerated erosion

in adjoining unhardened beach areas, such that all of Ambon's remaining beaches are today threatened by erosion.

3.8 Exacerbation of Natural Hazards

According to government statistics, hundreds of casualties occur annually in Ambon City as a result of natural disasters (Kantor Statistik Kotamadya Ambon 1996). Known hazards include beach erosion, landslides, earthquakes, floods, drought, and hurricanes. River flooding is the most common disaster, causing substantial damage and losses annually. Annual flooding in areas adjacent to the five rivers flowing through the city affects an estimated 1,800 households. Larger floods occur less frequently but affect greater portions of the city (4,500 to 5,000 households). Large floods occurred in 1984, 1989, and 1996 (Yachiyo Engineering 1997, p. D-45). Flooding is exacerbated by the large volume of household waste that is dumped into rivers and by increased erosion and sedimentation resulting from residential construction, road-building, tree-cutting and other urban activities.

Ambon is located in an active seismic zone, and the island is undergoing rates of uplift as high as 30 mm per year. Frequent earthquakes (often over a thousand events per year) are recorded by the Geophysics Station of Ambon, although most of these go unnoticed by residents. In 1996 alone, the Ambon Geophysics station recorded 483 earthquake events of magnitude 4 or greater (Kantor Statistik Propinsi Maluku 1996). A number of devastating quakes have struck the City. The earliest documented killer quake struck in 1674, destroying many structures and killing two people (Beekman 1981). Subsequent large earthquakes struck in 1834, 1840, 1898, 1942, 1950, 1980, 1983, 1996 and 1997 damaging or destroying structures and causing human injury (Setyawan 1991, Setyawan and Supriyadi 1997). The risks of damage and loss of life from earthquakes are increased by the continued practice of constructing buildings close together in the city. Hazard is also increased by practices of building houses on steep, unstable slopes where earthquakes frequently trigger landslides. In 1996 at least 189 persons were injured or rendered homeless by landslides (Ongkosongo 1991, pp. 28–33).

High density living also creates extreme fire danger in Ambon, and fires frequently break out in the city. In 1994–1995, over 50 structures

burned and an estimated 1,146 people suffered loss or injury due to fire (Kantor Statistik Kotamadya Ambon 1996).

4 Conclusion: Urban Environment and Quality of Life

Environmental changes attending the rapid urbanization of Ambon have created numerous threats to urban quality of life. Not only has the physical capacity of the land to support human populations diminished but conditions are increasingly conducive to a whole range of health threats. Despite active urban and regional planning in the provincial capital, government has been unable to keep pace with the environmental needs of its burgeoning urban population. Although advances in urban infrastructure and services undeniably raised standards of living in the 1970s and 1980s, evidence from the 1990s indicates that gains in human health status and the condition of the urban environment may now have reached a point of reversal. Nowhere is this more apparent than in the poorest neighborhoods of Ambon, where threats from natural hazards, substandard housing, contaminated water, air and food, noise pollution and new diseases related to crowding and lack of sanitation have reached unprecedented levels.

Unfortunately Indonesia has recently experienced a devastating economic crisis which has exacerbated this situation by dragging the majority of Ambon's urban population below the poverty line and fuelling local ethnic conflict. Today, even as urban planners and environmental managers are recommending the incorporation of the entire island into the Ambon metropolitan administrative district, the lingering effects of the crisis cripple the efforts of government and local people to manage the urban environment. Rampant inflation, shutdowns and slowdowns of infrastructure and services, rollbacks of environmental protections, and a drastically reduced capacity to do environmental research all create serious obstacles to managing the urban environment.

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