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Urban Stormwater Management in Auckland Tāmaki Makaurau

Introduction

Urban environments and the natural environment are frequently at tension; urbanisation often comes at the cost of ecological sustainability. A significant issue facing Auckland Tāmaki Makaurau and all other urbanised areas is the challenge of stormwater management resulting from the proliferation of impervious surfaces, loss of vegetation, and increased intensity of rainfall events due to climate change. This essay will examine urban stormwater management through ecological principles and assess the planning systems' response, introducing and examining the Auckland Water Sensitive Design Manual as an example of how effective planning can address the challenge of urban stormwater.

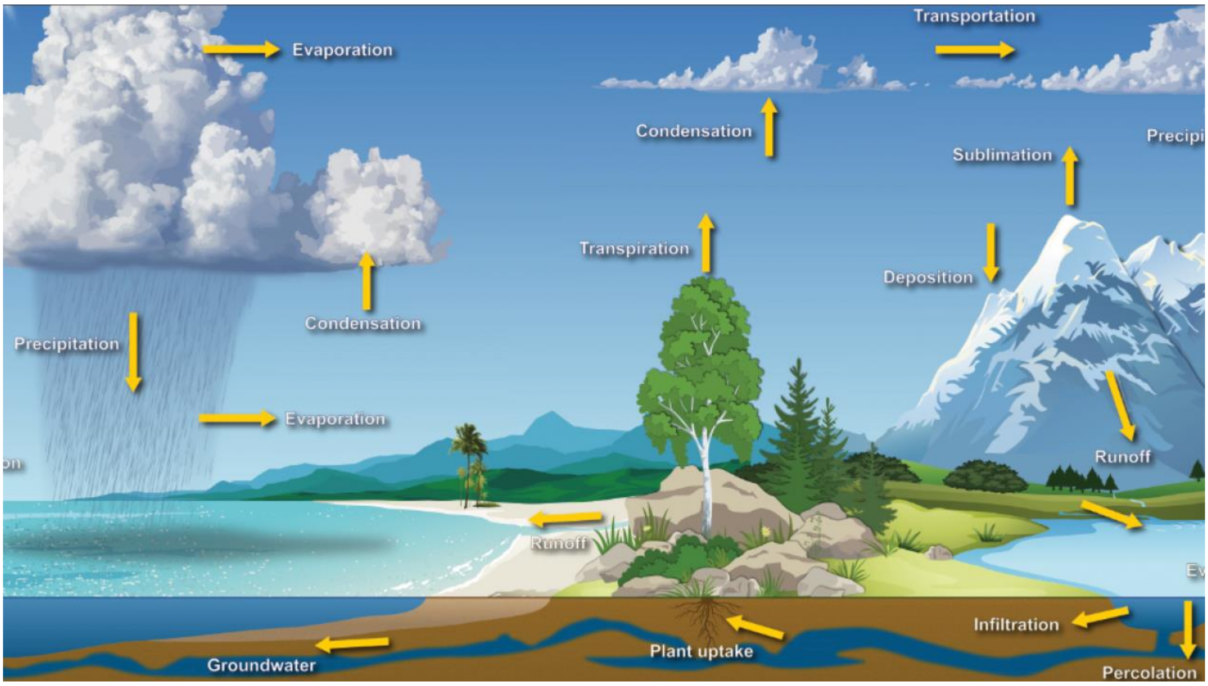
Ecological principle: Scale, interaction, and complexity

Harker et al. (2012) introduce three ecological principles to assess environmental sustainability; the first principle is scale, interaction, and complexity, which can be broken down into constituent parts for easier understanding and combined for a more comprehensive experience. The word scale refers to both spatial and temporal scales, how ecosystems exist throughout various geographical areas, and timelines (Harker et al., 2012). Interaction refers to ecosystems requiring interaction with other systems (Harker et al., 2012). When combined, scale and interaction bring about immense complexity. Ecosystems are nested; at any given time, multiple functions are happening (Harker et al., 2012). Furthermore, this leads to the understanding that ecosystems cannot be simply replicated through their constituent parts, as the interactions and resulting complexity are integral to the system.

The natural path of rain

The path of stormwater is complex and strenuous. As seen in Figure 1, when rain falls and contacts the ground, it has two possible paths: infiltration into the ground, where it can form groundwater and be used for plant uptake, or become runoff, travelling along the landscape towards water catchments of growing scales, such as rivers, lakes, seas, and oceans (National Oceanic and Atmospheric Administration, 2019).

Figure 1: *The Water Cycle*



Source: (National Oceanic and Atmospheric Administration, 2019)

The challenge of urban stormwater management

The issue arises when the urbanisation process leads to the loss of vegetation, which uptakes water, and introduces impermeable surfaces to the environment, disrupting the natural cycle (Suriya & Mudgal, 2012). Impermeable surfaces include asphalt, concrete roads, driveways, and building footprints that comprise a significant portion of our cities (Auckland Council, 2015). The introduction of impermeable surfaces reduces the amount of water that infiltrates into the ground and, therefore, increases the amount of runoff;

furthermore, the runoff produced is highly contaminated and polluted, which can be damaging to receiving catchments (Auckland Council, 2015).
Stormwater management focuses on how to reduce the impact of runoff on human populations by preventing flooding; furthermore, the focus is on slowing down water flow to allow for contaminants to be treated, water to infiltrate into the ground, and to discharge the rest of stormwater safely into water catchments (Auckland Council, n.d.-a, n.d.-b).

Stormwater, scale, interaction, and complexity

Urban stormwater can be examined through the lens of scale, interaction, and complexity to understand its ecological impacts better. Urban stormwater goes through various scales of ecosystems; its path takes it along highly urbanised areas ecosystems, where it picks up contaminants and pollutants; it can then travel along road surfaces or through pipes, where it is then discharged into watercourses of growing scales (Auckland Council, 2015).

Throughout the increasing scales of the path of urban stormwater, the subsequent ecosystems interact with each other, as the water carries the contaminants and pollutants of urban ecosystems into more natural ones, where the stormwater can be filtered; however, introducing contaminants and pollutants can also negatively impact the habitats of receiving catchments (Auckland Council, 2015).

Ecological principle: Biogeochemical cycles

The second principle of ecosystems that Harker et al. (2012) state is Bio-geochemical cycles. Biogeochemical cycles refer to the transformation and movement of matter through different biotic, abiotic forms (Harker et al., 2012). As with scale, interaction and complexity, bio-geochemical cycles are compound, and the interaction of constituent parts profoundly impacts ecosystems. Biogeochemical cycles arise from the interaction of the biosphere with geological components and chemicals; through biogeochemical cycles, matter moves and transforms into biotic and abiotic forms (Harker et al., 2012).

For example, carbon changes forms existing in plants before dying and decomposing into the ground, where it can concentrate into fossil fuels, which, when extracted and burnt, return the carbon into the atmosphere, where plants can use it for photosynthesis, and the cycle continues (U.S Department of Energy, n.d.).

Rain: a biogeochemical cycle

The sustainability of urban development can be examined through the lens of biogeochemical cycles; rain is a complex resource to manage. An understanding of rain: A biogeochemical cycle can help implement better stormwater management. The rain cycle starts with water in the atmosphere; this water then condensates, forming rain and falling to the ground; as stated, two paths are present for the rain to infiltrate the ground or form runoff (National Oceanic and Atmospheric Administration, 2019).

Urban stormwater management is a growing issue due to the rise in impervious surfaces in urban areas, not allowing water to infiltrate the ground and forcing it to become runoff. However, the same understanding of biogeochemical cycles can be utilised to better manage stormwater by creating green infrastructure, such as rain gardens and stormwater ponds, allowing filtration and infiltration (Auckland Council, 2015).

Urban runoff and algae blooms

Though rain is a biogeochemical cycle, its interaction with other ecosystems alters many other cycles. Urban runoff carries contaminants and other pollutants, including potential contamination with sewage or artificial fertilisers (Lembi, 2003 & Soni & Pareek, 2022). Once discharged into natural bodies of water, the increased concentration of contaminants and pollutants can lead to algae blooms. Algae bloom when extra nutrients are available in the water; this can be due to these nutrients being directly introduced as runoff picks up artificial fertilisers or produced indirectly through the microbial breakdown of contaminants (Lembi, 2003). Blooming algae utilises all the oxygen available in the water, creating dead zones and devastating the local ecosystem (Lembi, 2003).

Specificity of place:

The third principle Harker et al. (2012) set out is the specificity of place, which refers to how scale, interaction, complexity and biogeochemical occur at different rates in different places and therefore, each place has unique characteristics, such as species, local geology, soil chemistry, etc.

Auckland Tāmaki Makaurau Anniversary Day Floods:

On January 27, 2023, Auckland Tāmaki Makaurau experienced severe flash flooding, which came about due to heavy downpours (New Zealand Infrastructure Commission Te Waihanga, n.d.). Auckland Tāmaki Makaurau is a suburban city with many surfaces being impervious. Research from Auckland Regional Council (2009) shows that Auckland Tāmaki Makaurau has an abundance of impervious surfaces and that this amount increased from 2000 to 2007. The Specifity of ground imperviousness due to urbanisation in Auckland Tāmaki Makaurau is likely to have been a significant reason why the flooding was so severe. Overall, the amount of rain received was far too large and overwhelmed stormwater infrastructure, and due to impervious surfaces preventing infiltration, created massive floods. There is increasing awareness around green water infrastructure as is promoted by the Auckland

Water Sensitive Design Manual; however, it has yet to be applied at a scale large enough to counteract the amount of impervious surfaces.

Understanding urban stormwater through ecological principles

Utilising all three principles in conjunction helps to better understand urbanisation's effect through altering ecosystems and how to prevent further damage to the natural and built environment.

The scale of urban area matters, the scale of catchments matters, and the biogeochemical cycle of rain are impacted due to the prevention of infiltration, site-specific issues such as terrain or the amount of permeable surface further affect urban stormwaters' impact.

At its heart, urbanisation disrupts the biogeochemical cycle. As Harker et al. (2012) state, disruptions to these cycles can be accommodated; however, large-scale and cumulative disruptions can be catastrophic; the process of urbanisation changes terrains and landforms introduces impervious surfaces, and through the burning of fossil fuels and contributes to climate change, at the same time makes extreme weather events more likely to happen, and to be disruptive. However, the scale of this urbanisation matters; Auckland Tāmaki Makaurau is a sprawling city, with some regions containing very little vegetation due to suburban development; the sheer scale of the disruptions contributed significantly to the horrible outcome of the Auckland Tāmaki Makaurau Anniversary Floods. Furthermore, the interaction of the new urban ecosystem with pre-existing ones can be examined, as urban runoff carries pollutants and contaminants into nearby water catchments, throwing off the balance of natural biogeochemical cycles in those local habitats and having adverse effects on the local ecological population. The specificity of place principle is essential to consider, as looking elsewhere to areas less urbanised can share a glimpse of what has gone wrong, what cycles and interactions have been disrupted, and how more sustainable green water infrastructure can be utilised to manage stormwater in a way that is better for residents and the environment.

Auckland Water Sensitive Design Manual: An ecological planning response

The Auckland Water Sensitive Design Manual is designed to help planners and designers better implement designs sensitive to water and better manage stormwater, taking lessons from nature on how to do so; it aims to integrate small-scale on-site stormwater management such as rain gardens, swales, and stormwater ponds (Auckland Council, 2015). Urbanisation's overall disruption of the rain biogeochemical cycle can be reduced as increased chances for filtration and infiltration are provided. This benefits the population, reduces the chance of flooding, and mitigates the destruction caused by discharging significant runoff into the lower catchment areas (Auckland Council, 2015).

Moreover, the Water Sensitive Design Manual promotes using materials that do not leach contaminants and urges that when impervious surfaces are present in development, the runoff is directed to landscaping elements as a first line of treatment (Auckland Council, 2015). It is through the utilisation of ecological principles that the Auckland Water Sensitive Design Manual sets out its aims and hopes. It aims to create small-scale water treatment facilities on-site and use natural biogeochemical cycles to filter stormwaters microbially (Auckland Council, 2015). Furthermore, it aims to minimise the disruption of urbanisation on biogeochemical cycles by urging the reduction of impervious surfaces and using proper design techniques to manage the contaminated runoff created by using impervious surfaces (Auckland Council, 2015).

Conclusion

Overall, the principles set out by Harker et al. (2012) are that scale, planners can utilise interaction and complexity, biogeochemical cycles, and specificity of place to understand ecosystems better and whether they are sustainable. A thorough understanding of sustainable ecological systems allows us to design planning responses, such as the Auckland Water Sensitive Design Manual, that aim to minimise the disruption caused by urbanisation on the natural environment. This can be done by reducing impervious surfaces and introducing and enhancing green water infrastructure such as rain gardens, swales, retention ponds and more, which can filter the contamination due to increased runoff.

Word Count: 1811

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