



**ΠΑΝΕΠΙΣΤΗΜΙΟ ΠΕΙΡΑΙΩΣ
ΣΧΟΛΗ ΟΙΚΟΝΟΜΙΚΩΝ, ΕΠΙΧΕΙΡΗΜΑΤΙΚΩΝ ΚΑΙ ΔΙΕΘΝΩΝ ΣΠΟΥΔΩΝ
ΤΜΗΜΑ ΟΙΚΟΝΟΜΙΚΗΣ ΕΠΙΣΤΗΜΗΣ**

**ΠΡΟΓΡΑΜΜΑ ΜΕΤΑΠΤΥΧΙΑΚΩΝ ΣΠΟΥΔΩΝ
«ΒΙΟΟΙΚΟΝΟΜΙΑ, ΚΥΚΛΙΚΗ ΟΙΚΟΝΟΜΙΑ
& ΒΙΩΣΙΜΗ ΑΝΑΠΤΥΞΗ»**

**Η ΗΠΙΑ ΠΑΡΕΜΒΑΣΗ (NUDGING) ΓΙΑ ΤΗ
ΠΡΩΘΗΣΗ ΤΗΣ ΒΙΩΣΙΜΟΤΗΤΑΣ
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ΜΕΤΑΚΙΝΗΣΗ, ΕΝΕΡΓΕΙΑ ΚΑΙ ΔΙΑΧΕΙΡΙΣΗ
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Γερασιμίνα-Ραφαηλία Ρούσσου

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University of Piraeus
SCHOOL OF ECONOMICS, BUSINESS AND INTERNATIONAL STUDIES
DEPARTMENT OF ECONOMICS

**MSc. in Bioeconomy, Circular Economy & Sustainable
Development**

**NUDGING FOR SUSTAINABILITY
IN EU CITIES:
TRANSPORT, ENERGY AND WASTE MANAGEMENT**

By Gerasimina-Rafailia Roussou

Piraeus, Greece, July 2026



ΤΜΗΜΑ
ΟΙΚΟΝΟΜΙΚΗΣ ΕΠΙΣΤΗΜΗΣ
ΠΑΝΕΠΙΣΤΗΜΙΟ ΠΕΙΡΑΙΩΣ

ΒΕΒΑΙΩΣΗ ΕΚΠΟΝΗΣΗΣ ΔΙΠΛΩΜΑΤΙΚΗΣ ΕΡΓΑΣΙΑΣ

«Δηλώνω υπεύθυνα ότι το έργο που εκπονήθηκε και παρουσιάζεται στην υποβαλλόμενη διπλωματική εργασία, για τη λήψη του μεταπτυχιακού τίτλου σπουδών, στη «Βιοοικονομία, Κυκλική Οικονομία και Βιώσιμη Ανάπτυξη» με τίτλο:

Nudging for Sustainability in EU Cities :

Transport, Energy and Waste Management

έχει γραφτεί από εμένα αποκλειστικά στο σύνολό της. Δεν έχει υποβληθεί ούτε εγκριθεί στο πλαίσιο κάποιου άλλου μεταπτυχιακού προγράμματος ή προπτυχιακού τίτλου σπουδών στην Ελλάδα ή στο εξωτερικό, ούτε είναι εργασία ή τμήμα εργασίας ακαδημαϊκού ή επαγγελματικού χαρακτήρα.

Δηλώνω επίσης υπεύθυνα ότι οι πηγές στις οποίες ανέτρεξα για την εκπόνηση της συγκεκριμένης εργασίας αναφέρονται στο σύνολό τους, κάνοντάς πλήρη αναφορά στους συγγραφείς, τον εκδοτικό οίκο ή το περιοδικό, συμπεριλαμβανομένων και των πηγών που ενδεχομένως χρησιμοποιήθηκαν από το διαδίκτυο. Παράβαση της ανωτέρω ακαδημαϊκής μου ευθύνης αποτελεί ουσιώδη λόγο για την ανάκληση του πτυχίου μου.»

Υπογραφή Μεταπτυχιακού Φοιτητή

Όνοματεπώνυμο

Γερασιμίνη-Ραφαηλία Ράββου

Στην οικογένειά μου.

Η Ήπια Παρέμβαση (Nudging) για τη Προώθηση της Αστικής Βιωσιμότητας σε Πόλεις της ΕΕ: Μετακίνηση, Ενέργεια και Διαχείριση Απορριμμάτων

Σημαντικοί Όροι: Αστική Βιωσιμότητα, Ήπια Παρέμβαση, Πράσινη Ωθηση, Τεχνικές Ωθησης, Συμπεριφορικά Οικονομικά, Βιώσιμες Συμπεριφορές, Βιώσιμη Αστική Κινητικότητα

Περίληψη

Η αντιμετώπιση της κλιματικής αλλαγής και η εξασφάλιση ενός βιώσιμου μέλλοντος για την ανθρωπότητα και τον πλανήτη απαιτούν σημαντικές αλλαγές στις καθημερινές πρακτικές των καταναλωτών, επιχειρήσεων και κυβερνήσεων. Οι βιώσιμες συμπεριφορές και δράσεις παίζουν καθοριστικό ρόλο στη διαμόρφωση αυτού του μέλλοντος, κάτι το οποίο είναι και το θέμα αυτής της μελέτης. Η παρούσα εργασία συνεπώς αφορά την τεχνική της “ώθησης” ή “ήπιας παρέμβασης” (nudge) και πώς εκείνη μπορεί να αξιοποιηθεί από δημόσιους φορείς και ευρύτερους οργανισμούς μιας πόλης ώστε να προωθηθούν οι βιώσιμες συμπεριφορές των πολιτών με έναν περισσότερο έμμεσο τρόπο.

Στα συμπεριφορικά οικονομικά, η ώθηση αναφέρεται σε μια τροποποίηση στον τρόπο παρουσίασης των επιλογών ενός ατόμου (“αρχιτεκτονική επιλογής”/choice architecture), με μοναδικό σκοπό την προβλέψιμη μεταβολή της συμπεριφοράς του. Η ώθηση επηρεάζει διακριτικά τη συμπεριφορά, κατευθύνοντας το άτομο προς μια συγκεκριμένη επιλογή, χωρίς να το εξαναγκάζει και χωρίς να εξαλείφει τις εναλλακτικές του. Για να χαρακτηριστεί ως απλή ώθηση, η παρέμβαση πρέπει να είναι εύκολη, η αποφυγή της να μην συνεπάγεται σημαντικό κόστος και η εφαρμογή της να μην αποκλείει τις υπόλοιπες διαθέσιμες επιλογές.

Ιδιαίτερη έμφαση δίνεται σε τέσσερις (4) συγκεκριμένους τύπους/τεχνικές ώθησης:

- (α) τις προεπιλεγμένες επιλογές (default options),
- (β) την ανατροφοδότηση σε πραγματικό χρόνο (real-time feedback),
- (γ) τις ωθήσεις που χρησιμοποιούν την ανάδειξη των φυσικών χαρακτηριστικών ή οπτικών ερεθισμάτων (salience or visual cue nudges)
- (δ) τις ωθήσεις που χρησιμοποιούν κοινωνικές νόρμες (social norms nudging).

Οι “βιώσιμες συμπεριφορές” (συμπεριφορές που προωθούν τη βιωσιμότητα) που θα εξεταστούν σε αυτή την εργασία επιλέχθηκαν με βάση τις μεγαλύτερες προκλήσεις που αντιμετωπίζουν οι πόλεις σε σχέση με τη βιωσιμότητα στη σύγχρονη εποχή. Αυτές αφορούν την Βιώσιμη Μετακίνηση, τη Βιώσιμη Κατανάλωση Ενέργειας και την Βιώσιμη Διαχείριση Αποβλήτων και Ανακύκλωση. Κάθε ένας από αυτούς τους πυλώνες της σύγχρονης αστικής βιωσιμότητας παρουσιάζεται μέσα από διάφορες ευρωπαϊκές πόλεις που εφάρμοσαν κάποιες συγκεκριμένες τεχνικές ωθήσεων (nudging techniques) ή χαρακτηριστικά αυτών για την προώθηση της εκάστοτε συμπεριφοράς - στόχου βιωσιμότητας που σχετίζεται με τον συγκεκριμένο πυλώνα.

Εν κατακλείδι, η παρούσα εργασία διερευνά και υπερτονίζει πώς οι μικρές αλλαγές συμπεριφοράς, που προωθούνται μέσω της ώθησης, μπορούν να συμβάλουν ως

συμπληρωματικό εργαλείο παράλληλα με ευρύτερες δομικές και ρυθμιστικές παρεμβάσεις. Χρειάζεται να σημειωθεί ότι η ώθηση δεν αρκεί από μόνη της για την αντιμετώπιση της συστημικής φύσης των προκλήσεων βιωσιμότητας, είτε αφορά αστικά περιβάλλοντα, αγροτικές περιοχές ή σε παγκόσμια οικοσυστήματα. Πλέον κρίνεται ολοένα και πιο αναγκαίο οι παγκόσμιοι πολιτικοί θεσμοί να αναλάβουν γρήγορη και αποφασιστική δράση για να ρυθμίσουν τις οικονομικές και περιβαλλοντικές δραστηριότητες των μεγάλων εταιρειών, οι οποίες ευθύνονται για ένα σημαντικό ποσοστό της περιβαλλοντικής υποβάθμισης που παρατηρείται σήμερα.

Nudging for Sustainability in EU Cities: Transport, Energy and Waste Management)

Key Words: Nudging, Urban Sustainability, Sustainable Cities, Behavioural Economics, Sustainable Transport, Modal Shift

Abstract

Addressing climate change and ensuring a sustainable future for mankind and the planet alike require significant shifts in the everyday practices of consumers, businesses and governments. Sustainable behaviours and actions therefore play a decisive role in shaping this future, which is the focus of this study. Emphasis is therefore placed on how residents within urban areas can be influenced into adopting more sustainable behaviours through techniques rooted in behavioural economics. The focus of this dissertation concerns the “nudge/nudging” or “soft intervention” technique found in behavioural economics theory and how it can be utilised by public bodies and broader organisations of a city to promote sustainable behaviours within urban environments in a more subtle and indirect way.

In behavioural economics, a nudge refers to a modification in the way of presenting an individual’s choices (choice architecture), with the sole aim of predictably changing his behaviour. Nudging therefore subtly influences behaviour, directing individuals towards a specific choice, without forcing them and without eliminating their alternatives. To be characterised as a “simple nudge”, the intervention must be easy, its avoidance must not entail significant costs (financial or otherwise) and its implementation must not exclude the remaining available options.

Special emphasis is given on (4) four specific nudge types/techniques:

- (a) default nudges,
- (b) real-time feedback,
- (c) salience or visual cue nudges and
- (d) social norms nudges.

The “sustainable behaviours” (behaviours that promote sustainability) examined in this dissertation are selected based on the major challenges that cities face in relation to sustainability in the modern era. These relate to Sustainable Transport, Sustainable Energy Consumption and Sustainable Waste Management and Recycling. Each of these pillars of modern urban sustainability is presented through various European cities that implement elements of nudging techniques to promote the respective target sustainability behaviour associated with each pillar.

In conclusion, this dissertation explores and emphasises how small behavioural changes, promoted through nudging, can serve as a complementary tool alongside broader structural and regulatory interventions. As a final remark, it must be noted that nudging alone is not sufficient to address the systemic nature of sustainability challenges, whether in urban environments, rural areas, or global ecosystems. It is increasingly necessary for global political institutions to take swift and decisive action to regulate the economic and environmental activities of large

corporations, which are responsible for a significant portion of the environmental degradation observed today.

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Chapter 1

URBAN SUSTAINABILITY, SUSTAINABLE DEVELOPMENT AND URBANISATION IN THE 21ST CENTURY

*“The ice age is coming, the sun’s zooming in
Meltdown expected, the wheat is growing thin”*

– London Calling, The Clash

1.1 Introduction

The term sustainability comes from the Latin word *sustinere*, a verb that translates “*to sustain*”, meaning “*to maintain, support, uphold, or endure*”. Sustainability is defined then as the general “*ability to continue an activity over a long period of time*”. This can refer to the ability for environmental, social or economic well-being and for current generations to exist in the present without damaging future ones. The eponymous “Brundtland Commission” significantly shaped the modern meaning of sustainable development, providing a definition for the word for the first time at the 1983 United Nations’ Commission on Environment and Development. The report titled “Our Common Future”, defined it as:

“Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs”

Urban sustainability then is the process of applying the principles of modern sustainability into urban environments. It refers to cities that meet present needs while simultaneously preserving environmental, social and economic systems for future generations to come. Urbanisation is a process that is also tightly linked to urban sustainability. It is used to refer to the population shift from rural to urban areas, as well as the corresponding decrease in the proportion of people living in rural areas, increasing population “density” in cities and decreasing it in other areas.

Modern urbanisation historically refers to the period after the advent of industrial capitalism and the First Industrial Revolution taking place roughly in the 18th century. That was when modern humans first left their tightly knit communities in rural, feudal areas to join the workforce in big cities, participating in the broader liberalisation of the nature of work and capital. Since then, urbanisation has been a force ever-expanding in the globe, that also trends upwards in future predictions.

During the last two centuries alone, the percentage of the world's population currently inhabiting urban areas has risen significantly. It is currently estimated at about 50% and is projected to rise to near 70% by 2050, as shown in Chart 1.1 below. These numbers are backed by numerous organisations, including the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD) and The World Bank.

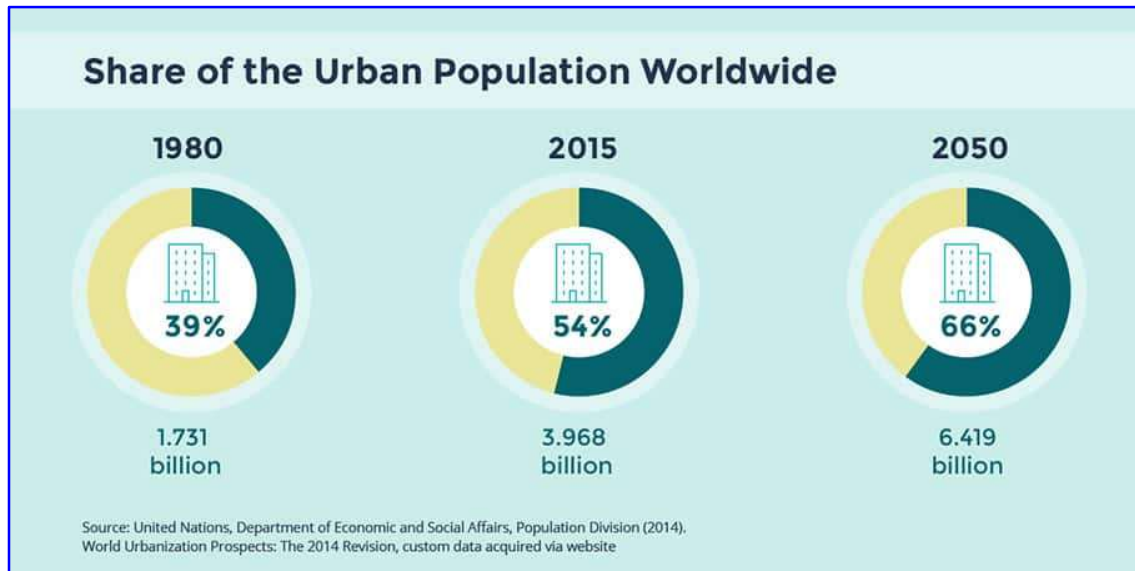


Chart 1.1: Share of the Urban Population Worldwide (source: United Nations)

Despite those significantly large numbers, the process itself has not yet reached its peak. In fact, global urbanisation is expected to continue until a projected peak in 2080, when 85-90% of the world's population could inhabit cities, according to the United Nations' review titled "World Population Prospects 2024". Projections indicate that the global urban population will continue to grow significantly, with the United Nations projecting two-thirds of people living in cities by 2050.

Researchers (McGranahan, 2007) that study the phenomenon note that urbanisation can be harnessed and driven to produce a force against climate change, rather than working for it. This further intensifies the need for the development of sustainable lifestyles and ways of being for the residents living in highly population-concentrated urban areas. Different policy instruments have been explored in the past, with nudging being considered as one low-cost, non-intrusive form of intervention that can elicit sustainable behaviour-change. In this way, urban areas with residents that have developed high environmental consciousness can serve globally as hubs of sustainability that promote climate change action (W. Fang, 2014).

1.2 Urban Household Activity and Environmental Degradation

The most important environmental challenges that modern cities of the world face today due to rising levels of urbanisation include urban emissions driven by energy overconsumption, air

quality degradation driven by transport, waste management issues, overheating, water quality degradation and loss of natural green spaces.

Overheating can be seen as a secondary effect, as the outcome of mainly urban emissions from buildings and vehicles and the subsequent air degradation and for this reason will not be analysed separately. Similarly, water quality degradation can also largely be seen as an outcome to (but not limited to) waste mismanagement. Most of these issues are in fact highly interconnected, with urban activities directly contributing to global climate change, which then in turn are making cities more vulnerable to other natural disasters like floods and droughts, ultimately producing a vicious cycle of unsustainability. The loss of natural green spaces also will not be analysed separately, not for lack of importance, but because it also connects to the broader city infrastructure and for this can be seen as secondary.

Special importance to all this will be placed on individual household environmental activity, especially regarding transport, consumption and waste management and recycling, as the nudging interventions that are further analysed will be regarding individual residents' activity, designed to propel them towards sustainable actions.

1.2.1 Urban Emissions and Household Energy Consumption

Urban emissions refer to the release of various air pollutants, including gases and particulates, from sources within cities and other urban areas. With the concentration of many resources in a limited space that drive consumption and population rates, modern cities currently serve as global "CO₂ hotspots". As shown in Figure 1.1, the main contributing sectors for city emissions are: Commercial and Residential Buildings, Industry, Electricity Power Plants and Transport. As will be explored in later chapters, behavioural interventions that incorporate nudging have been implemented in urban environments across Europe in the past for sustainable transport and sustainable energy consumption.

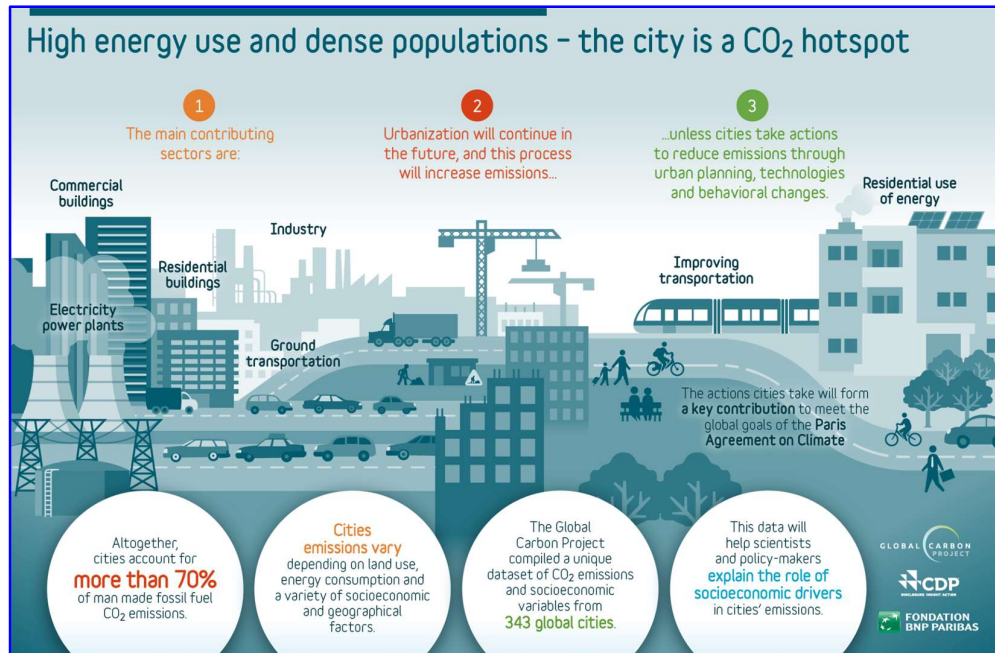


Figure 1.1: City Emissions (source: Global Carbon Atlas)

Studies worldwide seem to conclude that energy, transport and buildings are the sectors that show the most pollution on a global scale. A lot of research throughout the years has been focusing on determining the exact percentage of total CO₂ emitted from each sector. One study (D. Y. Ahn, 2023) found that 890 million tons of FFCO₂ are emitted from 78 C40 cities annually. Across the 78 C40 cities, the Energy Sector contributes 17% to citywide FFCO₂ emissions, the residential/commercial/industrial sector contributes 32%, while the transportation sector contributes the most, at 51%.

It was also found that regionally, cities in Europe have the largest energy sector contribution to CO₂ emissions in that subset of cities ($33 \pm 30\%$), and cities in North America have the lowest energy sector contribution ($7 \pm 10\%$). Transportation contributes the most to FFCO₂ emissions in cities in Latin America ($65 \pm 18\%$) and the least in Central East Asian cities ($32 \pm 24\%$). Socioeconomic factors such as population, area and population density are also shown to be positively linked with citywide CO₂ emissions.

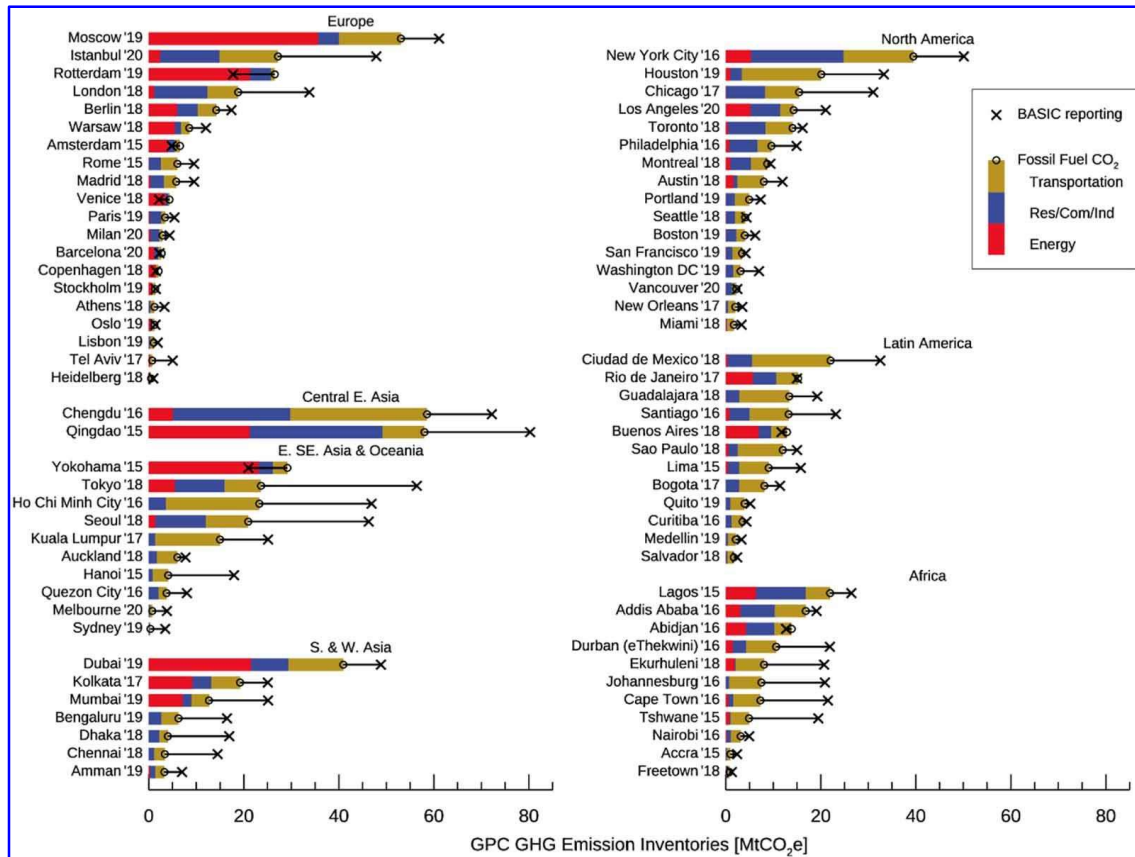


Chart 1.2: FFCO2 Emissions Submitted by 78 C40 Cities (source: Environmental Research Letters, IOPScience)

The IPCC's Sixth Assessment Report (P.R. Shukla et al., 2022) found that global net greenhouse gas (GHG) emissions that are derived from human activity reached their highest levels in human history during the decade 2010–2019. The analysis further highlighted that, worldwide, increases in per capita gross domestic product (GDP) and population growth were the dominant forces driving the rise in CO₂ emissions from fossil fuel combustion. In 2019 the energy sector accounted for approximately 34% of global emissions, followed by industry at around 24%, transport at 15%, and buildings at 5.6% when considering direct emissions only (Summary for Policymakers, paragraph B.2.1).

Urban energy consumption refers to the total amount of energy used within a city's systems, including buildings, transportation and industry. Energy consumption in urban environments is positively linked to urban emissions. A city that consumes more, produces more emissions and vice versa, since most cities still largely depend on the use of fossil fuel for most of their activities. The main sector drivers of urban energy use that also drive emissions are buildings (use of heating, cooling, lighting, appliances), transport (private cars, aviation, urban public transport) and industry.

While corporations are commonly found responsible for much of the degradation that urban environments experience today, residential household consumption still holds an important role in it that needs to be addressed for sustainability to finally become a concrete reality within cities. There have been several studies and researchers over the years that

highlight this. Most notably, Ivanova et al. (2016) and Hertwich and Peters (2009) have estimated that **household consumption accounts for approximately 72% of global greenhouse gas emissions**. The 2009 study also specified that food accounts for 20% of GHG emissions, operation and maintenance of residences for 19% and mobility for 17%.

However, all households though do not pollute alike, as there are socioeconomic criteria that define residential areas which play a more important role in determining the level of pollution experienced within cities. The 2016 (Ivanova et al.) study that found that household consumption drives over 60% of global greenhouse gas emissions and 50 to 80% of total land, material and water use also found that higher income levels directly correlate to higher per capita environmental impacts. **Urban affluence**, as was noted in another study (McGranahan, 2007), was found to positively coincide with increased pollution. This means that the concentration of high income, wealth and elevated consumption patterns within cities tends to produce the most polluting neighbourhoods. In that fortunate state of economic prosperity, where residents have significant disposable income, high purchasing power and access to a wide array of specialised services and luxury goods, high consumption patterns again mean increased pollution.

When it comes to residential and commercial buildings, most existing urban infrastructure has been deemed as largely unsustainable (Luqman, 2023), with statistics (World Bank, 2021) showing that, while urban areas occupy just 2% of the planet's land area, they are nonetheless responsible for more than 70% to 75% of global energy-related CO₂ emissions. This increased energy consumption in urban areas as compared to rural areas can lead to future strained food resources, especially in countries already facing food insecurity due to changing environmental conditions.

1.2.2 Air Pollution Caused by Private Vehicle Use

Air pollution refers to the concentration of substances (pollutants) in the air in levels that are endangering the health of humans, other living beings and the environment. Those substances can exist in the form of gases, like ozone or nitrogen oxides, or small particles like soot and dust, both indoors and outdoors. To quantify the negative load of air pollution, it is important to mention 7 million premature deaths annually are estimated to be caused by it (WHO, 2014) and is therefore recognised as a major risk factor for a wide range of non-communicable diseases, including stroke, heart disease, asthma and lung cancer. Beyond human health, air pollution is also damaging for ecosystems and economies alike: ground-level ozone reduces agricultural yields, while the pollutants that cause acid rain degrade forests and freshwater systems. The World Bank (2016) has estimated that the combined welfare losses from premature mortality and productivity losses from reduced labour capacity amount to more than 8 trillion dollars per year.

Motorised traffic, especially from older diesel vehicles, releases significant amounts of harmful pollutants, the “classic” ones being lead, total suspended particles (TSP), ozone, carbon monoxide (CO), Sulphur dioxide (SO₂), Nitrogen dioxide (NO₂), as well as other air toxin emissions such as benzene and poly-aromatic hydrocarbons (PAHs). Extensive private vehicle

use that coincides with older vehicles is also found to be linked to increased air pollution within urban areas.

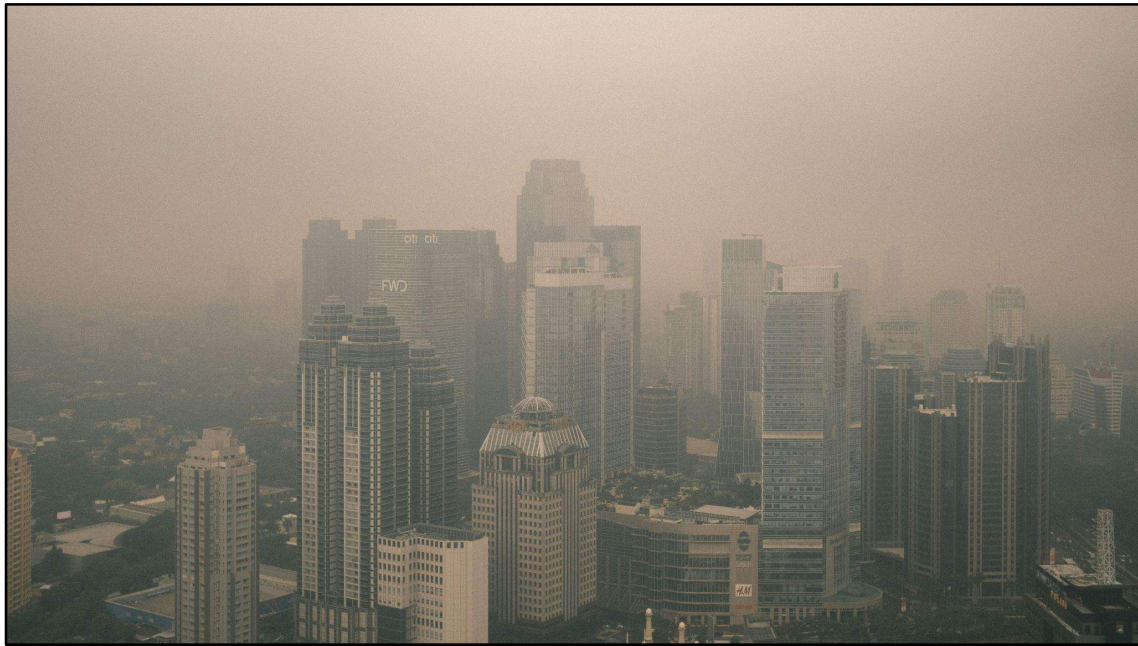


Figure 1.2: City skyline obscured by dense smog and haze in Jakarta, Indonesia by David Kristianto (@davidkristianto)

Exposure to outdoor air pollution is most severe in lower to middle income countries. More specifically, pollution tends to increase with economic growth at an exponential rate, until finally reaching a single point or peak where the economy finally starts incorporating cleaner technologies. This is called the “turning point”, reflecting the dynamics described by the environmental Kuznets curve (Chart 1.4). This framework suggests that pollution levels peak in economies heavily dependent on manufacturing before environmental regulation and cleaner technologies become a priority. Indoor air pollution is similarly most acute in low-income countries, particularly across Southeast Asia, the Western Pacific, as well as parts of Africa, where reliance on solid fuels for cooking and heating remains widespread.

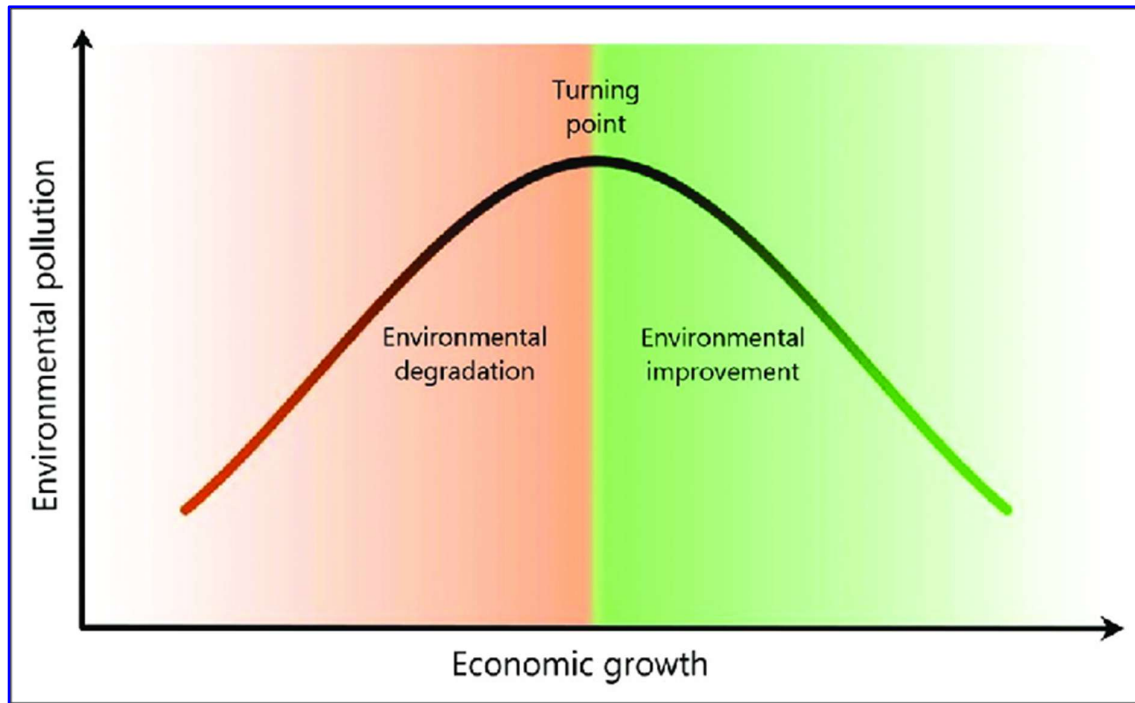


Chart 1.4: Environmental Kuznets Curve (source: *Nexus between Nuclear Energy, Economic Growth, and Greenhouse Gas Emissions in India*, Research Gate)

1.2.3 Household Waste Generation and Recycling

Waste generation refers to the mass creation of materials and substances, considered worthless or of no further use by their owner, that are usually no longer desired or have no economic value. As such, it encompasses all discarded materials produced from human activities such as industry, agriculture, mining and households, leading to a stream of solid, liquid, or gaseous wastes that require management and disposal. Solid or physical waste refers to often discarded materials like trash and debris, while liquid waste consists of liquids such as sewage, chemicals, and industrial wastewater. The term “waste generation” specifically refers to the amount of waste produced before it is diverted to be processed (or managed) for recycling, composting, landfilling, or incineration.

Waste management is the process of systematic collecting, treating, recycling and disposing of waste materials, that aims at minimising negative impacts on human health and the environment by conserving natural resources, reducing pollution and promoting a circular economy, turning waste into valuable resources. It involves processes from the moment waste is created to its final resting place (“from the cradle to the grave”), including reducing waste generation, reusing materials, recycling them into new products, and safely disposing of what remains.

Global waste generation is currently trending upwards at an unprecedented pace. As countries transition from low to middle and high-income status, their waste management systems evolve in both scale and complexity. Charts 1.5 and 1.6 respectively show that economic growth and urbanisation are closely associated with rising per capita waste

generation, as higher levels of consumption usually accompany greater prosperity. Rapid urban expansion and population growth lead to increasingly dense population centres, making it progressively more challenging to ensure comprehensive waste collection and to secure adequate land for treatment and disposal facilities.

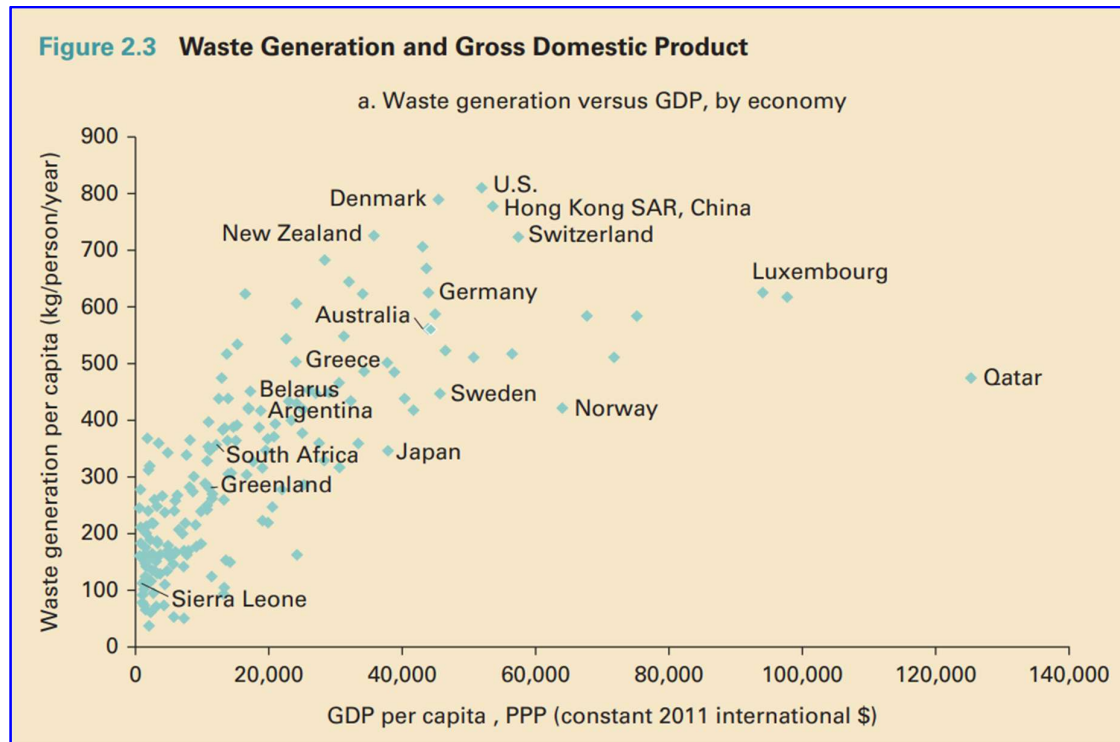


Chart 1.5: Waste Generation and Gross Domestic Product a. Waste Generation Versus GDP, by Economy (source: Figure 2.3a. of the World Bank's report "What a Waste 2.0", 2018)

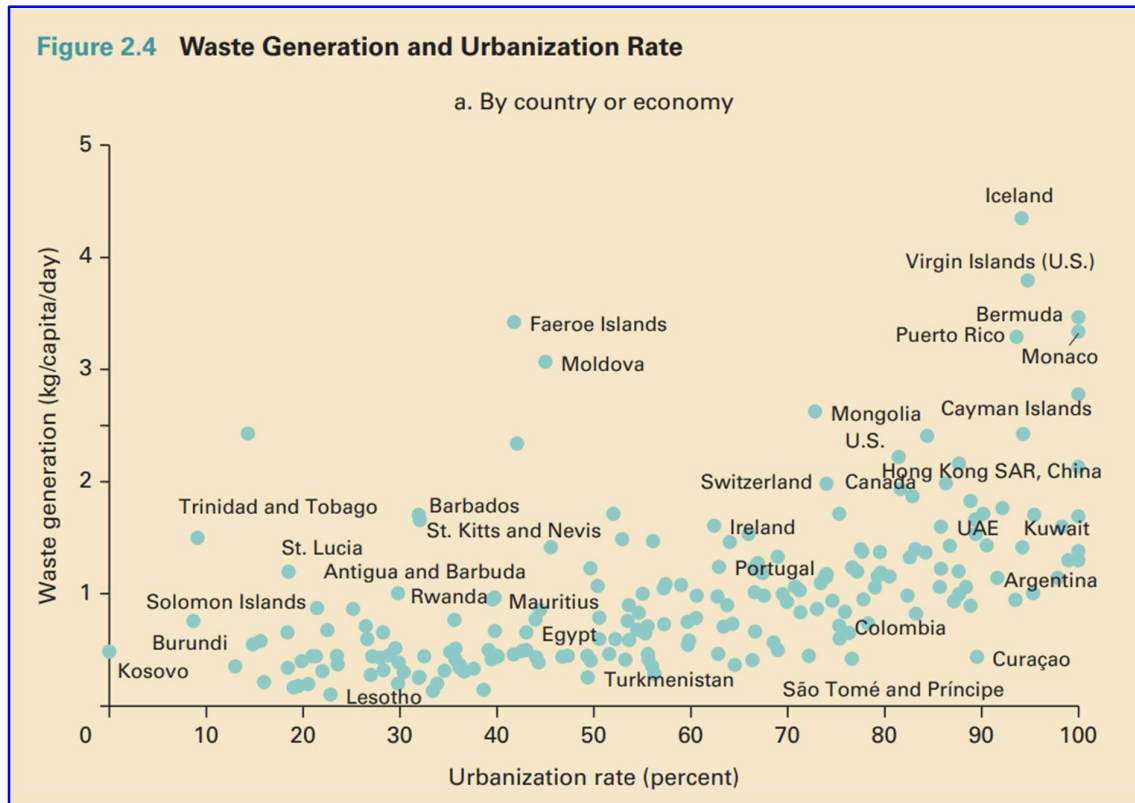


Chart 1.6: Waste Generation and Urbanisation Rate a. By Country or Economy (source: Figure 2.4a. of the World Bank's report "What a Waste 2.0", 2018)

In low-income countries, approximately 48% of waste is collected in urban areas, while collection rates fall steeply to about 26% in rural regions. This reflects a pronounced disparity in waste management coverage between cities and the countryside (World Bank, 2018). When it comes to future estimations, the figures are again striking: the World Bank (What a Waste 2.0, 2018) projects that global waste production will soar from 2.01 billion tonnes in 2016 to 3.40 billion tonnes by 2050. Out of that waste, around 33% is still handled unsafely today, often disposed of in open dumps or burned in the open air. Globally, an average of 0.74 kilograms of waste is generated per person per day, though national figures vary considerably, ranging from 0.11 to 4.54 kilograms per capita daily. This variation closely correlates with both income level and degree of urbanisation. High-income countries and advanced economies tend to be more urbanised and consequently generate greater amounts of waste, both in total and on a per capita basis. At the regional scale, North America, which has the world's highest urbanisation rate of approximately 82%, produces around 2.21 kilograms of waste per person per day, whereas Sub-Saharan Africa, with an urbanisation rate of only 38%, generates about 0.46 kilograms per person per day, as shown in Chart 1.7.

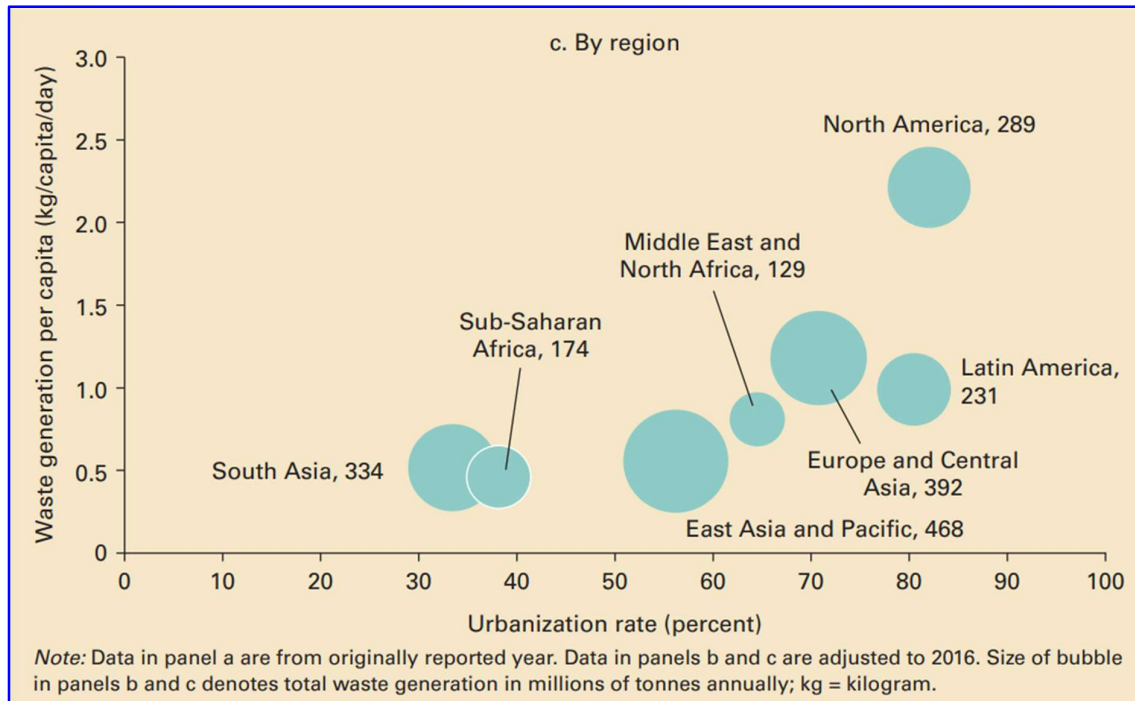


Chart 1.7: Waste Generation and Urbanisation Rate c. By Region (source: Figure 2.4c. of the World Bank's report "What a Waste 2.0", 2018)

According to Eurostat (2022) each European generated on average five tonnes of waste in 2022, which adds up to more than 2.2 billion tonnes in total. As shown in Figures 1.3 and 1.4 below, construction saw the highest rates of waste generation in the EU, it being 38.4% of all waste generated, followed by mining and quarrying (22.7%), waste and water services (10.5%), manufacturing (10.4%) and households (8.9%). Other economic activities, mainly services (5.2%) and energy (3.0%), generated the remaining percentage (9.2%).

Waste generation by economic activities and households, 2022

(% share of total waste)

	Mining and quarrying	Manufacturing	Energy	Waste/water	Construction and demolition	Other economic activities	Households
EU	22.7	10.3	3.0	10.5	38.4	6.1	9.0
Belgium	0.0	12.6	0.2	24.7	41.4	13.4	7.7
Bulgaria	72.4	5.5	10.0	4.4	1.6	3.5	2.6
Czechia	0.3	12.5	1.0	13.5	43.8	17.9	11.0
Denmark	0.1	5.6	4.0	7.7	56.1	10.0	16.6
Germany	1.3	14.4	2.1	13.1	55.1	4.7	9.4
Estonia	11.5	17.2	50.2	3.5	9.0	6.0	2.6
Ireland	8.8	31.3	1.6	13.4	18.5	14.3	12.0
Greece⁽¹⁾	11.6	14.5	5.8	13.5	33.5	7.8	13.4
Spain	7.0	12.0	0.8	19.6	30.6	9.9	20.0
France	0.1	5.3	0.2	7.3	71.6	5.3	10.0
Croatia	10.0	7.6	1.4	20.1	24.8	18.8	17.3
Italy	0.8	14.9	1.2	21.5	42.5	3.8	15.3
Cyprus	5.4	15.0	0.1	12.5	28.0	26.3	12.7
Latvia	0.1	12.3	1.1	36.3	12.5	9.9	28.0
Lithuania	0.4	19.2	3.8	23.1	9.9	18.7	24.9
Luxembourg	8.2	6.0	0.2	4.5	75.3	3.2	2.6
Hungary	0.2	16.0	18.3	4.0	37.4	6.2	17.9
Malta	1.5	0.9	0.0	6.4	77.7	6.1	7.4
Netherlands	0.1	10.8	0.5	7.7	64.7	9.5	6.8
Austria	0.0	7.9	0.6	3.9	76.6	4.9	6.1
Poland	36.5	14.8	7.9	13.9	12.3	6.6	8.0
Portugal	0.2	15.7	1.1	20.5	19.7	15.6	27.2
Romania	85.2	4.1	3.4	1.8	0.5	2.1	2.8
Slovenia	0.1	12.9	4.3	3.4	6.6	67.0	5.7
Slovakia	1.2	27.0	6.7	9.4	9.8	26.5	19.4
Finland	76.4	9.4	0.9	1.0	9.6	1.2	1.5
Sweden ⁽²⁾	77.3		1.2	5.2	8.3		2.6
Iceland ⁽³⁾	0.0	24.2	0.0	2.0	3.6	31.0	39.2
Liechtenstein	0.0	0.6	0.0	0.3	91.8	0.1	7.3
Norway	1.6	13.9	2.0	8.7	39.3	18.7	15.9
Montenegro	21.0	1.8	26.6	0.7	18.4	11.2	20.2
North Macedonia	26.1	25.8	0.5	11.5	3.4	6.1	26.6
Serbia	93.2	0.6	3.7	0.5	0.4	0.3	1.3
Türkiye	24.1	20.3	25.4	0.3	0.0	5.3	24.6
Albania ⁽⁴⁾	1.0	68.0	0.0	6.2	0.0	24.9	0.0
Bosnia and Herzegovina	0.2	35.6	47.2	0.0	1.6	0.5	15.0
Kosovo ⁽⁵⁾	0.3	10.2	84.6	0.4	2.5	2.0	0.0

(¹) provisional data.

(²) confidential data on waste generated by manufacturing.

(³) 2020 data.

(⁴) 2021 data.

(⁵) This designation is without prejudice to positions on status, and is in line with UNSCR 1244/1999 and the ICJ Opinion on the Kosovo Declaration of Independence.

Source: Eurostat (online data code: env_wasgen)

Figure 1.3: T1 Waste generation by economic activities and households, 2022 (% share of total waste) (Source: Eurostat, Waste statistics - Statistics Explained - Eurostat)

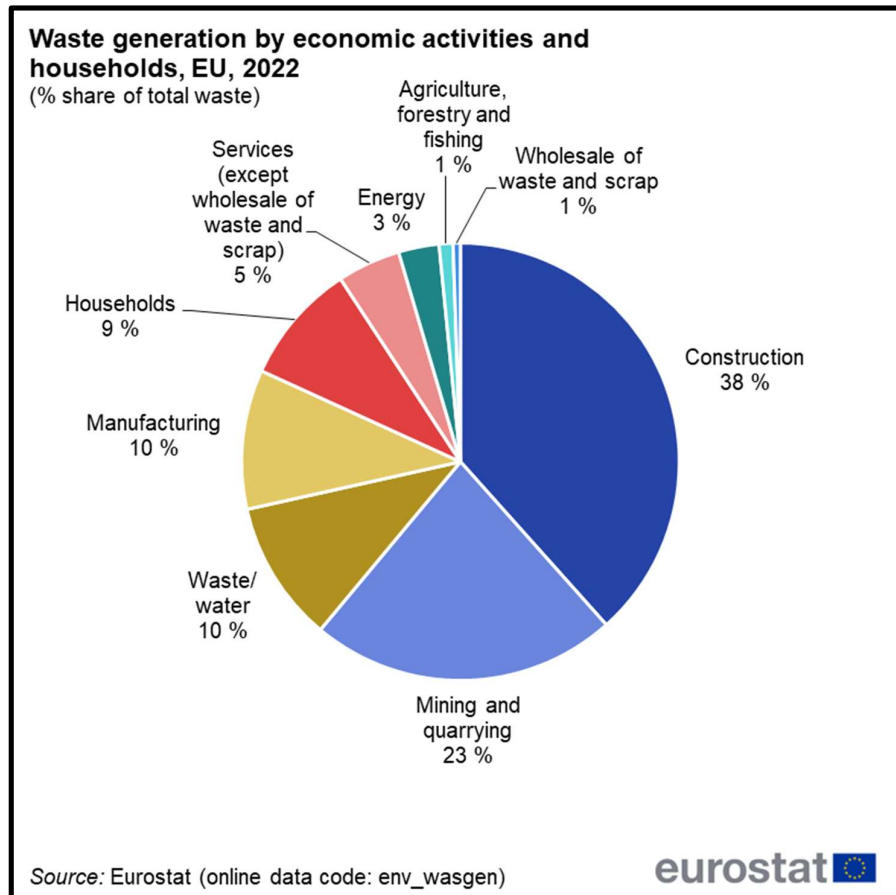


Figure 1.4: Waste generation by economic activities and households, EU, 2022 (% share of total waste) (Source: Eurostat, [Waste statistics - Statistics Explained - Eurostat](#))

According to official statistics (Eurostat, 2022), in 2022 40.8% of waste were recycled and 30.2% landfilled in the EU. In 2022, approximately 1,992 million tonnes of waste were treated in the EU, which does not include exported waste, but does include the treatment of waste imported into the EU. Figure 1.5 below depicts the development of total waste treatment in the EU, as well as for the two main treatment categories: recovery and disposal, during the period 2004-2022.

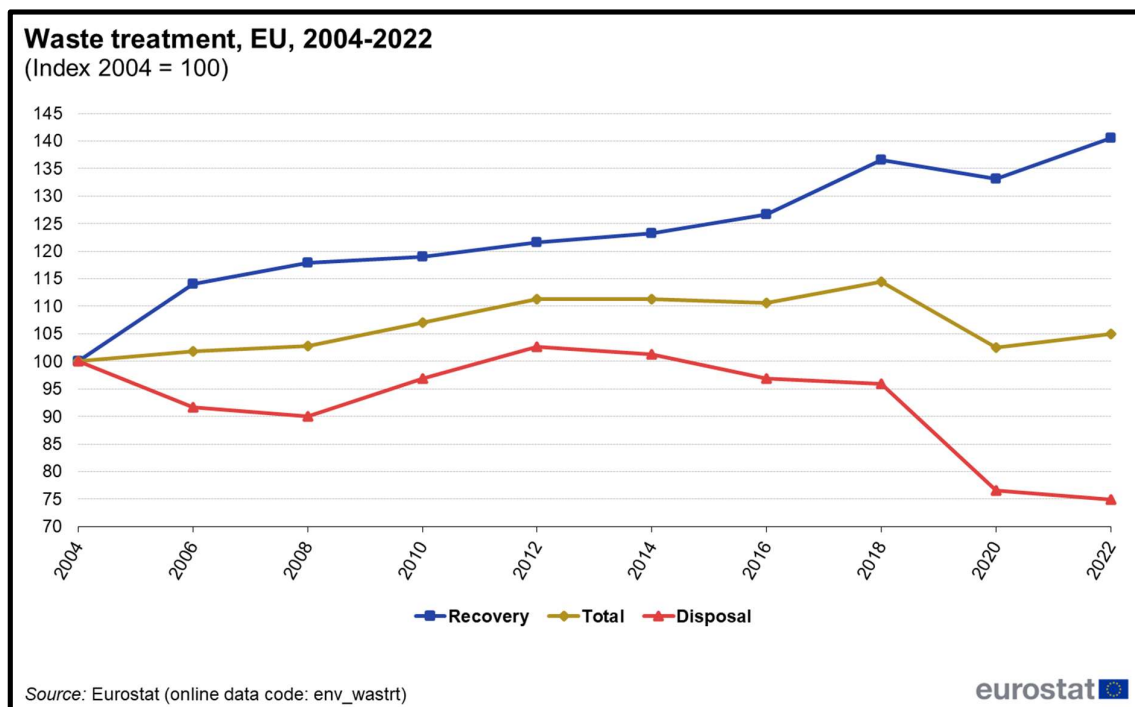
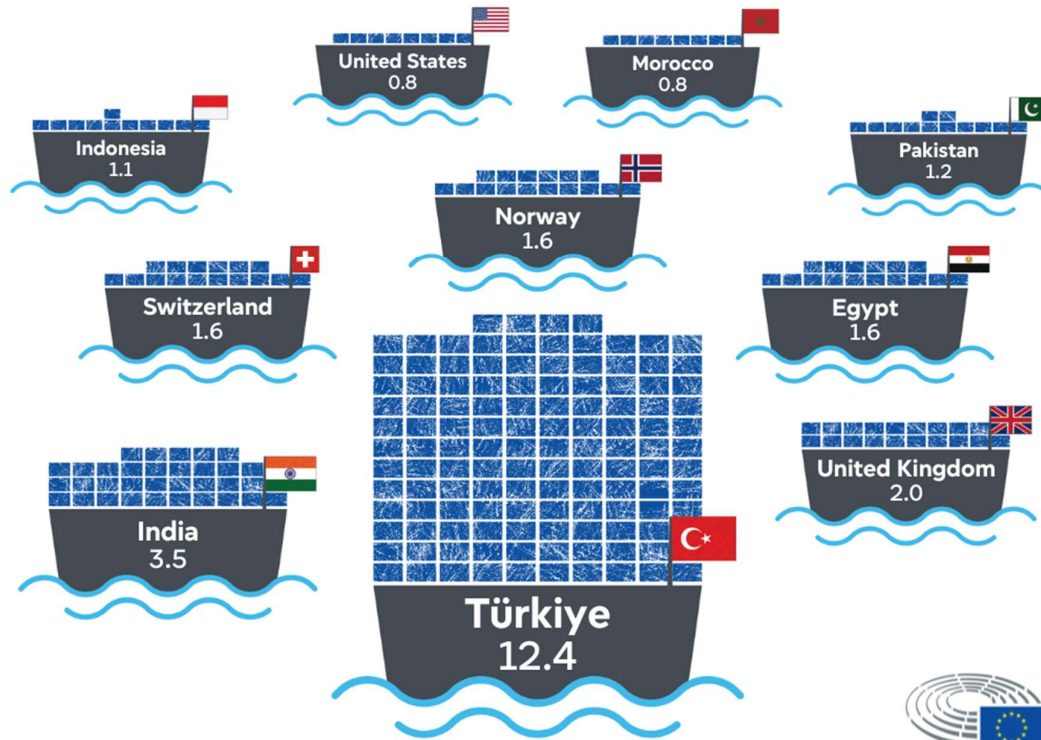


Figure 1.5: Waste treatment, EU, 2004-2022 (Index 2004 = 100) (Source: Eurostat, [Waste statistics - Statistics Explained - Eurostat](#))

Backfilling refers to the use of waste in excavated areas for the purpose of slope reclamation, safety or for engineering purposes in landscaping. The amount of waste recovered or recycled which was used for backfilling or incinerated with energy recovery, increased by 40.6% from 870 million tonnes in 2004 to 1,223 million tonnes in 2022. The resulting outcome was that the share of such recovery in total waste treatment rose from 45.9% in 2004 to 61.4% in 2022. The quantity of waste subject to disposal decreased from 1,027 million tonnes in 2004 to 769 million tonnes in 2022, a 25.1% decrease. The share of disposal in total waste treatment decreased from 54.1% in 2004 to 38.6% in 2022.

According to the European Parliament, in 2022 waste exports to non-EU countries totalled approximately 32.1 million tonnes, which represents a modest decline of about 3% compared to 2021 levels. More than half of these exports (around 55%) consisted of ferrous metal waste, primarily iron and steel, with Türkiye serving as the main destination. Paper waste accounted for roughly 15% of total exports, with India emerging as the largest recipient. In terms of overall distribution, Türkiye received the largest share of EU waste exports in 2022 (approximately 12.4 million tonnes, or 39%), followed by India (3.5 million tonnes), the United Kingdom (2.0 million tonnes), Switzerland (1.6 million tonnes) and Norway (1.6 million tonnes).

Main destinations for **waste** from the EU (in million tonnes)



Source: Eurostat [env_wastrdmp] · most recent data available (2022)



Figure 1.6: Infographic showing the principal waste destinations from the European Union
(Source: Eurostat)

According to the European Environment Agency (EEA) in an article published in 02 December 2024 on its website titled “Waste Generation in Europe”, patterns of waste generation have historically mirrored broader economic cycles. As periods of economic expansion tend to be accompanied by rising waste volumes, downturns, such as the COVID slowdown of 2020, temporarily reduce overall waste output, followed again by increases during recovery phases. Although the European Union has set the objective of significantly reducing total waste generation by 2030, recent data suggest that the structural link between economic growth and waste production has not been fully broken. While some signs of relative decoupling are evident, meaning waste has grown more slowly than GDP in certain periods, absolute reductions remain limited.

1.3 The Three Pillars of Urban Sustainability

As seen in Subchapter 1.3, the main “culprits” for most environmental degradation in urban areas are urban emissions driven by energy overconsumption, air quality degradation driven by transport and waste generation mismanagement. For sustainability then, these all can be summarised into three big categories: **Urban (Sustainable) Transport, Urban (Sustainable) Energy Consumption and Urban (Urban) Waste Generation and Management**. It is useful to think of these categories as “pillars”, as they can have precisely the ability to serve as the “sustainability-backbones”, the fundamentals upon which the city can environmentally thrive. If one of the pillars is lacking in some way, this then can put the whole structure at stake, with sustainability taking the back seat and the environment and human populations suffering for it.

Each of the three encompassing categories connect with specific environmental effects of urbanisation and urban household activity. Urban Transport is mostly connected to urban private vehicle emissions and air pollution, which in turn cause overheating and the loss of natural green spaces. Urban Energy Consumption on the other hand is more connected to urban emissions from residential buildings and energy overconsumption, responsible again for air quality degradation and overheating. Lastly, Urban Waste Generation is naturally connected to waste management issues and recycling.

Finally, because the nudging interventions that will be discussed focus on encouraging sustainable lifestyles on an individual level, the following pillars will be distilled in chapter 3 to regard just the environmental effects from household vehicle use, household energy consumption, as well as household recycling.

1.3.1 Pillar 1: Transport

Achieving sustainable urban transport is a multi-level and multi-variable process that requires technological innovation, infrastructure investment, rigorous and innovative policy and coordinated planning in the city and nation-level. Most of the policies used fall into two major categories or strategies, that either discourage in some way the use of private cars and encourage alternative modes of transport, or improve in some way the use of cars. In this study these categories are classified as “Strategy A” and “Strategy B”.

These two all-encompassing strategy domains for achieving sustainable transport are widely recognized in both urban mobility research and EU policy frameworks, in the EU Urban Mobility Framework, Sustainable Urban Mobility Plans (SUMPs), as well as the European Green Deal. They represent the theoretical foundations for Europe’s transition toward a climate-neutral transport system. Public policy instruments that are motivated by behavioural science, like nudging, are a relatively newer “invention” that can significantly aid in this green transition for both modal shift and improving private car use.

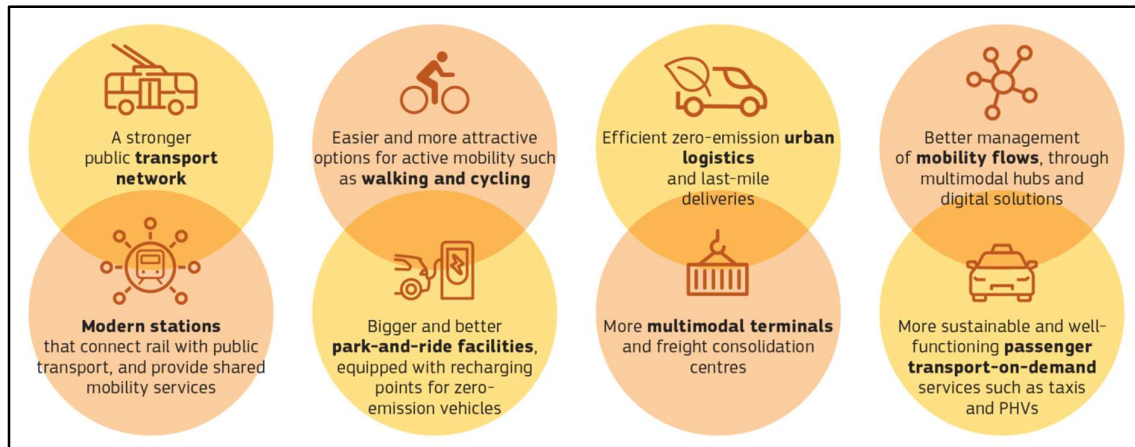


Figure 1.7: Sustainable Urban Mobility Toolbox (Source: European Commission, https://transport.ec.europa.eu/transport-themes/urban-transport/sustainable-urban-mobility_en)

Strategy A: Encourage Modal Shift, Discourage the Use of Private Vehicles

Strategy A points out policies that encourage **transport modal shift** aimed at reducing private car use all-together and facilitating the shift towards sustainable modes of transport, such as via public transport (buses, trains etc), walking or cycling. Here “active mobility” takes the lead stage, with walking and cycling famous for their benefits for the environment and the human body alike, as low-cost, low-emission and healthy ways of transport in urban areas.

The **EU Urban Mobility Framework** (European Parliament, 2023) in specific was established to talk openly about challenges with urban mobility that modern cities face, as well as increase the total percentage of sustainable transport modes (public transport and active mobility in particular) as well as zero-emission urban logistics, last mile deliveries and urban fleets in the form of taxis and ride-hailing services. To help the European Union reduce greenhouse gas emissions by at least 55% by 2030 and by 90% by 2050, the Urban Mobility Framework initiative proposes measures to encourage EU Member States to develop urban transport choices that are low-danger, easily accessible, non-exclusive, low-cost, smart, long-standing and low-emission.

The EU Urban Mobility Framework promotes active mobility by using information campaigns that highlight its benefits, including the growing role of e-bikes, as well as strengthens policy support by prioritising active modes in updated **Sustainable Urban Mobility Plans** (European Commission, 2019), encouraging employers to promote active travel through mobility management plans, improving safety standards for vulnerable road users and linking EU funding for urban mobility projects to the existence of SUMP and a safe-system approach. Complementing this, the revised TEN-T Regulation or Trans-European Transport Network (European Union, 2024) advances active mobility by requiring 431 major cities and regional hubs to adopt SUMP and collect relevant data by 2027. This further ensures that multimodal urban hubs support “first-” and “last-mile” connections, which guarantees continuous and accessible cycling infrastructure across transport networks, expanding bicycle parking near railway stations.

The EU promotes safe active mobility also through advanced research and innovation, notably via Horizon-funded road safety projects and continued support under the Horizon Europe (European Union, 2021) programme. Policy measures also reinforce practical uptake, including new requirements under the revised Energy Performance of Buildings Directive for adequate bicycle and e-bike parking, as well as readiness for charging infrastructure in both public and residential buildings. Active mobility is further highlighted as a key tool for reducing dependence on fossil fuels in the EU Save Energy Communication (European Commission, 2022) under the REPowerEU (European Commission, 2022) package. In addition, the Mobility Transition Pathway (European Commission, 2023) now formally includes the bicycle industry value chain within the wider mobility ecosystem, supporting its green and digital transition while strengthening competitiveness and resilience. Stakeholders are actively involved in shaping this pathway through pledges and joint commitments, with further opportunities for participation expected in the next round of submissions.

Strategy B: Improve the Use of Private Vehicles

Relying on primarily sustainable modes of transport alternative to car use for enhancing sustainability can be proven quite useful for accelerating sustainable mobility but cannot be deemed as “the only way forward”. The use of private vehicles can be “made green” via policies that focus on **improving energy efficiency** of existing vehicles, reducing fuel consumption and their subsequent emissions. Increasing the replacement of old, fuel inefficient vehicles and increasing the adoption of newer, cleaner private cars is another example of improving the use and not strict modal shift, since it doesn’t replace one mode of transport for another but merely enhances it.

In the section “Accelerating the Shift to Sustainable and Smart Mobility” of the European Green Deal, it is written that: “In December 2020, the Commission proposed a Sustainable and Smart Mobility Strategy. The strategy is based on three pillars:

1st Pillar: Make all modes of transport more sustainable

2nd Pillar: Make sustainable alternatives widely available
in a multi-modal transport system

3rd Pillar: Put in place the right **incentives** to drive the transition

It sets out a vision for 2030, 2035 and 2050. For 2030, the strategy plans to have at least 30 million zero-emission cars on the streets of Europe (For comparison, in 2018 there were 292 million registered cars in Europe)."

From this it is easy to extrapolate how pressing it is the need for the replacement of conventional cars with others that are zero-emission. When referring to incentivisation under pillar 3, “put in place the right incentives to drive the transition”, nudging theory can be deemed helpful, since it focuses on subtly shaping behaviour without restricting choice. In this context, incentives can act as effective nudges, influencing decisions through small, well-designed interventions that make sustainable transport options more attractive, convenient or socially desirable, rather than through direct regulation or compulsion, as will be explored in more detail in Chapters 2 and 3.

Another factor that plays a major role in the achievement of sustainable transport via the use of private vehicles, is the reformation and regulation of parking behaviour and land use, which can be done via policies that help reshape travel decisions through changes in parking availability, pricing, defaults and urban design. At EU level, these approaches are again supported through frameworks such as the EU Urban Mobility Framework (European Parliament, 2023) and the Sustainable Urban Mobility Plan/SUMP (European Commission, 2019) concept, which encourage cities to integrate parking management, land-use planning and demand management measures into a coherent urban mobility strategy. SUMPs explicitly promote the use of parking policies as tools to discourage car dependency, for example by reducing on-street parking, prioritising space for active modes and public transport and aligning parking supply with sustainability objectives. In parallel, EU cohesion and recovery funding increasingly supports urban redesign projects that reallocate street space away from private cars towards walking, cycling, greenery and public spaces.

Finally, **route choice** and **travel-time optimisation** can also be harnessed, encouraging private vehicle drivers to adopt **more efficient, less congested**, or **lower-carbon routes**. At EU policy level, this approach is supported through several policy frameworks that promote smarter, data-driven mobility. Once again, the EU Urban Mobility Framework (European Parliament, 2023) along with the Sustainable Urban Mobility Plan (SUMP) (European Commission, 2019) concept encourage cities to use intelligent transport systems (ITS), real-time traffic information and digital tools to optimise traffic flows and reduce congestion and emissions.

1.3.2 Pillar 2: Energy Consumption

Energy consumption is inextricably tied to the city's total emissions, which come from commercial and residential buildings, industry, electricity power plants and transport. Because of this, measures under this pillar range from promoting energy-efficient vehicles and electrification, to optimising building energy use per-se, whilst integrating smart grids and enabling low-energy urban mobility solutions. Because Pillar 1 is solely dedicated to sustainable transport, Pillar 2 is geared more towards energy conservation, especially within residential buildings, focusing on measures and policies that conserve energy use in those areas. Limiting energy over-expenditure means limiting total urban emissions, since they are two quantities that are positively correlated. Energy conservation then takes the centre stage as the other important pillar in the city's sustainability framework.

To do so, EU cities can utilise new sustainability standards and initiatives from the ground-up to build green anew or to improve current infrastructure via smart tech solutions, specialised renovations, governance tools and behavioural change. The EU places particular emphasis on renovations and smart-tech implementations, as is supported by the existence of numerous official initiatives and policies that seek to implement them. Research shows that nudging principles can be used complementary with smart tech to further enhance energy conservation.

Strategy A: Build Green, Anew

When it comes to EU policy, there are many frameworks that have been established to guide energy efficiency in new buildings, focusing on building sustainable, green infrastructure. At the heart of it all lies the revised Energy Performance of Buildings Directive or EPBD (Directive 2024/1275), which sets out to transform the EU's building stock into Zero-Emission Buildings (ZEB's) by 2050, with all new buildings meeting zero-emission criteria by 2030 and public buildings by 2028. The Fit for 55 package also accounts for the European Union's ambitious set of legislative proposals to cut its net greenhouse gas (GHG) emissions by at least 55% by 2030 (from 1990 levels) and achieve climate neutrality by 2050, implementing the European Green Deal by reforming energy, transport, industry and carbon pricing systems.

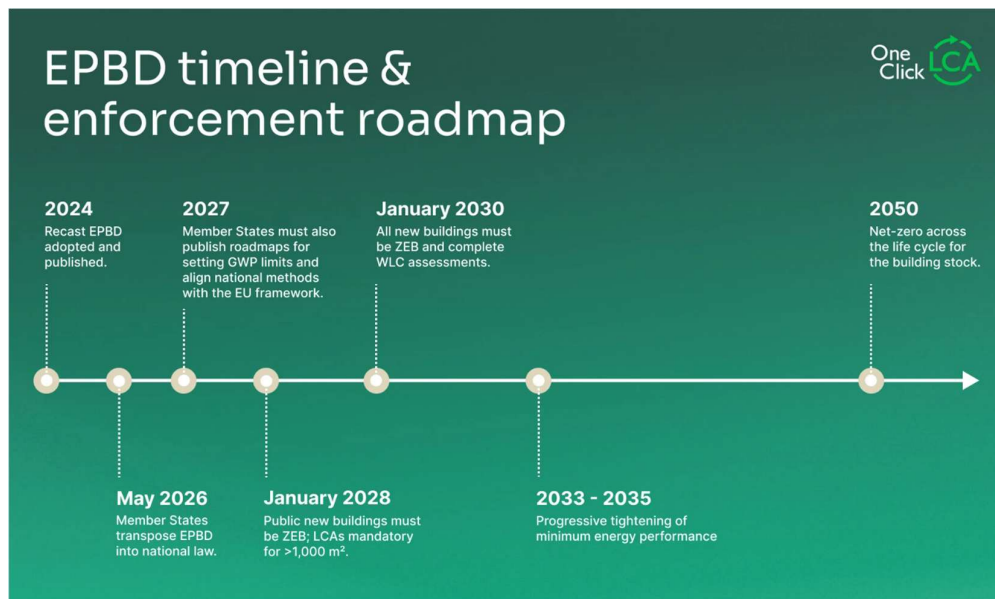


Figure 1.8: EPBD Timeline and Enforcement Roadmap, OneClick LCA, Online Article,
Link: [EPBD: A guide to the Energy Performance of Buildings Directive](#)

Strategy B: Renovate Green, Using Technology and Governance Tools

As it is clearly stated within the Directive (2024/1275):

“Buildings account for 40% of final energy consumption in the Union and 36% of its energy-related greenhouse gas emissions while 75% of Union buildings are still energy-inefficient”
(number 6 of the Directive)

Therefore, EU Member States are now obliged to adopt national building renovation plans and progressively improve the energy performance of existing residential and non-residential buildings, including through minimum energy performance standards and deep renovations, to cut energy use and emissions in the building sector. There's a designated timeline being drawn, where the 31 EU countries are expected to submit their final national building renovation plans by late December of 2026.

Complementing all this, the EU Renovation Wave's main goal is to at least double annual renovation rates by 2030, which is roughly 35 million buildings, focusing on **energy-**

poor households, public buildings and social infrastructure. Urban authorities play a central role in this effort, as cities are responsible for planning, permitting and often co-financing renovation projects. By improving insulation, heating systems and energy management in buildings, the Renovation Wave directly supports energy conservation while delivering co-benefits such as improved indoor comfort, lower energy bills and reduced energy poverty (European Commission, 2020):

“With nearly 34 million Europeans unable to afford keeping their home adequately warm, tackling energy poverty is an urgent task for the EU and its Member States. Each year, 800,000 social homes need renovation, requiring an estimated EUR 57 billion of additional funding per year.” (4.1. *Tackling energy poverty and worst-performing buildings*)

Beyond binding directives, the EU promotes integrated approaches that link energy conservation in buildings with urban sustainability more broadly. The Energy and Smart Cities Initiative encourages the integration of digital technologies and smart energy systems in the built environment to better manage energy demand and support climate goals. Similarly, EU missions such as the EU Mission on Climate-Neutral and Smart Cities foster innovative practices and cross-sectoral solutions that combine energy-efficient buildings, smart grids and low-carbon mobility in participating cities.

Other EU initiatives such as the Clean Energy for All Europeans Package and the Smart Readiness Indicator (SRI) also encourage the integration of smart meters, automated energy management systems and demand-response technologies in buildings. These systems provide valuable, real-time feedback that allows users to monitor and adjust their energy consumption in real time, shifting demand away from peak periods and reducing unnecessary energy use. At city level, smart grids and district energy systems further enhance efficiency by optimising energy distribution and reducing losses across urban networks.

The REPowerEU Plan and the associated EU Save Energy Communication place additional emphasis on behavioural energy savings, particularly in response to energy security concerns. These initiatives explicitly acknowledge that short-term energy conservation can be achieved not only through technological upgrades, but also through changes in everyday household behaviour, such as reduced heating demand, more efficient appliance use and increased awareness of energy consumption patterns (European Commission, 2022).

From a governance perspective, cities are increasingly encouraged to integrate energy conservation into broader urban planning through instruments such as Sustainable Energy and Climate Action Plans (SECAPs) under the Covenant of Mayors initiative. These plans effectively provide a structured framework for municipalities to set energy reduction targets, monitor progress and implement local measures across buildings, public lighting, municipal services and local energy generation. EU funding mechanisms, including Cohesion Policy funds, the Recovery and Resilience Facility and Horizon Europe, further support urban energy conservation projects by linking financial assistance to measurable energy efficiency and emission-reduction outcomes, funding innovative sustainability-related research.

Energy conservation policies create a fertile ground for the application of behavioural economics and nudging approaches. Measures such as energy-use feedback using smart-meters, social norm comparisons, default temperature settings, time-based pricing and simplified

information labels align closely with EU policy objectives while simultaneously preserving individual freedom of choice. By subtly shaping decision-making environments, such interventions can significantly enhance the effectiveness of regulatory and technological measures, reinforcing energy conservation as a central pillar of sustainable urban development, as will be examined in greater detail within the following chapters.

1.3.3 Pillar 3: Waste Management and Recycling

Waste management and recycling are central to urban sustainability because Municipal Solid Waste (MSW) generation is tied directly to consumption patterns, resource use and emissions. Waste reduction, reuse and recycling therefore form a distinct pillar of sustainable urban policy, complementing energy conservation and sustainable transport by minimising resource input and maximising circularity. European policies focus mainly on transforming waste management using Circular Economy principles of “the three R’s”: Reuse, Reduce, Recycle. Ensuring that exported waste is treated in an environmentally conscious way is also within the range of EU’s concerns and practical policies. To sum up, most of the policies are dedicated towards encouraging the production of less waste and more recycling, as well as the reuse and designing of products using environmentally conscious principles, all of which regard long-established circular economy principles, as well as finally ensuring that exported waste is treated in a sustainable manner.

Strategy A: Implementing Circular Economy Principles

For this, the Circular Economy Action Plan (CEAP) takes the leading role in EU policy. Originally adopted in 2015 and significantly updated under the European Green Deal in 2020, it reoriented EU waste policy from the linear “production to disposal” systems toward a much more circular model, in which materials are kept in use for longer and waste is designed out of the system whenever possible (European Commission, 2020). This can lead to a shift that aligns with climate neutrality goals, reducing demand for virgin materials, lowering energy consumption associated with production and reducing landfill methane emissions. Rather than focusing solely on waste treatment, the Action Plan aims to prevent waste at its source by promoting sustainable product design requirements with production techniques that adhere to the famous motto in Life Cycle Assessment “from the cradle to the grave”, increased durability, reparability and recyclability, reduced packaging waste, as well as mandatory recycled content in selected products.

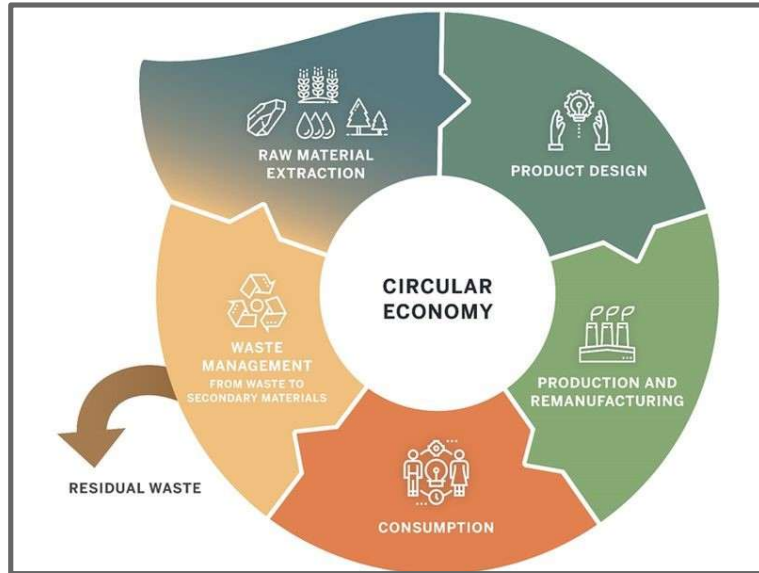


Figure 1.9: The EU's Circular Economy Action Plan

(Source: CEN-CENELEC, [The EU's Circular Economy Action Plan - CEN-CENELEC](#))

Another major guiding force within EU waste management policy is the Waste Framework Directive (Directive 2008/98/EC, amended in 2018), which establishes the waste hierarchy as a guiding principle, ranking waste management options in order of environmental preference. In this, Member States are legally required to prioritise waste prevention and recycling over landfilling and final disposal. As it is written in its Article 4:

“The following waste hierarchy shall apply as a priority order in waste prevention and management legislation and policy:

- (a) prevention;*
- (b) preparing for re-use;*
- (c) recycling;*
- (d) other recovery, e.g. energy recovery; and*
- (e) disposal.”*

The Directive also sets binding recycling targets for municipal waste and introduces the principle of Extended Producer Responsibility (EPR), which makes producers financially or operationally responsible for the end-of-life management of their products. Though it is recognised and promoted globally by organisations like the OECD and UN Environment Programme (UNEP), the ERP is primarily a policy approach heavily implemented and mandated within the European Union (EU) as a core component of its circular economy and waste directives. As shown in Figure 1.10 the four main pillars of the EPR are the duty of preventing pollution, the life-cycle concept, the polluter-pays principle and the internalisation of costs. In combination to this, to combat marine plastic pollution, the Single-Use Plastics Directive (2019/904) was established to target the most found plastic items in marine environments. More specifically, the Directive bans certain single-use plastic products, for

example, plastic cutlery, straws and cotton buds and introduces consumption reduction measures, design requirements and EPR schemes for others.

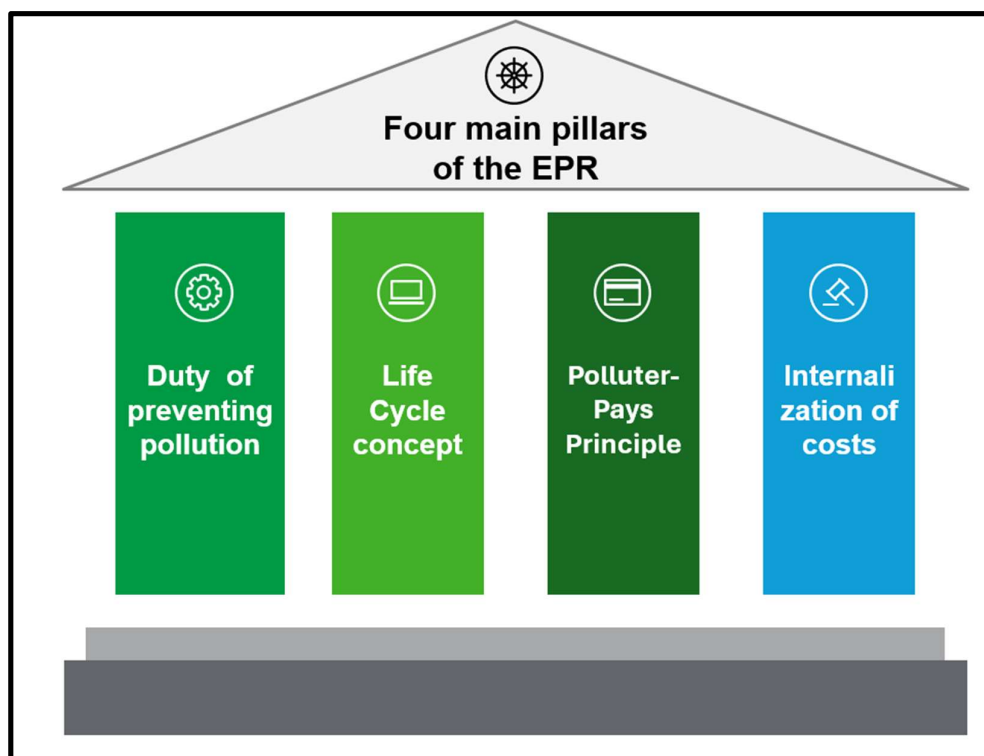


Figure 1.10: Four Main Pillars of the EPR (Source: United Nations Environmental Programme, Extended Producer Responsibility, <https://www.unep.org/ietc/what-we-do/extended-producer-responsibility>)

For MSW management, the Landfill Directive (1999/31/EC, amended 2018) has set strict limits on landfilling, including a target to reduce municipal waste landfilled to 10% or less by 2035. The Directive also restricts the disposal of untreated waste and requires methane capture and environmental safeguards. It aims to minimise greenhouse gas emissions and especially methane and to prevent groundwater contamination by imposing strict technical and operational standards on landfill sites. Landfills are also categorised into hazardous, non-hazardous and inert waste facilities, each subject to specific regulatory requirements. The Directive further imposes strict rules on site permitting, location, leachate and water control, and landfill gas management, while banning or restricting certain waste types, including liquid waste, flammable materials, used tyres and clinical waste.

Strategy B: Ensuring Exported Waste is Treated Sustainably

As discussed in 1.3.3 Household Waste Generation, the European Union sends a portion of its waste beyond its borders, but, as concerns rise over environmental standards and illegal trafficking, the EU has begun tightening its regulatory framework on such shipments. To address these challenges, the European Parliament approved stricter rules in February 2024 aimed at ensuring that exported waste is treated in an environmentally sound manner. The revised framework bans the export of plastic waste to non-OECD countries and imposes more

stringent controls on shipments to OECD members. Additionally, transfers of waste between EU Member States are now permitted only under limited and clearly defined circumstances.

Finally, although EU waste legislation sets overarching targets, implementation largely occurs at national and municipal levels. Cities play a pivotal role in organising waste collection systems, introducing pay-as-you-throw schemes, improving sorting infrastructure and fostering public awareness. EU cohesion funding and recovery instruments support urban waste infrastructure investments, particularly in regions lagging recycling targets. Nudging interventions specifically can be implemented alongside already established policies, especially with regards to recycling. This touches more the circular economy principles that are referred within the broader Strategy A category.

1.4 Conclusion

The purpose of this chapter was to form the theoretical basis regarding modern urban sustainability issues, so that more practical case-study examples can be examined in the later chapters. More theoretical analysis of sustainability, urbanisation and its environmental effects is presented along with related statistics from official organisations and the EU, as well as some EU-located policy initiatives, taken to combat the presented issues.

Firstly, the phenomena of (urban) sustainability, sustainable development and urbanisation in the 21st century are presented, to establish interlinks and relationships between them, as well as to better understand each of their own specific function and consequently deepen comprehension. It is established that sustainability is the long-term objective of living within planetary limits and with respect to future generations, while sustainable development represents the active, ongoing processes and pathways used to achieve it.

Urbanisation is also then brought into the light of analysis, establishing another connection between sustainability and it. Specifically, it is made clear how its acceleration negatively correlates to urban sustainability, with rising population growths over-expanding urban infrastructures' limits, causing environmental and social degradation. With more than half of the world's population already living in cities and projections pointing toward nearly 70% by 2050, urban areas are emerging as the central arenas where the fight against climate change and for sustainability can be fought, using related policies.

The environmental effects of urbanisation mainly emerge through urban emissions and energy consumption, air pollution and transport, waste generation, overheating, water quality degradation and the loss of natural green spaces. These are all then comprised into three (3) all-encompassing categories or pillars, to facilitate better analysis: Sustainable Transport, Sustainable Energy Consumption and Conservation and Sustainable Waste Management. EU policy is explored for each pillar, showcasing the most important initiatives that the EU chose to establish to enhance urban sustainability using governance tools.

For sustainable transport most policies discourage the use of private cars and encourage alternative modes of transport or improve in some way the use of cars via technological enhancements for fuel efficiency.

For energy conservation policymakers are increasingly prioritising the construction of new buildings using energy-efficient standards that are documented within the Energy Performance of Buildings Directive and the enhancement of old buildings using smart tech solutions to save energy.

Finally, for sustainable waste management the policies focus on implementing circular economy principles that encompass the whole production cycle (from-cradle-to-grave) and waste management, while also ensuring that the waste that is finally exported towards third countries is also treated sustainably.

In conclusion, it is established that the road to urban sustainability in European cities is paved with the use of regulatory, technological and infrastructural measures. Residents, firms and institutions alike make daily decisions regarding mobility, energy use and consumption patterns that ultimately shape net emissions and waste production. The following chapters will examine how behavioural interventions can assist in this transition and operate within these three sustainability pillars, as well as finally assess their potential to enhance the effectiveness of the EU's process of sustainable development.

Chapter 2

NUDGING FOR URBAN SUSTAINABILITY

“For those especially concerned about the problem of climate change, the lesson is clear. Whether or not governments choose some kind of incentive-based system, they can help to reduce energy use, and thus reduce greenhouse gas emissions, with a nudge.”

– “Saving the Planet” excerpt from R.H Thaler’s & C. Sunstein’s book
Nudge: Improving Decisions About Health, Wealth and Happiness (2008)

2.1 Introduction

Nudging as a concept is defined in R. Thaler and C. Sunstein’s 2008 book “Nudge: Improving Decisions about Health, Wealth, and Happiness” as:

*“...any aspect of the **choice architecture** that alters people’s behaviour in a predictable way without forbidding any options or significantly changing their economic incentives.”*

A nudge therefore needs to be qualified with a few specific characteristics to be deemed a true (or “mere”, as will be later called) nudge. To clarify:

a) A nudge is an aspect of choice architecture

Choice architecture as a concept was first seen in that nudging definition and, as such, was conceived of and first popularised by R. Thaler and C. Sunstein. It refers to all the different ways -the “architecture”- in which choices can be organised by policymakers to be presented to decision makers and the ultimate impact that that presentation has on decision-making. When considering choice architecture, it is significant to acknowledge how options are arranged and presented and it therefore influences decision-making across a wide range of choices, mainly focusing on consumer choice. To put it in simpler terms, choice architecture basically recognizes that the *context* (in the form of a nudge) has a significant impact on final decisions. The “aspects” of choice architecture are defined as the different nudging techniques themselves.

Choice architecture and physical architecture both deeply respect environmental design and both recognise that there is no such thing as a “neutral” design. In traditional architecture tiny, seemingly unimportant details in a building’s architecture can subtly influence how the people that use the building interact. Similarly, in choice architecture the “architect” (a policy maker, a marketist etc) can guide individuals or consumers towards or away from a specific decision, by subtly altering the way those decisions are presented or organised. A choice architect then according to Thaler and Sunstein is the individual who “has the responsibility for organising the context in which people make decisions” (2008). When applying traditional or

“true” nudging techniques, the aim is for behaviour to be influenced in a subtle way, harnessing psychological “loopholes” already operating in the human mind and psychology, which come in the form of the cognitive biases and heuristics mentioned in the previous subchapter. This includes using techniques such as framing, default options, (non-financial) incentives, or feedback.

b) Behaviour must be altered in a predictable way

“Predictable” here is written in regard to the established literature within behavioural economics and psychology, which documents which behavioural tendencies are activated when nudges are in place, all of the cognitive biases, heuristics and mental shortcuts and in general what effects nudges are established to have in guiding decision-making. Nudges then have a “predictable” effect, in the sense of literature already having documented that effect.

One example is the implementation of default effects as a nudge to encourage a specific decisional outcome. This means setting some choices as “default” to encourage their ultimate adoption by the users, by opting to not alter their use as “default” or *stick to defaults*. Behavioural economics literature predicts that economic agents have the tendency to generally accept the default option in each strategic interaction. In the same book (2008) Thaler and Sustain use the example of organ donations, claiming that default effects increase organ donation rates, though evidence from subsequent scientific research has proven it to have mixed results (M. Dallacker et al., 2024). In any case, estimations regarding the behavioural effects of nudges must be deeply grounded in behavioural economics literature, in order for the intervention to be qualified as an actual “nudge”.

c) Options must not be forbidden

In nudge theory options are encouraged or discouraged in subtle ways, but no options are forbidden or banned. Nudge as a form of *libertarian paternalism* subtly guides individuals (paternalism) while simultaneously preserving their freedom to choose between all available options (libertarianism).

d) Economic incentives must not be significantly altered

Nudges generally refer to the implementation of non-monetary psychological techniques, like defaults, social norms, or informational cues, so monetary incentives are traditionally not deemed “true nudges”.

Thaler and Sunstein then also move on to claim that:

*“To count as a mere nudge, the intervention must be **easy and cheap to avoid**. Nudges are not mandates. Putting the fruit at eye level counts as a nudge. Banning junk food does not.”*

This means that:

e) The intervention must be easy to avoid

The *freedom of choice* aspect of nudges is again lightly touched here, the key idea being that the intervention must not meaningfully constrain choice, with any refusal or opt-out of suggested options being relatively easy by the agent/consumer/user. In the literature on nudging and Behavioural Economics, the concept of “easy” refers to the effort required to opt out of the influence created by the choice architecture. A nudge then is considered “easy to avoid” if a person can reject it with minimal effort, for example by a single click, ticking or unticking a box, choosing another item on the menu or ignoring the suggested option.

f) The intervention must be cheap to avoid

For an intervention to qualify as a “mere” nudge, avoiding it must not impose significant costs on the individual. “Cheap” here refers to the cost of opting out of the nudge, that comes in any form, whether that be financial, chronological, administrative or simply the use of cognitive effort.

g) Nudges are not mandates

Similarly, this means that freedom of choice for the individual must be preserved. The nudge’s implementation must include no coercion and no prohibition of options for the individuals. The authors then present banning fast food as an example of a “non-nudge” intervention to increase fruit consumption and juxtaposing it with the actual behavioural intervention of placing fruits at an eye level. This is a nudging technique that improves salience, gently prompting the consumers towards the purchase of more fruits.

2.2 Nudge Theory

This dissertation presents and focuses on **four (4) main nudge types/techniques**, as seen in the selected case studies. The nudges are default nudges, real-time feedback, salience or visual cue nudges and social norms nudges.

Below is a presentation of these nudges.

1. Default Nudges

Default nudges employ a simple manner to steer individual behaviour, by setting up specific options for the nudgees, assuming they will tend to keep at them and not opt out of them in the process. These nudges are borne out of the observed tendency for individuals to generally accept a default option within a strategic interaction and generally “go with the flow”, commonly referred to as *Default Effects* within nudge theory. Default nudges exploit this, by making the options the default whilst still preserving all other options and maintaining freedom of choice. The individual can then opt-out or opt-in any time, in true “libertarian paternalism” manner, but often chooses not to.

2. (Real Time) Feedback

Feedback nudges refer to the act of providing immediate or “near-real-time” information towards the nudgees in real-time regarding their actions. Doing so can help them to better connect their actions with the consequences that they produce, nudging them into re-adjusting their behaviours, producing different decisions. This can be achieved via the use of smart technology, for example using smart indicator systems and meters, in-app messaging or pop-up messaging, so it constitutes a kind of “dynamic learning tool”, where learning is achieved through time via the interaction with the device.

3. Salience Nudges or Visual Cue Nudges

Salience literally means “importance” or “notability”, prominence. Salience as a nudge then, refers to the act of highlighting, emphasising or otherwise drawing particular attention to specific choices or information, making them stand out to increase their memorability or the likelihood to be chosen by the nudgees. The usefulness of these nudges is more apparent within environments with lots of information or choices, helping to guide the users’ towards the options that are most beneficial or critical. This can be done physically via the use of bright colours or bold fonts or using contrasting shades.

Salience nudges the individual into a specific outcome by exploiting the *Salience Bias*, which marks the tendency to focus on information, items, or other physical stimuli that are more prominent or emotionally striking, while overlooking more subtle or objective data.

4. Social Norms Nudges

This type of nudging informs users/other agents about the behaviours of others, to encourage similar behaviour, for example regarding recycling. Social norms nudges harness the Conformity Bias/Social Proof Heuristic, that is observed when people tend to evaluate behaviour relative to others and even replicate it, as well as the Social Bias or Groupthink. Herd behaviour as a form of heuristic and cognitive effect also applies here, that reflects the tendency of people to mimic what everyone else is doing and follow the consensus.

2.2.1 Effectiveness of Nudging Interventions

The effectiveness of nudging interventions is considered highly **context-dependent** because it relies heavily on the specific setting, timing and social environment in which they are implemented. Nudging effectiveness can be seen as highly variable and is dependent upon the intervention’s own unique characteristics of where it takes place, who are the subjects/nudgees, what nudge is being implemented and in which way, as well as when it is taking place. Referring to the same nudging technique then, what can work in one intervention can fail in a different intervention or experiment, depending on the special context or existing conditions.

Generally, a nudge is deemed “effective” to the degree that it satisfies its original definition, to successfully alter behaviour in a predictable manner, without forbidding any options or significantly altering economic incentives. Therefore, the first parameter that measures effectiveness is the **degree of behaviour change** observed.

In recent years, there has been an increasing attention to nudging interventions that produce lasting behavioural change. “**Lastingness**” therefore can be seen as an additional parameter of effectiveness for nudging techniques. The focus has shifted from measuring the more short-term effects of nudges, to considering the long-term results that prove the technique has endured in time, within the context of the intervention. However, despite this growing interest, evidence on the long-term durability of nudges remains limited and understanding whether their effects can “withstand the test of time” continues to be an important challenge for the field.

Its overall effectiveness is generally considered a matter of debate within the scientific community, while still retaining a positive outlook. For example, one meta-analysis (L. Dung, 2025) showed that nudging may have “*a much smaller average effect than earlier discussions assumed*”, yet not statistically insignificant. It also noted that the term itself encompasses many different interventions that possess a significant variability in their effects. Another meta-analysis done (Mertens et al., 2022) of more than 440 choice architecture interventions across behavioural domains, showed that it is “*an effective and widely applicable behaviour change tool that facilitates personally and socially desirable choices across behavioural domains, geographical locations, and populations*”.

Nudging effectiveness is also highly dependent on the **type** implemented. Default nudges are often noted (D. Hummel, A. Maedche, 2019) as being the “*most effective*” within literature like other “decision structure” nudges, especially defaults, which are found (Mertens et al., 2022) to outperform others. Other nudges that are noted for their effectiveness are simplification and convenience/removing friction (Cadario & Chandon, 2020) and social norms.

2.2.2 Short Term Effects and Behaviour Change

The short-term or immediate effects of nudges are more well-researched and documented within the literature and experimental practice, as compared to the more long-term effects of nudges. This is derived from the nature of the nudging interventions themselves, most of them being randomised controlled trials that run for a specific amount of time. The short-term effects of nudges refer to the behaviour change observed immediately after the nudge application. These are the effects that are usually referred to when discussing nudging effects.

2.2.3 Long-Term Effects and Lastingness

Currently there is limited existing research regarding nudges’ impacts and effects on individuals’ behaviour within a long-term horizon, with more research geared towards measuring the more short-term behaviour change effects of nudging, though there is a growing shift towards the long-term horizon, within recent years. Scholars have highlighted the need to understand whether nudges lead to **sustained behavioural change** or merely produce temporary adjustments (Brandon et al., 2017; Banerjee & John, 2022). Despite this growing interest, evidence on the long-term effectiveness of nudges remains limited and findings are

mixed, with some studies indicating that effects may decay over time (Van Rookhuijzen et al., 2021).

The ultimate question that is then formed is whether nudges can ever possess the ability to permanently alter habits, affect perceptions and **alter preferences** of the individuals involved, perhaps as an effect of temporal spillover that leads to lasting change. Traditional nudging theory by Thaler and Sunstein focuses on temporary behaviour change, with restructuring the choice architecture and exploiting existing cognitive biases, perhaps not even “registering” more long-term results. However, it is estimated that the systematic alteration of behaviour can, presumably, lead to habit formation, which may then shift preferences, perceptions and eventually lead to the establishment of new norms for the collective.

Real-time or “near-real-time” feedback nudges are an example of this, as they can become a sort of dynamic learning tool with the use of smart indicator systems and meters, with learning being seen as more permanent as it alters perception of a given situation. Information nudges have also demonstrated their ability to alter preferences within experimental settings (M. De Salvo et al., 2025), with the study however not specifically measuring whether these changes persisted beyond that immediate context.

2.2.4 Side Effects: Temporal Spillover, Moral Licensing and Reactance

Nudging side effects refer to the unintended, secondary or otherwise “unaccounted for” by the nudge designer effects that can arise after the intervention. If nudges are implemented in order to alter behaviour in a predictable manner, the side effects are all the unintended consequences which can form. Depending on their contribution to or deviation from the intended policy goal and their overall effect towards the environment and the subject’s wellbeing, they can have a neutral, positive or negative impact on the nudge’s effectiveness. The side effects themselves can happen during the short term or the long-term horizon of an intervention.

A common side effect of some nudging policies is the so-called **temporal spillover effect**, which, like the techniques themselves, is highly context-dependent and can retain a positive, neutral or negative character. It refers to the phenomenon in which future behaviour is influenced by the initial intervention or behaviour, sometimes long after the original nudge is removed. In this case the temporal spillover effects refer mostly to the long-term horizon of a policy, where **lastingness** is measured. For example, an experiment (M. Van Rookhuijzen et al., 2021) that nudged participants into completing a long questionnaire, showed that this affected their decision for the same behaviour a day later without the presence of a nudge. However, the same study showed that nudging participants into a healthier food choice did not in fact produce the same effect. This demonstrates that some behaviours have a better potential to yield temporal spillover effects than others, meaning the temporal spillover effects can be present, but with a high variability between certain behaviours and circumstances, due to their context-dependance.

Negative temporal spillover effects can sometimes appear as “**boomerang effects**” within the nudging policy literature. They can occur when the intervention’s “goal behaviour” is not only reversed over time but shifts towards the opposite direction. This is especially

evident in interventions based on social norm feedback, where individuals who initially outperform the average may adjust their behaviour downward after being exposed to comparative information (P.W. Schulz et al., 2007). As a result, what begins as a short-term positive behavioural change may, over time, produce unintended negative consequences, thereby significantly undermining the overall effectiveness of the intervention.

Moral licensing effects can also be observed, where an initial positive/“good” behaviour supplies individuals with a sense of newly earned moral credit, so that they subsequently engage in a behaviour in the opposite direction. For example, a study (A.M. Burger et al., 2022) showed that reminding individuals of past climate-friendly behaviour decreased the discomfort regarding ongoing problematic behaviour in another domain and reduced the motivation to change the latter behaviour, effectively morally “licensing” them to behave in an environmentally unconscious way. In this way, licensing represents an internal, self-justifying mechanism that can negatively impact a nudge’s lastingness.

Finally, **reactance** is observed whenever nudges perceive the nudgees as being manipulative, controlling or otherwise restrictive towards their decision-making ability, in which case resistance to the intended behavioural goal set by the nudger is formed in place of the intended behaviour. This can occur for example when the nudges are too prescriptive by using wording that is overly directive, or use explicit moral framing that implies judgement, repeated messaging and overt social pressure. There currently exists a varying level of reactance regarding different nudging strategies, as shown by a recent study (H. Bruns & G. Perino, 2023). From the nudgees’ point of view recommendations are the least freedom-threatening, followed by defaults and then mandates. Intrinsic motivation was also found to moderate these effects, while interventions by an expert was perceived as less freedom-threatening and angering.

2.3 Green Nudges for Urban Sustainability

Green nudges are behavioural interventions that focus on choice architecture aimed at promoting environmentally sustainable behaviours. In their 2008 book “Nudge: Improving decisions about health, wealth, and happiness”, Thaler and Sunstein explored the different ways nudging could be implemented in policies to curb climate change, in its dedicated subsection titled “Saving the Planet”. The choice architecture mechanisms they specifically mentioned were:

In the “*Better Incentives*” Section (page 185):

1. Providing better incentives to not pollute via the implementation of environmental or green taxes for polluters, for example carbon taxes and cap-and-trade systems. This can also be done by combining nudges with more “traditional” incentive-based policies, like congestion charges, fuel taxes, or tradable pollution permits, which they argue could increase policy effectiveness.

In the “*Feedback and Information*” Section (page 188):

2. Enhancing information and disclosure systems by implementing simplified and more meaningful labelling (for example translating fuel efficiency into annual monetary costs), as well as broader environmental transparency mechanisms such as pollution inventories.
3. Using social norm nudges to promote pro-environmental behaviour via social comparison, as part of broader “*information disclosure efforts*” (page 191).
Thaler and Sunstein emphasise that reputational effects, such as public disclosure of high polluters, can generate powerful behavioural change, as actors often adjust their behaviour to avoid being “blacklisted” by environmental groups and the concerned public. The Greenhouse Gas Inventory was proposed, that would require disclosure of the most significant emitters.

In the “*Ambitious Environmental Ideas*” Section (page 193):

4. Providing better information via real-time feedback on energy or water consumption (page 194).
5. Encouraging the participation in voluntary and choice-architecture-based sustainability programs, such as government-supported efficiency labelling schemes and opt-in environmental standards for firms (page 194).

For the past 18 years since the release of Thaler and Sunstein’s book, what they supported in their Saving the Planet subsection about the supposed benefits of nudging used in sustainability policy has been put to the test around the world by governments and research groups alike, with varying levels of success, that nonetheless prove to be promising in shaping the future of public policy:

1. Implementing **green taxes** for polluters was generally found to be effective (Antoñi V. et al. 2025) with many studies concluding in its effectiveness for curbing car generated air pollution (W. Tang, 2023; J. Luo, 2025).
One study (M. Meireles, 2021) that documented car use in Mediterranean countries concluded that it effectively promoted more sustainable mobility by encouraging the use of collective transport and creating incentives for consumers to purchase less-polluting vehicles.
2. Providing better information via **real-time feedback** on:
 - a) energy, more specifically via **smart meter technology** was found to be effective (K.G. Kokouvinos et al., 2025), with consumption reductions ranging from 0–4,5% (Bauer, M. et al., 2018), 3–3,4% (BIT & DESNZ, 2023) and even a 15% reduction in overall energy consumption plus a 10% decrease in peak-hour usage (Mao Y. et al., 2024).

- b) water consumption was found (University of Bonn, 2017) to be effective to reduce water and energy consumption when showering on average by 22%.
- 3. Using **social nudges** to promote pro-environmental behaviour via social comparison was found to be effective, regarding:
 - a) household energy conservation (H. Allcott, 2011), some (P. W. Schultz et al., 2008) also documenting and overcoming expected boomerang effects, while others (K. Farrow et al., 2017) find descriptive norms to seemingly demonstrate particularly consistent effects
 - b) water usage, where it was found (P. J. Ferraro et al., 2013) that households receiving social comparison feedback about water use reduced consumption.
 - c) recycling, with studies showing that households increased recycling after receiving feedback that targeted personal and social norms (W. Schultz, 1999).
- 4. Finally, evidence on whether using a **combination of policy–nudges**, for example “traditional” incentive-based policies, like congestion charges, fuel taxes, or tradable pollution permits, can be effective in promoting sustainable behaviours, is still a subject of debate.

A meta-analysis (A. Marius et al., 2024) showed even a negative synergy effect, suggesting that policy mixes are less effective than the sum of the single constituting interventions, while still, a stand-alone intervention, outperforming single interventions as they are more comparatively more effective than the most effective single intervention contained in the policy mix.

2.4 Conclusion

Nudging currently exists as an innovative behavioural policy tool for promoting urban sustainability. Beginning with the original conceptualisation of nudging by Richard H. Thaler and Cass R. Sunstein, it was established that nudges operate through modifications of the choice architecture that steer behaviour in predictable ways without restricting freedom of choice or significantly altering economic incentives.

The focus of this dissertation lies in a few specific nudging techniques: default nudges, real-time feedback, salience or visual cue nudges and social norms nudges. Nudging interventions’ effectiveness is itself highly context-dependent and varies according to the behavioural domain, implementation method and surrounding social environment. Particular attention is given between short-term behavioural effects and long-term lastingness, including the possibility that repeated behavioural adjustments may eventually contribute to habit formation and evolving social norms. Unintended side effects associated with nudging interventions such as temporal spillover effects, moral licensing and psychological reactance, retain also the ability to either strengthen or undermine policy effectiveness over time.

Frameworks such as the European Law Institute’s “A Framework for Good Green Nudging” can provide a much-needed ethical and regulatory backbone for environmentally

oriented behavioural interventions. Principles such as those of Necessity, Proportionality, Privacy, Transparency, Autonomy, Dignity, Effectiveness and Oversight eventually guide the legitimacy of green nudging, establishing accountability, public trust and respect for fundamental rights between the individual nudgees and the nudging organisations.

Having established the conceptual and normative foundation necessary, the subsequent chapter presents a case study analysis, which examines real-world implementations of nudging in urban sustainability contexts across European cities, covering the three main urban sustainability pillars: Transport, Energy Consumption and Conservation and Waste Management and Recycling.

CHAPTER 3

SELECTED EXAMPLES FROM EU CITIES

*“A developed country is not a place where the poor have cars.
It's where the rich use public transportation.”*

– Enrique Peñalosa

3.1 Introduction

This chapter features a case study presentation in which Default, Real-Time Feedback, Salience and Social Norms nudges interventions within urban environments are explored within each sustainability pillar. For each pillar a specific behaviour is targeted. For Sustainable Transport the focus is on instigating modal shift away from private vehicle use, for Sustainable Energy Consumption the focus lies on promoting efficient use of electronic appliances, while in Sustainable Waste Management and Recycling the focus lies on promoting recycling and producing less waste.

Across the case studies, **a total of twelve (12) examples are presented.** These are distributed across the three sustainability pillars as follows:

- Sustainable Transport includes six (6) examples, comprised of:
 1. Default Nudges: three (3) examples
 2. Real-time Feedback Nudges: two (2) examples
 3. Salience Nudges: one (1) example
- Sustainable Energy Consumption includes two (2) examples:
 1. one case study covering both Default Nudges
 2. and Real-Time Feedback Nudges, and
 3. Social Norms Nudges: one (1) example
- Sustainable Waste Management & Recycling includes four (4) examples, consisting of:
 1. Real-Time Feedback Nudges: two (2) examples
 2. Salience Nudges: one (1) example and
 3. Social Norms Nudge: one (1) example

3.2 Sustainable Transport

As discussed in Pillar 1: Transport, there are two main strategies for inspiring sustainable transport in urban environments: Strategy A involves discouraging the use of private vehicles (and encouraging modal shift), while Strategy B involves improving the use of private vehicles and making it more sustainable by improving efficiency and opting for less-congested routes. The nudges discussed within this section all mainly pertain to Strategy A's modal shift

initiatives, focusing on the ways individuals can be nudged into adopting sustainable modes of transport and establishing them as the new “norm” within their daily routines.

3.2.1 Default Nudges

In default nudging interventions utilised to inspire sustainable transport, the choice architecture environment is slightly altered, in such a way that the sustainable choice (for example, using public transport) becomes automatic, deeming it the “default option” for the individual. In practice this can be done using methods such as automatic enrolment or passive acceptance mechanisms, where individuals remain free to opt out, but the sustainable option occurs unless the individual actively opts for the alternative. Using infrastructural changes, such as increasing bike lanes can facilitate these kinds of nudges, since the physical environment is made to promote sustainable behaviours (e.g. cycling). Broader infrastructural measures, such as designing cities where walking, cycling and public transit are the most convenient, affordable and safe choices, is therefore a significant way to make sustainable transport the default option.

Below are some real-life examples where default effect nudges were utilised in EU cities to promote sustainable transport:

a) *(Automatic Enrolment)* The Deutschlandticket/Jobticket – Germany, Austria

An example of an automatic enrolment scheme that encourages sustainable modes of transport as the default, is the widely used in Germany and Austria “**JobTicket**”, which is a heavily discounted annual public transport pass purchased partly and subsidised by employers for their employees. This ticket typically offers significant savings for transporters of often 20% or more and can be used for both commuting and private travel, frequently covering nationwide regional transport.

Employers are incentivised to purchase these, as the tickets themselves are tax-deductible, with the option to then claim them as a “Jobticket” for tax purposes. Subsidies for the Deutschlandticket are generally tax-free and social security-free for the employer when provided in addition to the employee’s regular salary. They are also fully deductible as business expenses. As of January 1, 2026, an employee typically pays a maximum of 44,10 euros per month for the Deutschlandticket Job (*source: VRS, Germany Ticket Job Article, 2026*).

The JobTicket system operates as a **continuous subscription**, which automatically renews every month until canceled, making it the default state for the employee. And, while employees still possess the option to opt-out of the system throughout, the convenience of the heavily subsidised national ticket makes it an easy, preferred option over traditional commuting methods. The ticket is also provided digitally by default, further simplifying the process and encouraging uptake.

b) *(Default Bike Lanes)* Copenhagen, Amsterdam (and other major “bicycle cities”)

In a 2025 article, EU’s URBACT notes default effects as “*a powerful type of passive nudge*” using Copenhagen as an example, in which default cycle lanes were integrated with public transit systems to encourage cycling and use of public transport over driving. Following this, in Amsterdam, bicycle lanes are systematically integrated into virtually all major urban

corridors and rail-station access routes, while extensive bicycle parking is automatically provided at transit hubs.



Figure 3.1: Default Bike Lanes in Copenhagen taken from an online article,
Source: [Copenhagen uses this one trick to make room for bikeways on nearly every street](#)

c) Broader Infrastructural Changes – Redesigning Cities to be Less “Car-Centric”

Broader infrastructural changes that make cities less “car-centric” are vital in urging commuters to opt for more sustainable options such as using public transport, walking or cycling, finally assuming them as the default option. This cannot be done in cities that are centred towards private vehicle use, with limited bike lanes, hostile road architecture that promotes, with limited cycling networks.

“**15-Minute Cities**” aspire to do just that, by redesigning urban areas to ensure that daily necessities regarding work and leisure are within a 15-minute walk or bike ride, reducing the need for long car commutes. Enhancing public transit infrastructure is also critical, by investing in Bus Rapid Transit (BRT) and upgrading metro systems to act as the primary mode of transportation.

Some measures even go as far as essentially banning car-use altogether, which, although highly efficient in protecting areas from air pollution, cannot technically be deemed a default nudge, since alternative options to sustainable ones (car-use) is banned. This happens for example in environments where the conservation of traditional cultural elements is highly valued, such as in the island of Hydra, Greece, where transportation relies heavily upon horses, mules and plain walking, banning car-use and even bicycle use altogether, but can be seen in cities such as Barcelona, Spain, which implemented “**superblocks**” in which inner-block traffic is restricted to residents, essentially closing off residential areas to through-traffic.

3.2.2 Real-Time Feedback

Nudging via real-time feedback to inspire sustainable transport means providing individuals with immediate (real-time) information, regarding their actions, with regards to their mobility. The individuals, by self-monitoring their action, can then shift behaviour, opting for the most sustainable option. This can be implemented mainly using technological means, such as smartphone apps using digital notifications and smart gear (smart watches etc). This was done in practice in:

a) The “Smart Ways to Antwerp” Initiative, Antwerp, Belgium

The “Smart Ways to Antwerp” (launched in 2016) initiative utilises a comprehensive **digital platform** that provides real-time information regarding the available transport options for its users, encouraging multimodal route planning. To specify, when a user searches for a route, the app displays valuable information that affects the user’s final decision, regarding travel time, cost and caloric burn for cycling versus driving in current traffic. The user can then compare his/her options to make an informed decision. By seeing that a bicycle is often faster than a car during peak hours in the city centre, users are **nudged to switch modes** based on immediate efficiency and health benefits.

Real-time feedback is often seen to be working in digital environments (apps and similar online platforms) alongside gamification techniques that focus on providing a fun experience for the user by implementing game-like elements within app-design, such as collecting and redeeming points, achievements and various micro-rewards and benefits.

A notable EU example is:

b) The “Bella Mossa” (*Good Job*) Initiative in Bologna, Italy

Bologna in 2018 used the Bella Mossa app to gamify sustainable mobility via a **rewarding system**. The feedback mechanism was harnessed by informing the users on their current traveling decisions, with points incentivising them to opt for sustainable commuting options. Each trip made by walking, cycling, using the public transport system or car-pooling was collected and assigned a score which, if reaches a certain threshold, can then be redeemed via available rewards for the user to spend in various discounts around the city or payment through 85 retailers, including supermarkets, sports retailers, bike stores, bookshops, cinemas and restaurants. The collected data was also available to public administration for planning purposes. The app gave a reward not only to users who opted for modal shift, but also to users who already moved in a more sustainable way.

3.2.3 Salience Nudges

Salience nudges work by making the sustainable choice more “salient” in some manner, for example by being more sensory and physically attractive to the individual using physical means (visual or auditory cues). The sustainable option is more easily recognised by the individual, it is being “highlighted” within the choice architecture environment, when compared to other

options. This method usually implies physical installations and city redesigns that take place within the individual's immediate physical environment.

An example of this is Denmark's "Green Wave for Bicycles" initiative, first launched in 2004 Copenhagen. It includes a **system of synchronised traffic lights** on major bike routes that allows cyclists to maintain a continuous flow without stopping at red lights. This is achieved by timing the lights to travel at an average speed, typically around 20 km/h (12.4 mph). This improves the salience of cycling, by making cycling faster and more comfortable and was finally expanded to new routes. Copenhagen implemented its first "green wave for bicycles" in 2004 along a pilot section of Nørrebrogade, a major street. The initial success of the pilot then paved the way for the program to be adopted more widely. The intervention is technically simple and low-cost compared to other infrastructural expansions such as lane widening or metro line additions.

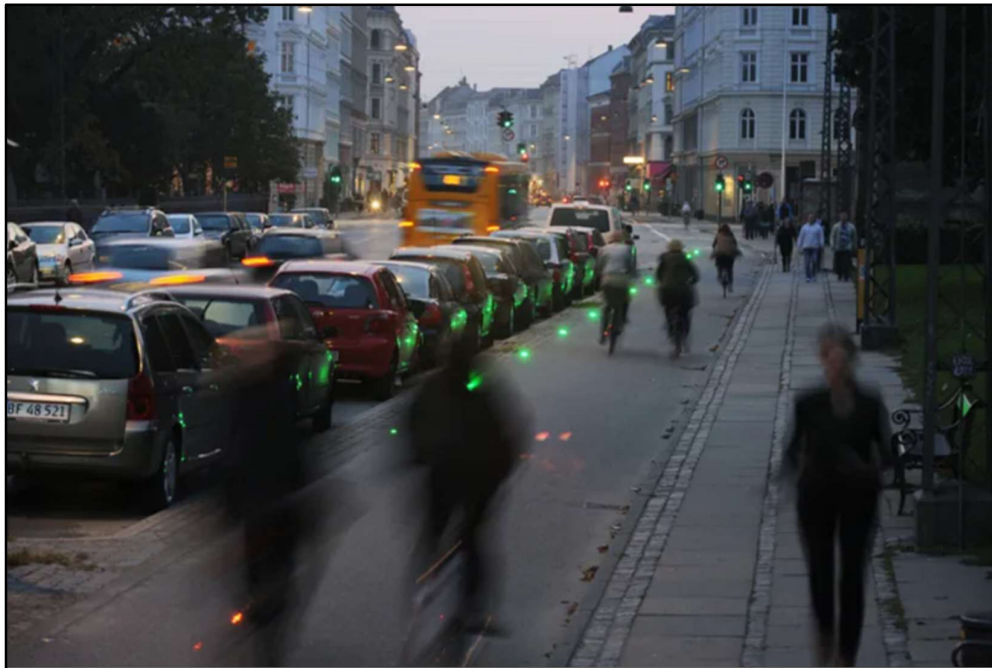


Figure 3.2 The Green Wave for Bicycles in Denmark, source: [Bike-Friendly Cities](#) | SWARCO

If a cyclist is met with a series of green lights and can maintain a steady pace of around 20 km/h, she can be certain that she will "ride the wave" of green lights, safely being transported across roads, without ever having to stop at red lights. If one sees the green lights disappearing, that means they must hurry and pick up speed to keep up. The initiative therefore implements a combination of nudges, mainly harnessing real-time feedback and salience mechanisms: real-time feedback is providing users with real-time data information on their route choice and speed, via the small speed-indicator lights that were placed along the bike path, subtly encouraging cyclists to maintain the optimal "green-wave speed", whereas salience is existent due to the lights serving as prominent visual cues in the city-environment, making cycling an attractive experience.

3.3 Sustainable Energy Consumption

As discussed in Pillar 2: Energy Conservation, initiatives that promote urban sustainable energy consumption within residential areas and buildings can be separated into two broader categories: Strategy A, which involves building green buildings anew, using novel frameworks to guide energy efficiency in new buildings and Strategy B which involves renovating old structures so that they can fit new needs for energy efficiency and conservation.

The nudges discussed in this section all adhere to Strategy B's "Renovate Green, Using Technology and Governance Tools", since they utilise technological means and novel governance tools (nudges) to inspire sustainable energy consumption within already established structures and residential areas, requiring little to no infrastructural change, while relying heavily on smart and innovative technological solutions to achieve it.

3.3.1 Default Nudges

Default nudging within sustainable energy consumption means establishing the energy-conservation choice as the default one within a residential area. Interventions that use default nudging to inspire sustainable energy consumption rely mainly on **pre-selecting** the more sustainable, energy-conservative option for the user of a certain **smart appliance**. The individual that participates in said intervention can opt-out at any given moment from this and choosing a different, "less-sustainable" option is still well within his range of abilities.

The EU-funded **NUDGE project** was a large-scale research and innovation initiative implemented to further the EU's goal of cutting energy consumption by 11.7%. As the acronym suggests, it utilised behavioural science by using nudges to promote energy saving, testing strategies like **smart meters** and social comparisons in residential settings across Europe to meet EU energy goals. The behavioural interventions were tested in real-world energy settings across five EU member states: Belgium, Croatia, Germany, Greece and Portugal. The project targeted households, electric vehicle (EV) users and energy consumers more broadly, aligning closely with the EU Clean Energy Package, the European Green Deal and the general goal of empowering consumers as active participants in the sustainable energy transition.

The following types of nudges mentioned in this dissertation were identified through analysis of official project deliverables (Deliverable D 4.2 "Report on pilot results: final report") and policy briefs (Deliverable 5.4 "Compilation of policy briefs") which explicitly describe the behavioural mechanisms underpinning each intervention. The project was orchestrated around the use of three primary nudges, also stated explicitly in the reports, Feedback, Default Options and Social Norms nudges.

Default options nudges were used to alter choice architecture of consumers, making sustainable consumption of energy the "default option". This was done via the use of **smart meters** and **digital interfaces**, which allowed energy-saving settings to be applied as default options, which participants could then easily opt out of or adjust.

3.3.2 Real-Time Feedback Nudges

Real-time feedback nudges initiatives promote sustainable energy consumption by reminding or informing users of a specific platform or a device regarding their energy use. They are then given the option to adjust their behaviour so that they can opt to conserve more energy. A recent (2023-24) **empirical study** conducted by researchers from the Massachusetts Institute of Technology (MIT) Senseable City Lab, in collaboration with the Amsterdam Institute for Advanced Metropolitan Solutions (AMS Institute), evaluated the energy coaching intervention that was administered with the objective of reducing inefficient energy consumption and alleviating energy poverty.

During the field experiment, households were divided into two (2) groups the first group received a detailed energy use report and **personalised coaching** on energy-saving behaviours, while the second received the same advice supplemented with a **smart device** that provided real-time feedback on electricity and gas consumption. All participating homes also received modest physical improvements such as insulation enhancements at the outset of the study. Participants self-selected into the smart information group largely based on willingness to engage with technology, privacy comfort and availability of a smart meter, though demographic characteristics across groups were broadly comparable.

While real-time feedback was implemented as a nudge only in the second group, across both groups participating households achieved substantial reductions in energy use and costs: average monthly electricity consumption declined by approximately 33%, while natural gas use dropped by about 42 %. Associated monthly energy costs declined by ~€104 (53%), yielding a dramatic reduction in the percentage of income spent on energy from 10.1% to 5.3%, moving approximately 75 % of participating homes out of the defined energy poverty threshold.

Across all intervention homes, several efficiency behaviours increased significantly from baseline to follow-up, particularly in areas related to heating and thermal management, such as heating only occupied rooms (significant pre-post change), opening windows for short, controlled intervals, closing curtains at night, unplugging devices when not in use. Notably, homes in the smart information group demonstrated significant changes in 6 out of 7 measured behaviours, compared to 4 out of 7 in the static group.

Comparative statistical analysis also revealed that electricity consumption reduced significantly in both intervention groups relative to controls, with smart information homes showing larger decreases than static information homes, gas consumption decreased significantly in intervention homes versus controls, though differences between smart and static groups were not statistically significant for gas alone.

3.3.3 Social Norms Nudges

Social norm nudges implemented to curb energy consumption work by enabling social comparison within users, giving them the ability to compare their energy use with others to their proximity, opting to save energy, for example when seeing that others opt so as well.

In the EU-funded **NUDGE project**, social norm nudges were implemented by enabling **social comparison**, using different means to facilitate comparison with other peers (friends, neighbours, consumers with similar demographic characteristics). Consumers were also encouraged to make a **formal commitment** to reduce the energy they consume, often in exchange for a (non-monetary) reward, an example of target setting and commitment. In the Belgian Pilot for example, a target was set to lowering the heating temperature at home by 1 degree. It was also found that children especially enjoyed comparing their consumption patterns with others.

While the study succeeded in documenting the effects of nudges in different households around Europe, the nudges' own individual successes varied, in some cases showing mixed results. However, whether the actual intervention was successful in nudging towards energy consumption or not, the findings still can be invaluable for informing future policy implementers, organisations and other research groups. More specifically, it was found that nudging to increase self-consumption from PVs had a positive effect in Germany and mixed results in Croatia, while reducing electricity consumption was successful in Germany, whereas it showed mixed results in Portugal. For Greece, reducing heat consumption through nudging was not effective, while in Belgium it proved to be successful. As for improving energy knowledge, there was no evidence for such in Belgium.

3.4 Sustainable Waste Management & Recycling

Within Urban Sustainability Pillar 3: Waste Management & Recycling, there are two (2) main strategies proposed: Strategy A proposes implementing circular economy principles into the everyday lives of consumers, whereas Strategy B advocates for ensuring that exported waste is treated in a sustainable fashion. Since waste treatment is not within the scope of daily, individual consumer activity, the subsequent nudging interventions belong to Strategy A and are themselves ways in which circular economy principles were successfully implemented and embedded within the daily lives of individuals.

3.4.1 Real-Time Feedback Nudges

Real-time feedback nudges work by informing individuals about their actions regarding a certain behaviour, urging them to self-monitor and manage their actions. In sustainable waste management and recycling, real-time feedback can be used to help individuals track how much waste they produce, see how much they recycle correctly, compare current behaviour with past behaviour, or monitor personal recycling scores/costs through **apps**, dashboards, or **smart-bin systems**.

a) The Sensoneo App, Multiple EU Cities

The **Sensoneo smart waste system**, used in several EU cities including Bratislava, as well as other municipalities across Central and Western Europe provides smart waste management solutions using IoT sensors and software to monitor bin fill levels in real time, optimising collection routes and helping cities reduce operational costs, along with businesses. Sensoneo's

Waste Monitoring App is also available for the broader public, connecting individuals directly to the Smart Waste Management System, allowing them to locate the nearest available bin, check its fill-level in real time and navigate to it easily. Individuals also can report damaged or overflowing bins.

Other interventions have evolved this **smart-bin approach**, taking it one step further by incorporating individuals' personal data to help drive sustainable waste management and recycling. An example of this includes:

b) The MIWA My Waste App, Waasland, BE

The “**MIWA My Waste**” **application**, implemented by the intermunicipal waste authority MIWA in the Waasland region of Belgium, provides residents with a digital platform for monitoring and comparing their own personal household waste production with others. The system allows users to track their residual waste output and compare their performance against municipal averages, with the aim of encouraging waste reduction and better sorting behaviour.

Residents can access smart waste infrastructure using a personalised badge and linked digital account. In municipalities using underground or “diftar” containers, waste deposits are registered automatically through smart container systems and connected to the user's profile. The MIWA My Waste app then displays information such as residual waste consumption, collection data and household waste statistics. The application also incorporates **gamification** features and **social comparison** nudges, by letting users compare their waste performance with that of other residents in their municipality and receive points and star-based rewards when their waste production remains relatively low. These mechanisms further incentivise more sustainable household waste behaviour.

3.4.2 Salience Nudges

Salience as a nudge works by highlighting a specific environmental characteristic, to stoke individual interest towards a particular behaviour. For waste management, this includes **visual cues** such as clearly colour-coded recycling bins (e.g blue for paper, yellow for plastics, green for glass), prominent signage showing correct sorting instructions, or transparent bins that make contamination visible, all of which draw attention to the correct disposal choice at the moment of decision. Salience nudges can also be implemented via floor markings (“footsteps”) and street-level signs near waste stations, or graphic labels using simple imagery instead of text, with the goal of making the sustainable option immediately more noticeable and cognitively easier to select.

A notable example of this lies in **Ljubljana's zero-waste strategy** and the way its circular economy model was implemented. The capital of Slovenia, amassing approximately 295,000 inhabitants, has emerged as a leading European example of municipal waste management reform, its residents producing about 33% less rubbish than the average European.



Figure 3.3: Ljubljana's Separate-Coloured Bins, "Responsible Waste Management" Online Article by visitljubljana: <https://www.visitljubljana.com/en/visitors/sustainable-tourism-in-ljubljana/responsible-waste-management/>

Salience was employed in external, physical environments, using **clearly colour-coded bins**, prominent labelling and **consistent visual cues** that distinguish recyclable, organic and residual waste streams. This had the result of making correct waste separation immediately recognisable and perceptually salient, increasing habituality and the probability of correct waste disposal being made.

3.4.3 Social Norms Nudges

Social norms nudges can be harnessed to implement **messaging** that imply that **most people already recycle**, reduce waste etc, to nudge the individual into adopting such actions as well. Urban food waste is a major sustainability challenge in EU cities, contributing significantly to greenhouse gas emissions through landfill methane and inefficient resource use. In Stockholm, despite the availability of separate food-waste collection infrastructure, participation among residents of multi-family housing remained inconsistent. With traditional policy tools proven to be inefficient with regards to reaching environmental sustainability goals, researchers in Sweden suggested following an alternative approach, conducting research that was behaviourally informed.

The intervention was implemented as a **natural field experiment** in early 2016 in a residential area of Hökarängen. A total of four hundred and seventy-four (474) households participated out of which two hundred and sixty-four (264) in the treatment group received the leaflet, while the remaining two hundred and ten (210) in the control group did not. The leaflet explained the benefits of separating food waste from general household waste and used social norms messaging such as *"join your neighbours to recycle your food waste"*. Households in the treatment area also received two recycling bags to support behaviour change. Recycling stations in both treatment and control areas were monitored for food waste amounts over nearly two years, allowing for both short- and long-term impact assessment.

The intervention heavily relied on social norms nudges, framing food waste recycling as a behaviour already practiced by neighbours and peers. Messages encouraging households to “**join your neighbours**” such as what was shown on leaflet’s front page, subtly communicated that recycling was a common and socially accepted practice. This leveraged individuals’ tendency to conform to perceived majority behaviour, particularly in shared residential settings where social comparison is salient.

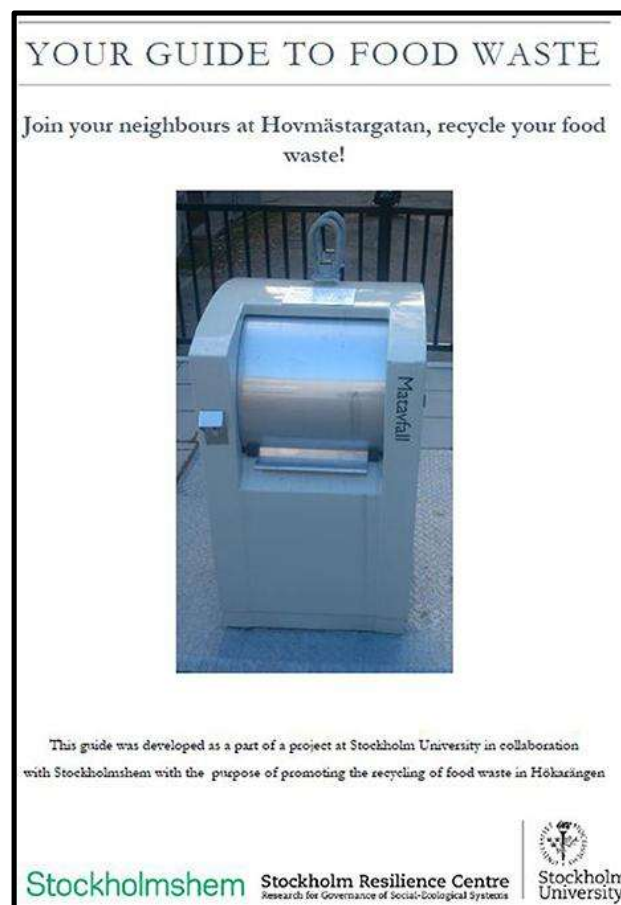


Figure 3.4: Front Page of the leaflet translated in English from Swedish

3.5 Conclusion

This chapter closely examined how nudging-based interventions are operationalised in practice across European cities to promote urban sustainability, focusing on three key domains/pillars: sustainable transport, energy consumption and waste management. Building on the theoretical foundations introduced in Chapters 1 and 2, the analysis demonstrated how choice-architectural principles are translated into concrete policy tools and digital infrastructures within real urban environments.

Across all three sustainability pillars, the case studies showed how green nudges were implemented through a limited set of types: default effects, real-time feedback, salience

enhancements and social norm messaging. In transport systems, cities such as Copenhagen, Amsterdam, Antwerp and Bologna use default infrastructures to shift mobility behaviour without removing alternatives, effectively making sustainable transport the path of least resistance. Similarly, real-time feedback systems and gamified mobility apps are used to reinforce behavioural adaptation in everyday commuting decisions.

In the domain of energy consumption, EU-wide initiatives such as the NUDGE project and smart meter-based interventions implemented feedback and social comparison to reduce household energy use and promote energy efficiency.

Finally, in waste management and recycling systems, smart-bin technologies, digital monitoring platforms and behavioural comparison tools such as those implemented in Sensoneo-supported cities and the MIWA My Waste system combine individual-level data collection with gamification, feedback and social comparison to encourage recycling compliance and reduce residual waste. Salience-based interventions, such as colour-coded bins and visual cues in cities like Ljubljana are also useful to guide sustainable action and promote recycling.

The subsequent and final chapter of this dissertation will provide some final remarks regarding nudging as a policy tool for urban sustainability. Reflecting on the key findings from Chapters 2 and 3, the effectiveness of nudges in real-world applications will be assessed, along with the limitations that emerge in terms of context-dependence, ethical concerns and long-term behavioural impact.

CHAPTER 4

DISCUSSION OF KEY FINDINGS AND CONCLUDING REMARKS

“The climate is changing, why aren’t we?”

- Unknown

4.1 Introduction

This chapter analyses the case examples presented within the previous chapter, regarding the infrastructural changes needed to achieve them. This is done to translate how these nudge types materialise in practice through the interventions, by utilising either concrete, physical infrastructural changes and installations and/or adopting technological innovations available. Nuance then arises, in understanding how different sectors and nudges require different infrastructural approaches to fully create a sustainable transition.

In short, infrastructural changes are defined as the modifications, upgrades or replacement of fundamental **physical structures** (like roads or power grids) or **organisational systems** (IT architecture or social services) that support society and businesses. It involves enhancing, upgrading, or shifting these core systems to increase efficiency, adapt to new technologies to finally improve sustainability.

In this dissertation physical, urban infrastructural changes such as bike-lane installations and city redesigns are defined as **“Urban Infrastructural Changes”**, whereas the utilisation of Digital/IT Infrastructure Modernisation using digital platforms, apps or IoT technologies is defined as **“Smart Technology”**. Therefore, the adoption of smart technology through newly installed smart devices within residences for example will not be registered as “Urban/Physical Infrastructural Changes” and will be defined simply as “Smart Technology”.

Institutional and organisational infrastructural changes are also deemed as highly important in driving urban sustainability. These changes focus on the frameworks, policies and systems that manage how society or a business operates. While those will not be discussed in this dissertation, they can be found in many of the case studies presented.

After the presentation of the case studies’ key findings, their further analysis and discussion, some final remarks regarding the use of nudging in sustainability policy are made, along with some compiled advantages and disadvantages of its use, that arise from the aggregate theoretical analysis seen in the previous chapters.

4.2 Sustainable Transport

Pillar 1: Sustainable Transport saw interventions that implemented Strategy A’s “Encourage Modal Shift, Discourage the Use of Private Vehicles”. Technology and infrastructural changes

were seen to play a great role here; by utilising online platforms, smartphone apps combined with city re-designs (15-minute-cities, superblocks) to curb car use and enable alternative modes of transport. Furthermore, in all three nudge-type categories smart technology in some form was used, while important infrastructural changes were made in all instances except in interventions that used Real-Time Feedback nudges. Specifically:

1. Default Nudges: Automatic Enrolment Schemes / Passive-Acceptance Mechanisms + Physical Infrastructural Changes (bike lanes) + Broader Physical Infrastructural Measures (re-designing cities so that walking, cycling and public transit are the most convenient, affordable and safe / 15-Minute-Cities)
⇒ **Smart Technology, Important Urban Infrastructural Change**
2. Real-Time Feedback Nudges → Technological Means, such as Smartphone Apps using digital notifications and smart gear, Digital Platforms, Apps and Gamification
⇒ **Smart Technology, No Important Urban Infrastructural Change**
3. Salience Nudges → Physical Installations (Green Wave) + City Redesigns
⇒ **Smart Technology, Important Urban Infrastructural Change**

4.3 Sustainable Energy Consumption

Pillar 2: Sustainable Energy Consumption saw interventions that implemented Strategy B's "Renovate Green, Using Technology and Governance Tools". This was made possible mainly via the use of new technological solutions and tools, such as using smart appliances and smart apps that gave the ability to check consumption levels and enable social comparison with others. No significant infrastructural change via significant physical installations or re-designs was observed in any of the broader nudge categories. Specifically:

1. Default Nudges → Preselecting the more sustainable, energy-conservative option for the user of a certain smart appliance
⇒ **Smart Technology, No Urban Infrastructural Change**
2. Real-Time Feedback Nudges → Reminding/Informing users on their energy consumption level
⇒ **Smart Technology, No Urban Infrastructural Change**
3. Social Norms Nudges → Enabling Social Comparison + Formal Commitment
⇒ **Smart Technology, No Urban Infrastructural Change**

4.4 Sustainable Waste Management and Recycling

Pillar 2: Sustainable Waste Management and Recycling saw interventions that implemented Strategy A's "Implement Circular Economy Principles".

1. Real-Time Feedback Nudges → Apps + Smart-Bin Systems + Gamification

⇒ **Smart Technology, Important Urban Infrastructural Change**

2. Saliency Nudges → Clearly Colour-Coded Bins + Prominent Labelling + Consistent Visual Cues

⇒ **No Smart Technology, Important Urban Infrastructural Change**

3. Social Norms Nudging → Messaging that Emphasises Target Behaviour as Already Popular

⇒ **No Smart Technology, No Urban Infrastructural Change**

4.5 Cross-Sector Comparison

By comparing all three sectors' key findings it is possible to draw some meaningful conclusions regarding technology use and urban infrastructural changes implemented.

- Sustainable Transport appears as the sector that **relied the most heavily on concrete, physical infrastructural changes within the urban environment**, featuring significant city re-designs.

Smart technology was also implemented here, in all three of its subcategories.

- Sustainable Energy on the other hand **relied most heavily on technology** for the implementation and simultaneously **relied the least on significant physical, urban infrastructural changes**.

No major urban infrastructural changes were observed throughout the category's cases.

- Sustainable Waste, finally, features examples where **important physical infrastructural installations usually accompanied some smart technology application**.

It also presents as the only category which featured an intervention that required no significant use of either smart technology or infrastructural changes and add-ins (in 3. Social Norms Nudging), relying simply on an informational leaflet to promote recycling food waste.

To summarise, the sector that saw interventions that relied most on:

1. Urban Infrastructural Changes: Transport
2. Smart Technology: Energy Consumption
3. Both (and, in one case, neither): Waste Management & Recycling

4.6 Discussion of Key Findings

Key Finding #1: Sustainable Transport is the sector which relies most on major urban infrastructural changes to successfully implement the nudges, alongside smart technology applications.

This can be explained in part due to the nature of sustainable transport itself which shapes the kinds of changes needed to be made for it to be materialised. The goal behaviour

here of modal shift or opting for sustainable modes of commuting usually requires extensive infrastructural changes to be made in the first place, for it to be a success or default mode of transport.

Cyclists for example need assigned cycle lanes for them to safely commute from place to place, while pedestrians generally benefit from widened pavements and safer crossings that make walking both practical and attractive. Similarly, the effectiveness of transport nudges often depends on the availability of reliable and accessible public transport infrastructure. Without these foundational infrastructural changes, behavioural interventions alone are highly unlikely to produce long-term modal shifts, as individuals may still perceive sustainable options as inconvenient, unsafe and/or inefficient compared to traditional modes.

Key Finding #2: Sustainable Energy Consumption as the sector which was found to rely the least on major urban infrastructural changes to implement the nudges and most heavily on smart technology applications.

This can be attributed to the nature of the goal of sustainable energy consumption within residential areas itself and the changes that are needed for it to become reality. Individuals are usually already equipped with the appliances necessary for household energy consumption, but find that they use them inefficiently. The issue then isn't a lack of “infrastructure”, but mainly correct use of already existing appliances and efficiency, along with some minor technological enhancements (smart meters etc).

The Energy Coaching Amsterdam program for example did exactly that, by not relying on major urban infrastructural changes and instead focusing on providing personalised advice via Energy Coaches on energy-saving habits, combined with in-house smart device application. Finally, during the NUDGE project, smart meters and digital interfaces were installed in houses, allowing energy-saving settings to be applied as default options.

Key Finding #3: Waste Management & Recycling as the sector that showed “mixed results” regarding the use of urban infrastructural changes and smart technology applications. In it, urban infrastructural changes usually accompanied smart technology applications to implement the nudges, while also featuring a case where no smart technology or infrastructural change was needed.

Again, this can be explained in part due to the nature of the sector itself and the goal behaviour of more recycling. Bin systems are already well-established within modern urban environments, so the goal then shifts from how to upgrade them infrastructurally to how to nudge individuals into using them properly and more often, using proper recycling. This was the case with the social norms nudging information leaflet seen in the sector’s third case study. Increasing visibility and making bins more visually prominent can also assist in instigating pro-environmental behaviour, as seen in cities across the EU, including in Ljubljana.

Smart bin systems on the other hand, while they are technically known as incremental improvements or modifications to already-existing streetscapes that are often characterised as “micro-infrastructure”, can nonetheless represent a major shift in the function and policy of

established waste management systems. This is because they force a transition from simple waste collection to integrated, smart logistics.

All in all, the findings suggest that this sector displays potential for diversity in instigating behavioural change, drawing from a variety of technological–infrastructural–simple/informational approaches.

4.7 Advantages and Disadvantages Regarding the Use of Green Nudges

Starting from its own definition, a nudging is generally cost-effective, easy to construct and implement and cheap to avoid for the individual. It also protects personal freedom, by not serving as a mandate and not forbidding any options or significantly changing the economic incentives. This is beneficial for both the practitioners and the nudgees alike, as non-invasive, non-coercive, cost-effective interventions that fit with the values of modern democracies.

Secondly, its effectiveness has proven to be real for many research papers published and many behaviourally informed policies around the world. There might be a discrepancy that is observed between lesser vs more effective nudges and the effectiveness itself might be highly context-specific, however it is still evident in some cases and therefore, still serves as a promising tool for policymakers worldwide.

Thirdly, although nudges have been considered by some to be paternalistic and can potentially lean towards that direction if not sufficiently organised and executed, it is not necessary for that to be so. Guidebooks such as the “A Framework for Good Green Nudging” that was published in 2025 by the European Law Initiative, have been developed for this exact purpose –to guide practitioners and policymakers towards developing interventions that are respectful towards the freedoms of the individuals. Furthermore, there are nudges that inherently rely on the individuals’ conscious awareness, such as “Mindful” nudges, “Self-Imposed” nudges, as well as “Boosting Self-Control” nudges, with individuals volunteering for having their behaviour nudged towards a desirable outcome.

On the disadvantages’ side, nudges’ impact and capabilities in addressing complex, high environmental problems like climate change are still considered limited. This is why they are considered to function better in combination with regular policies, rather than posing as a substitute for it altogether. Importantly, nudging effectiveness is also not guaranteed, due to them being highly context specific. This poses an issue for scalability of interventions as what can work in one intervention/experiment can fail in a different one, making it difficult to establish scientific replicability of results. Lack of personalisation and overreliance on “cookie-cutter” nudging recipes can also prove to be detrimental for an intervention’s effectiveness.

Whether nudges can foster lasting behavioural change that inspires intrinsic motivation and constructs a new behavioural paradigm based on sustainable practice, is much debated. Nudges’ effectiveness currently rests on analysing the short-term effects, that are also the more obvious ones, for example in instigating immediate, superficial behaviour change. Lastingness, or whether an intervention can generate long-term behaviour change towards pro-sustainability behaviours is currently in need of more research.

Nudging interventions also can suffer side-effects, producing unintended results that can backtrack sustainability goals and even lead towards the opposite direction. Moral licensing can be observed where individuals, after engaging in a pro-environmental behaviour of, for example, recycling or reducing energy use, feel justified in subsequently engaging in less sustainable actions, thereby offsetting the initial positive impact.

Finally, the concept of libertarian paternalism, which underpins nudging practices, continues to generate significant ethical debate regarding the extent to which such interventions are indeed “libertarian”, as opposed to subtly paternalistic. While nudges are designed to preserve freedom of choice, they mainly rely on cognitive biases and heuristics to steer individuals toward outcomes, thereby raising concerns about manipulation and individual autonomy. Poor intervention planning with a combination of not following the “true/mere nudges” definition (*options must not be forbidden, economic incentives must not be significantly altered, nudges are not mandates*) can severely exacerbate this. Again, it is important to note the existence of several nudging guidebooks that can serve to guide policy-makers into developing nudging interventions that are ethical and which focus on upholding social welfare, as is covered for example in the “A Framework for Good Green Nudging” guidebook, created by the European Law Institute (2025).

4.8 Conclusion

This dissertation examined whether nudging techniques could contribute to the promotion of sustainable behaviours within European urban environments, focusing specifically on the areas of transport, energy consumption and waste management. Through the analysis of behavioural economics theory, EU sustainability frameworks and urban case studies, the study explored both the potential and the limitations of nudging as a policy instrument for sustainable development. It was found that nudging techniques can indeed positively influence sustainable behaviour in cities by subtly reshaping individual decision-making processes without restricting freedom of choice and have been implemented extensively across Europe via smart meter feedback, recycling and social norm interventions, as well as visual cues and default option nudges.

Many interventions demonstrated measurable short-term behavioural change, particularly where nudges were easy to understand, low-cost and integrated into existing infrastructure. However, effectiveness varied considerably depending on context, implementation quality and the targeted behaviour. Research on nudges’ long-term effectiveness, while limited, can prove very useful in determining the outcome of the interventions and should be employed where possible.

Overall, the dissertation concludes that nudging can be regarded as a potent tool to guide sustainable behavioural change but should not be viewed as a stand-alone replacement for structural environmental policy. Since the climate crisis and the environmental challenges associated with urbanisation are highly systemic in nature, behavioural interventions alone cannot fully address the scale of the problem without parallel investments in infrastructure, regulation, renewable energy systems and corporate environmental accountability.

Technological use and infrastructural upgrades were highly represented within the studies and were those that arguably facilitated the success of the nudging interventions themselves.

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