# The Impact of Current Transportation Infrastructure on the Environment and Human Health, as well as the Solutions Developed by Scientists to Circumvent its Security.

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**Abstract**

*Means of transportation become essential for countries on the global level and people on the national and social levels. Despite that, the infrastructure of certain transportation buildings such as roads, ports, and railways has its drawbacks. This research reviews specific identification of transportation, its infrastructure development, and types of transportation commonly used and demanded in the modern age. Furthermore, it investigates the main impacts of the transportation infrastructure and how its influence on environmental life and human health. Where the pollution these infrastructures leave behind is the main aspect concerned with these impacts. Detailed statistics are gathered to make the severity of these impacts realizable. In the end, we conclude that transportation is life-dependent demand for all nations, but the world must pay more attention to making it sustainable and eco-friendly. In this context, some modern prior solutions and mechanisms for reducing the effect of these implications are suggested.*

## I. Introduction.

Transportation services, and especially the roads, ports, and railway stations present important for socio-economic development. Transportation infrastructure presents a double-edged weapon. It has a positive impact on economic life by providing access to various jobs and the development of the marketing and business sector [1], [2]. The negative part represents the impact on the environment that vary from direct and indirect effects. For example, the effect of road construction leads to an increase in the emission of greenhouse gases and others that might cause adverse health effects and affect the biodiversity of the wild animals and microorganisms in the different types of soils. The resulting dataset indicates that 222 countries across the world include 21 million km of roads which is double or triple the current best available country-based global roads dataset [3]. The GDP (Gross Domestic Product) estimates from shared SSP (Shared Socioeconomic Pathway) scenarios that our World will obtain from 3-4.7 million km of additional road length by 2050 [3]. Each transportation infrastructure demands an environment of suitable soil with definite structure and components. No one can deny the great positive role of transportation means in providing many opportunities. They close distances between cities and people and make life much easier by transporting goods and services. Despite all of that, means of transport have serious direct and indirect impacts on the environment and human health. Many injuries can arise from road accidents in addition to the air

pollution caused by the emissions of harmful gases [4]. For instance, trying to explain the severity of these impacts, an estimation was done in 206 states that road transport contributes to the emissions of NOx (nitrogen oxide) by around 41.7% [5]. The research paper will go into the process of identifying the infrastructures' role and evolution, recommendations of prior solution that was recently added to aim in solving these harmful impacts of these various infrastructures, and an overview of their point of strengths and weaknesses.

## II. Basics of Civilizations.

This section discusses some information about infrastructures and their types.

### *i. What is Infrastructure?*

Infrastructures are a crucial component of any developed or developing country because it enhances countries' productivity by improving the transportation, communication, and production system in any country. In the recent decades and bypassing the industrial civilization, the modern infrastructure gave birth to many advancements from (new construction materials, computer tools, and machinery or technology in the process of project construction). But what is infrastructure? infrastructure ("infra" stems from the Latin language, meaning below, thus "infrastructure" can be taken to express "foundation"). The "engineering" meaning behind that topic is that infrastructure is a system that could manage and organize complex movements [1]. Others believe that infrastructure doesn't have a specific meaning; Grimsey and Lewis (Civil engineers) say that infrastructure is easier to identify than describe [2]. For nearly two centuries "Infrastructure" as an analytic concept was absent from the economic sector [3]. By the year 1990, The infrastructure concept was estimated that contributes to the development of economic growth [3]. The infrastructure is related to economic services as well as it's also a civil engineering topic [3]. Table (1) shows different infrastructure-associated services.

***Table 1*: Shows the relation Services associated with infrastructure**

| Service | Associated infrastructure |
|---|---|
| Transportation | Roads, bridges, tunnels, rail tracks, harbors, etc. |
| Water supply | Dams, reservoirs, pipes, treatment plants, etc. |
| Water disposal | Sewers, used water treatment plants, etc. |
| Irrigation | Dams, canals |
| Garbage disposal | Dumps, incinerators, compost units |
| District heating | Plant, network |
| Telecommunication | Telephone exchanges, telephone lines, etc. |
| Power | Power plants, transmission and distribution lines |

Source: Author's compilation.

### *ii. Types of Infrastructure Systems.*

Figure (1) represents a simple diagram that could classify the infrastructure systems that are classified mainly into two types that are (Physical and Social infrastructure) [7].

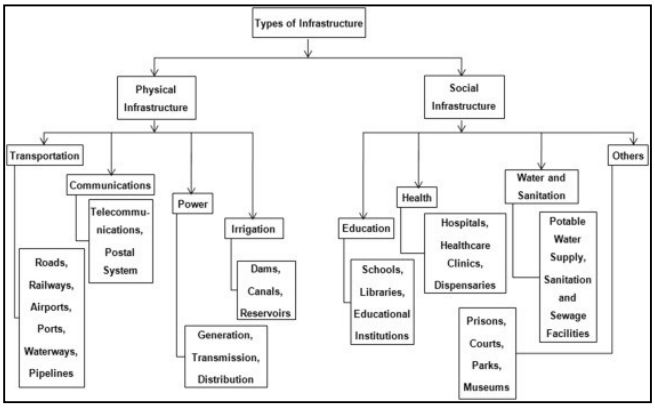


**Figure *1*: Present the main infrastructure system types**

### *iii. Integrated Infrastructure and Transportation.*

This type of infrastructure was much known by the engineers of the industrial civilization in Europe. The integrated infrastructure is the combination of two or more systems of the infrastructure due to shared relations between them such as (two or more sectors of infrastructure systems from transportation,

energy, water, railroad, etc.….) [1]. Integrated infrastructure can occur at various scales (urban, rural, and regional), across ecosystems (climate, social, land, and water), and between different sectors (economic, health, political, and social)[1].

According to these variables in the infrastructure independence, scientists classified them into some types of integrated infrastructure. The framework of infrastructure independence can be conducted at different levels from high to low[1].

- *Physical (material or physical flow from one entity to another);*
- *Cyber (information transfer);*
- *Geographical/spatial (physical proximity affecting components across multiple infrastructure systems);*
- *Logical (dependencies other than the above three categories).*

Transportation infrastructure is a wide range that contains many types of constructions and processes such as (roads, (air)ports, and railways). This type of infrastructure has a wide range of integration with many other types of infrastructures because it affects the environment from a different perspective as they affect the (Air, Land, and Water). All these integrations made it an interesting topic that attracted many scientists to put it into consideration.

The scientists claimed that transportation infrastructure failures can be divided into five types [1]:

- *Infrastructure is frequently the cause of failure in other infrastructure.*
- *Infrastructure is frequently affected by a failure of other infrastructure.*
- *The ratio of being a cause of failure relative to being affected by a failure.*
- *Certain types of infrastructure are frequently linked with another one.*
- *Most severe effects in terms of people affected and how they are affected.*

For example, for the first point in the above types. Water can affect a bridge's infrastructure by causing its basic components water erosion or the formation of iron rusting over long periods. Most integrated infrastructures, mainly transportation infrastructure characterized by "tight coupling". This means that both relations between the infrastructure depend mainly on the time which is the connecting bond between the infrastructures and the tight coupling is a main part in the transportation infrastructure development because a lot of the roads, waterways, and pipelines specifically are more dependently of their life that may reach decades and centuries because of the time presence the efficiency of a certain construction [7].

## III. Transportation Infrastructure.

### *i. Brief of Transportation Infrastructure.*

Since the earliest development of civilization all around the world, humankind needed to get from one place to another and trade various goods from one place to other. Passing time day by day, the demand for the transportation system became more advanced.

In ancient times people crafted simple boots from logs and then they advanced in land transportation and began to use devised wheeled vehicles as a means of transportation. Learning the human about energies and their different resources and forms, the human invented cars, trains, metros, etc.….. These advancements needed change in our environment and transportation infrastructure to be eligible for

these new means of transport. That was the time of the development of the transportation infrastructure field and became one of the most popular fields worldwide and it will still be as much as important over time because it keeps up the development of different fields over time.

### *ii. Materials used and Data collection.*

Before talking about the materials that are used in transportation infrastructure. They should be classified into different groups according to their different needs and effect on the environment. The types that will be discussed in this article are:

- *Pavement infrastructures.*
- *Waterway infrastructures.*

## IV. Pavement structure.

The roadway system is important for both the economic vitality of the nations over the world as well as its societal benefits. The roadway network and pavement structure provide a smooth and comfortable range for both vehicles and users. So, the reason behind the improving pavement structure and roadway system is because its potential development supports delivering tremendous environmental, social, and economic benefits [8].

Pavement structures and road networks are built in different layers that are present (subgrade, subbase, base, surface layer) as shown in figure (2) [8]. These layers are composed of different structures and materials that are commonly used such as (Gravel, Stone, Asphalt, Improved soil, and concrete) [4]. The control group in choosing the materials and their percentage from each layer is according to the traffic density in the place that the road or the pavement will be constructed to be able to keep up with its different conditions.

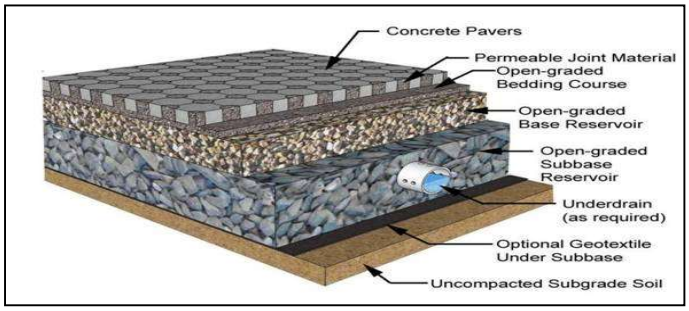


**Figure *2*: Illustration for the pavement structure components**

There are three main types of pavements. i.e., flexible (asphalt pavement), rigid ("PCC" (Portland Cement Concrete) pavement), and composite (the pavement is composed of both flexible and rigid pavements). The choosing processes from these types and the components that could be used depend mainly on different factors such as (Traffic, performance, design, location, and life cycle cost).

The most important Factors in the choosing processes are the (performance and life cost cycle):

- The performance is evaluating the used materials in laboratory tests including (fatigue, moisture sensitivity, and indirect tensile strength and fracture tests) [9]. Furthermore, rheological tests such as a temperature sweep and a Multiple Stress Creep Recovery (MSRC) are performed to better understand the impacts of waste materials on the viscoelastic properties of unaged and aged bituminous binders [9].

- The life cycle cost of any pavement consists of four main phases: raw material, construction, utility, and recycling. As the pavement life cycle is considered to be a

closed loop to help in improving its sustainability and minimize the effect of the waste materials on the environment [9]. Furthermore, the environmental impact and socioeconomic cost of various paving options should be evaluated. These expenses could be evaluated such as agency cost and used cost [9]. The costs of the agency include raw material processing, construction maintenance/rehabilitation, and recycling, whereas the costs of the pavement users typically include vehicle operation, delay, and accident costs [9]. Figure (3) [10] shows a simple mind mapping diagram about the life cycle of a pavement infrastructure.

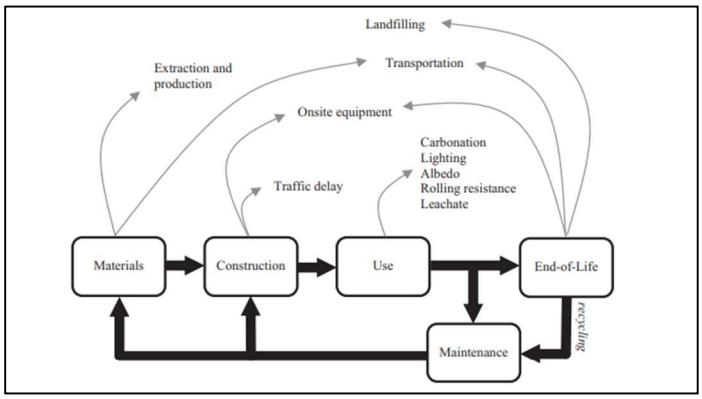


Figure *3*: Life cycle of pavement structure

The most important topic to be considered is that the cement industry alone accounts for about 5% of the total industrial energy consumption and contributes about 5% of the total global $CO_2$ emissions. That increase in the emissions increased the awareness of (transportation infrastructure as a field) toward climate change and sustainability [4]. The following figure (4) shows the relation between urban population, paved roads, unpaved roads, road sector energy consumption and $CO_2$ emissions for some countries.

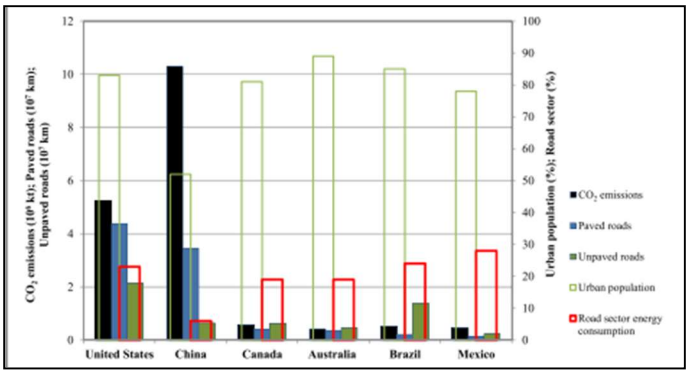


Figure 4: urban population, paved roads, unpaved roads, road sector energy consumption and 〖CO2〗 emissions for some countries

A survey was made by the Federal Highway Administration (FHWA) and National Asphalt Pavement Association (NAPA) in 2015. It showed that nearly 100% of the reclaimed asphalt pavement (RAP) has been put back to use in 2015, and nearly 74.2 million tons of RAP were recycled, leading to the formation of about 3.7 million tons of virgin asphalt binder conserved and 71 million ton aggregated saved [11].

A lot of scientists think that asphalt mixing containing RAP is higher stiffness resulting from a mixture of virgin asphalt binder with old asphalt blinder [4], [5]. According to the slope of the indirect tensile strength (ITS) in figure (5) [5], each additional percent of RAP raises the ITS of the combination by 13 kPa. Furthermore, the RAP's binder content reduces the optimal new binder content (OBC). Figure 1 depicts the inverse relationship between OBC and RAP concentrations. As a result, including RAP not only boosts the structural capacity of the asphalt mixture in terms of dynamic modulus and ITS but also reduces the volume of the new binder required, resulting in better sustainability benefits [4], [5].

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terms of dynamic modulus and ITS, it also reduces the necessary volume of the new binder, resulting in greater sustainability benefits [4], [5].

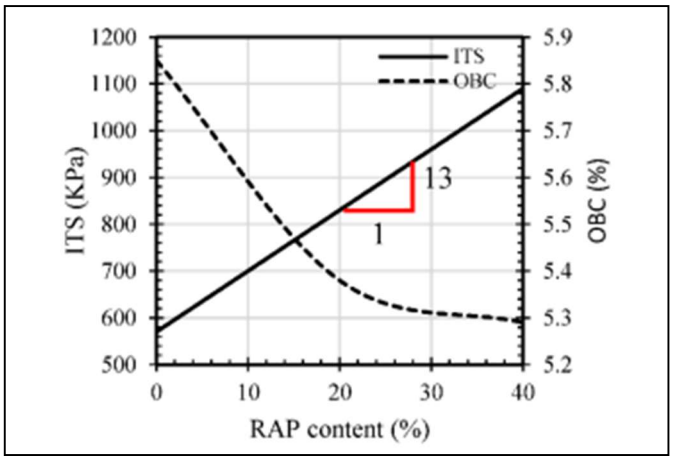


**Figure 5: Correlation between ITS and OBC and RAP content.**

i. *Environmental and human health impacts of transportation infrastructure.*

Roads are the most abundant mean of transport including the vast road networks connecting regions and cities. Being a major disadvantage of roads, emissions from traffic factors such as cars, trucks, and even motorcycles lead to air pollution which has a great impact on the atmosphere and soil. The main gases causing this pollution are nitrogen dioxide (NO2), carbon monoxide (CO), Sulphur dioxide (SO2), and polynuclear aromatic hydrocarbons (PAHs). These gases arise from the incomplete combustion of the engines of vehicles on the road [12]. These substances are considered fine by-products particles that will remain in the air for long period. Contrarily, there are large particulate substances that may be introduced to the road and vicinity around it. They are heavy metals that come from the corrosion of vehicles tires, leakage of oil, or even within the exhaust coming from the vehicles. Table (2) illustrates an estimation done in the Netherlands for the emitted PAHs and heavy metals based on the activity of 6 million vehicles [12].

Furthermore, building and implementing different means of transport in "green areas" has its consequences. This is because of disturbing the natural ecosystems like forests and water bodies in seas and oceans when deciding to construct a network of roads, railways, or ports in these areas. This leads to the destruction of the ecosystem, changing its activity by being no longer a habitat for many living organisms, and endangering the wildlife all in addition to the serious influence on the soil, water, and air [13].

**Table (*2*): An estimation for the emissions of heavy metals and PAHs in Netherlands**

| Contamination | Exhaust | Oil leaks | Tires | Brakes | Radiator | Total |
|---|---|---|---|---|---|---|
| Arsenic | 0.17 | 0.015 | 0.013 | 0.004 | | 0.199 |
| Cadmium | 1.2 | 0.002 | 0.73 | | | 1.932 |
| Chromium | 1.7 | 0.014 | 2.6 | 0.518 | | 4.832 |
| Copper | 0.25 | 0.061 | 3.65 | 9.072 | 50.910 | 63.943 |
| Lead | 240 | 1.96 | | 0.022 | 0.072 | 242.054 |
| Nickel | 1.7 | 0.007 | 2.48 | 0.285 | 0.192 | 4.664 |
| Zinc | 2.3 | 1.49 | 175 | 0.117 | 0.168 | 179.075 |
| PAH-10 | 187 | 2.32 | 1 | 0.004 | | 190.324 |

Asphalt and concrete are considered the most used materials in the manufacture of roads in the modern age. Being a complex mixture of nearly 55 chemical compounds, asphalt represents an environmental danger as it's a petroleum product containing PAHs. According to the United States Environmental Protection Agency, there are some PAHs in asphalt that might be possible carcinogens for humans, and others confirmed so as for animals, putting serious occupational hazards on workers who are in exposure to them for long periods [14]. Furthermore, to realize the severity of these impacts, an estimation done in 2013 proves that the black carbon and harmful substances in the emissions of transportation led to the death of 2.9 million attributable victims [15].

*ii. acts of Real-life Application Project in Kenya: SGR.*

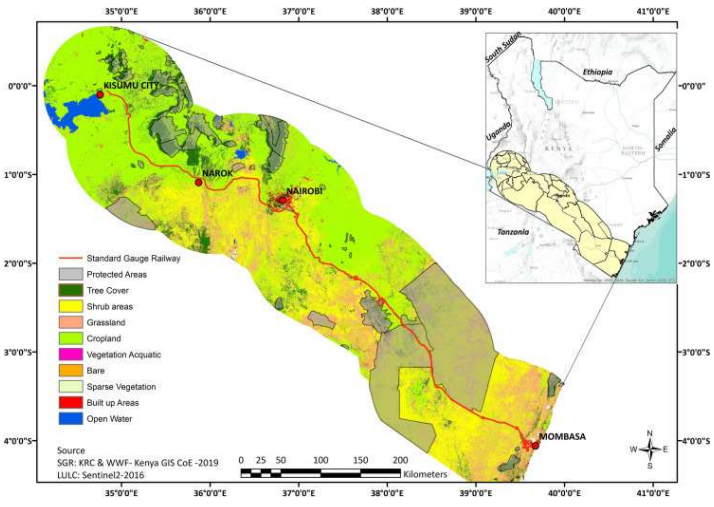


**Figure (6): A map for SGR passing through eight counties from Mombasa to Kisumu**

Kenya Standard Gauge Railway (SGR) is considered one of the projects that Kenya is keen on for its Vision 2030 development agenda. Figure (6) illustrates a map of the SGR pathway. Although it's confirmed to be the biggest transport infrastructure in the country's history, many analyses revealed that it has severe ecological impacts. Many reports came from different regions around the construction sites of SGR. Some of them ensure that the rail embankments affected the development of seeds in the soil and blocked water streams, resulting in overall soil degradation in specific areas. Other reports included observations of the noise pollution coming from the operations of the building affecting people and causing cracking in some buildings. The effect of noise didn't stop within humans but also arrived in animals. According to observers, some animals like elephants are becoming more aggressive as they perceive the noise as a trigger for human-danger coming, so they try to defend their selves. This trend will lead to an increase in human-wildlife conflicts [13].

## V. Waterway Infrastructure.

### *i. Brief Overview.*

Waterways were one of the first infrastructures in the world as it was used by many nations as a transportation process for goods and people. It's used for these purposes and much more for defending and in a lot of wars. Water systems usually consist of (rivers, canals, seas, and oceans) [16]. The most important type of waterway infrastructure is dam infrastructure as they present geographic and economic importance for the nations [16], [17]. Dams' infrastructure is concerned mainly with socio-economic and environmental effect because of its significant importance for many nations that depends mainly on dams as a source of their sustainability in different economical fields [17]. Compared with other transportations, waterways as ports represent an efficient means of transport for moving large quantities of goods and long-distance journeys. it is estimated that over 80% of the world's traded goods are transported through maritime shipping [18].

### *ii. Main Impacts of Ports Activities.*

Impacts that ports are concerned with are represented in the several pollutants emitted annually from the shipping and transportation activities done within seaports. To simplify, these pollutants, which are emitted from the chimneys of ships, can be classified into two categories. The first one is the group of greenhouse gases (GHG), where the most famous ones are methane (CH4) and carbon dioxide (CO2). The second one is the Common Air Contaminants (CAC), where nitrogen and Sulphur oxides (SOx and NOx) are the most recognizable ones. Table (3) shows other types of them [18]. The main indirect impact beyond port activities resulting from GHG emissions is their greenhouse effect which traps the infrared radiations within the atmosphere. This results in another serious problem which is global warming which is considered a worldwide problem

that all organizations and countries are trying to deal with. In addition, CAC originated from marine fuels, where NOx gases are generated inside the cylinders of these fuels as a result of high temperature and pressure. While SOx are produced from the combustion process of these fuels. The danger of these gases comes in their ability to stimulate the throat and nasal cavity respiratory diseases, especially in people infected with asthma. Moreover, SOx gases can develop into sulphuric acid when interacting with oxygen in the presence of NOx. This leads to polluting the environment through acid rains and hence the crops, animals, and people [18]. As proof of increasing the CO2 in the atmosphere, a study states that the total GHG emissions have increased from 977 million tons in 2012 to 1076 million tons in 2018 (9.6%) [19].

**Table 3: General classification of air pollutants**

| Type | Main Pollutants |
|---|---|
| Common Air Contaminants (CAC) | Oxides of Nitrogen ($NO_x$)<br>Oxides of Sulphur ($SO_x$)<br>Particulate Matter ($PM_{10}$ and $PM_{2.5}$)<br>Carbon Monoxide (CO)<br>Volatile Organic Compounds (VOC)<br>Ozone ($O_3$) |
| Greenhouse Gases (GHG) | Carbon dioxide ($CO_2$)<br>Methane ($CH_4$)<br>Nitrous Oxide ($N_2O$) |
| Other pollutants | Dust<br>Odors<br>(Noise) |

### *iii. Main Impacts of Dams.*

Dams are one of the major water infrastructure projects that were introduced to the world throughout the 20th century. They have significant positive aspects as they provide food protection, hydroelectric power, and drinking water supplies in addition to their role in maintaining the historical demand for agricultural irrigation [20]. Otherwise, dams have acute impacts on human health. Extending to the reservoir site and upstream and downstream of the river, dams and irrigation projects contribute to increasing the propagation of many diseases such as malaria, encephalitis, hemorrhagic fevers, schistosomiasis, gastroenteritis, filariasis, and intestinal parasites. In addition, they force the gathering families and communities to resettle in another place and leave their native one. Leaving their place and reliable source of drinking water, the preexisting communities and the following ones will have insufficient sources resulting in many water-related diseases such as cholera. Table (4) states the associated effects and impacts of dams in different areas [21].

## VI. Prior solutions.

**Table 4: Potential Health Impacts of Large Dam Projects**

| Impact Area | Effect of Dam | Health Impact |
|---|---|---|
| Upstream catchment and river | Loss of biodiversity, increased agriculture, sedimentation and flooding, changes in river flow regime | Changes in flood security, water-related diseases, difficulties with transportation and access to health facilities |
| Reservoir area | Inundation of land, presence of large man-made reservoir, pollution, changes in mineral content, decaying organic material, pollution | Involuntary resettlement, social disruption, vector-borne diseases, water-related diseases, reservoir-induced seismicity |
| Downstream river | Lower water levels, poor water quality, lack of seasonal variation, loss of biodiversity | Food security affected on flood plains and estuaries (farming and fishing), water-related diseases, dam failure and flooding |
| Irrigation areas | Increased water availability and agriculture, water weeds, changes in flow and mineral content, pollution | Changes in food security, vector-borne and water-related diseases |
| Construction activities | Migration, informal settlement, sex work, road traffic increase, hazardous construction | Water-related diseases, sexually transmitted diseases, HIV/AIDS, accidents and occupational injuries |
| Resettlement areas | Social disruption, pollution, pressure on natural resources | Communicable diseases, violence and injury, water-related disease, loss of food security |
| Country/regional/global | Reduced fuel imports, improved exports, loss of biodiversity, reallocation of funding, sustainability | Macro-economic impacts on health, inequitable allocation of revenue, health impacts of climate change |

The various water systems have to deal with the climate change problems. In response, a lot of the water managers in the city of Rotterdam developed new water strategies for the management processes of the water resources by combining the renewal of water infrastructure with neighbourhood revitalization projects [22]. Recognize that enhanced water retention in current urban areas can only be accomplished if these initiatives are tied to urban renewal programs. Furthermore, it was realized that through the new infrastructure, the social environment for degraded neighbourhoods may be rehabilitated [22]. According to the findings of this historical analysis, this shift in thinking began with the successful innovation of water policy in Rotterdam, where urban water policy is also utilized to solve other urban problems by improving the quality of public utilities [22]. This study discusses the primary reasons that contributed to this process and makes recommendations to further progress urban water management change [22]. Infrastructure and its relationship to spatial planning [22].

Researchers assessed the effects of the policy niche Rotterdam Water City 2035 on modifications in the water management regime. The spread of the Rotterdam Water City 2035 development strategy was investigated. The case study, in particular, concentrated on:

- *The impact of this policy speciality on broader urban water management policy [22].*
- *Investigate how innovations and ideas were incorporated into official urban water management and urban planning policies [22].*
- *Documents about local water policy, urban planning, internet resources, and project plans were examined. The relationship between water management and urban planning and development is an important component of a transformative planning approach. As a result, water management themes in urban planning documents and urban planning themes in urban water management papers received special attention. Local council planning papers and project plans were reviewed to examine the dissemination of the transformative approach from the municipal to the local levels [22].*
- *Key findings of solutions.*

*i. Regime developments in Rotterdam urban water management (1989–present)*

The first significant institutional shift occurred in 1989. The responsibility for urban surface water management was to be transferred from municipalities to waterboards, according to the Third National Memorandum on Water Management [23]. The advent of integrated water management in the 1980s was responsible for this transformation. This method stressed interdependence among water quantity, water quality, and environment, and emphasized the importance of collaboration. Waterboards have traditionally centred in the countryside The responsibility was transferred over the next 10 to 15 years. An attempt has been made in Rotterdam. The attempt to shift responsibilities was attempted in 1996, but it failed. The water boards and the municipality were unable to resolve the issue. Agree on asset valuation.

Furthermore, the waterboard reported that there was a lack of upkeep. This would necessitate more effort and result in increased water board taxes. Finally, after reaching an agreement, the transfer was completed in 2001. In 1998 and 1999, the municipality created the first water management plan (WP1) in collaboration with the water boards. This plan was created for two reasons: *(1) the approaching transfer of surface water management to the waterboards, and (2) the 40-year-old sewer system needed to be updated and modernized.*

At the end of the 1990s, it became evident that the capacity of urban water infrastructure was insufficient. Pluvial floods that occurred in 1998 in Western Holland, including the Rotterdam districts, prompted questions in parliament. Tielrooij was appointed to a committee for an investigation. In an investigation into the state of the Dutch water management systems, the authors of Water Management in the Twenty-First Century report the committee claimed that the water retention and detention capacity was inadequate [23]. The group proposed that water be given a directing role in regional and urban planning.

*ii. The policy niche of Rotterdam Water City 2035*

Rotterdam Water City 2035 (in Dutch: Rotterdam Waterstad 2035) was a significant step forward.

what we refer to as a transformational water management strategy Throughout this project, an integrative future vision for urban architecture was developed [22]. In conjunction with a climate adaptation plan the 2nd International Architecture Biennale Rotterdam established the policy niche (IABR). The IABR is a major architecture and design festival held every two years. The theme for 2005 was "The Flood." The task was to design and build a scale model of the city in the year 2035 [22].

The project's goal was to merge the water challenge and the urban challenge. The water challenge was stated as segregating pure water and wastewater, constructing adequate peak retention capacity, constructing seasonal water storage, and constructing a denser network of waterways to control groundwater [22]. The urban challenge was stated as making the city more appealing to inhabitants and entrepreneurs, encouraging a high level of social diversity, and boosting economic vitality [22].

To achieve integration Approaching, the appointed project leader requested a collaborative effort across municipal departments and water basins. In collaboration with the department head, 15 project members were chosen: six designers, five water management experts, a member of the Department of Economic Management, and three Aquarium visitors [22]. Participants were chosen with care. The relevant management sections did not permit the absence of project members. Facilitators urged project participants to translate their future visions into plans and measures [22]. They made the project members understand that creating a design without a "philosophy in time" was insufficient. In the coming decades, port and industrial activities will be relocated to new places outside of the city. This construction opens up chances for water-related business activity as well as waterfront development near the city Centre. Similarly, modern urban regeneration programs to restore dilapidated districts give chances for visible water retention infrastructure to be incorporated into the urban landscape [22]. Waterboards may be able to achieve the desired improvement in water retention capacity by taking advantage of these windows of opportunity.

River City in the city Centre, Water Network City in the south, and Channel City in the north are the three pictures in the final design. The riverbed in River City has been changed from an outdated port area to a bustling location with various commercial activities paired with ecological developments and floating dwellings [23]. To prepare for climate change, space for raising dikes must be set aside. These dikes will be constructed in conformity with the actual sea-level increase. Water Network City transforms the southern section of Rotterdam into an appealing living environment. The Channel City design aims to improve the existing water infrastructure of channels in the northern part of the city. Exciting water infrastructure innovations are introduced in this area. Squares are transformed into water retention squares to store excess water during periods of heavy rainfall. Buildings with flat roofs have green roofs that are used for water retention, to capture dust particles, and to improve water quality. Rotterdam Water City 2035 argued that water can contribute to the urban challenge by creating high diversity living environments [22].

The fact that Rotterdam Water City 2035 was a non-official policy process was a crucial success element. The non-official status reduced political danger. It would be a lost cause if it failed. The competition provided an opportunity for the development of a cross-disciplinary policy niche, the emergence of extreme ideas, and an unusually extended time

horizon [22]. The disadvantages of the non-official policy include poor status and priority. However, due to time constraints, the status of the event, the stringent screening of participants, and executive backing, this was not the case. This finding is consistent with the literature's notion that informal networks and change agents can prepare a system for the transition by exploring new choices and devising tactics [22]. Figure (7) shows Shifts in thinking toward a transformative approach to urban water management. Reframing has a tremendous impact on the collaboration of water management and designers. They learned to understand one another. Other's stakes and collaboration from the start the designers discovered that creating with water was 'fun.' This was a significant change in One of the respondents stated that even in 2004, urban designers considered water to be "one of the seven plagues" for the urban designer [22].

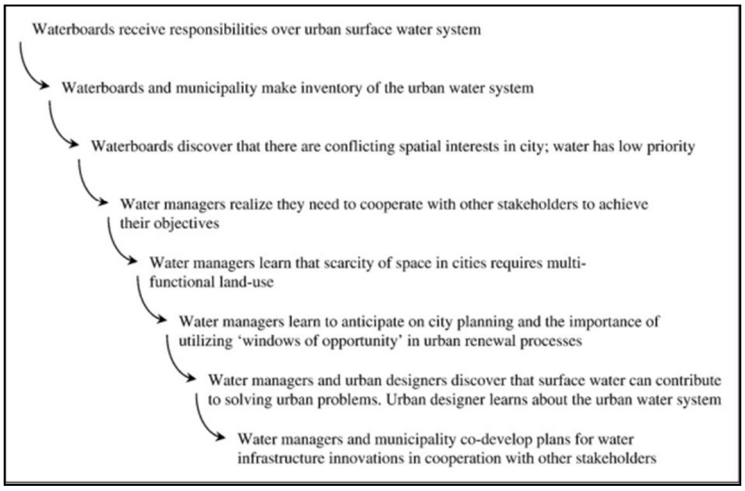


**Figure (7): Shifts in thinking towards a transformative approach in urban water management.**

The following figure (8) shows a simple illustration for World City 2035 Rotterdam.

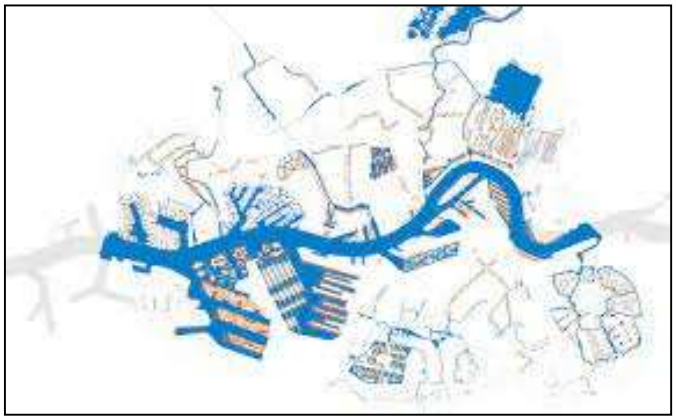

**Figure (8): World City 2035 Rotterdam**

## VII. Conclusion.

Passing with the time of the second industrial revolution in the 19th century. The world face development in many fields as using coal as a source of energy. The development in energy production led to the formation of modern cities that deal with the continuous improvement in our era. This development aimed to improvement in the infrastructure field with its various fields specifically the "Transportation infrastructure". This cause a great effect on the environment that show be in consideration. A lot of research was conducted by the researchers to solve this challenge. The FHWA and NAPA shared in the process of conducting solutions about the relation between the pavement structure and environmental impact. Many projects were conducted in solving this problem as the SGR railway project in Kenya as it is a project of the vision of 2030 Kenya to ensure that the rail embankments affected the development of seeds in the soil and blocked water streams, resulting in overall soil degradation in specific areas. Talking about the waterway infrastructure as it presents in civilization in humankind since the humans learned stability. Humans used canals, rivers, seas, and oceans as a transportation process to transfer goods

from one country to another and to help in the travelling process of humankind. A lot of classifications were conducted about the waterway infrastructure to determine its environmental impact. A lot of solutions were conducted to solve this problem as the Water City of Rotterdam 2035 aims to solve the problem of water infrastructure in Rotterdam without affecting the environment with a negative impact.

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