Share the Road

UN Avenue Report: Kenya Showcase Project

Nov 2011 – April 2013

Acknowledgments

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Share the Road

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Contents

List of Abbreviations and Acronyms

E.g.	exempli gratia; for example
FIA	Fédération Internationale de l'Automobile (International Automobile Federation)
iRap	International Road Assessment Programme
KURA	Kenya Urban Roads Authority
LED	Light-Emitting Diode
NMT	Non-Motorised Transport
UN	United Nations
UNEP	United Nations Environment Programme
USA	United States of America
UNON	United Nations Office in Nairobi

Part 1: Project Background

‘Share the Road’ is a UNEP initiative, developed with the Fédération Internationale de l'Automobile (FIA) Foundation. It brings together the environmental and safety agendas in the context of urban transport with an overall goal of catalyzing policies in government and donor agencies for systematic investments in walking and cycling road infrastructure, linked with public transport systems.

Investing in road infrastructure for walking and cycling leads to substantial benefits in environment, safety and accessibility. It reduces emissions of air pollutants and greenhouse gases, protects vulnerable road users, and increases affordable access to vital services and employment. Kenya became the first pilot country for the ‘Share the Road’ programme in 2009, when UNEP began working with the government’s lead agency on urban roads – the Kenya Urban Roads Authority (KURA) – on a Joint Showcase Road, United Nations Avenue, as a demonstration project to help realise how road infrastructure that includes non-motorised facilities could benefit from policy changes.

1.1 Project Area

UN Avenue is located within Nairobi North Sub-region of Gigiri in Nairobi County. The road starts at the junction with Limuru Road and ends at Runda Roundabout. It is approximately 2.20 km in length. Gigiri is an urban area comprising of low density, high income urban residential spaces, and is also densely populated with foreign embassies and other international institutions including the United Nations Offices in Nairobi (UNON).

Given its utility as residential access and a political neighbourhood, public transport is prohibited from utilizing UN Avenue. There is a public transport stage at the junction of UN Avenue and Limuru Road that most pedestrians use for accessing the area. Employees, visa applicants and other visitors use the road to access the different embassies located within the neighbourhood.

Gigiri is a self-contained neighbourhood with low connectivity to the surrounding areas. Access in and out the neighbourhood is possible through UN Avenue, or through a pedestrian access adjacent to the Village Market commercial centre at the western boundary of Gigiri. Runda, the adjacent neighbourhood presents similar characteristics; although its land use is predominantly residential. Runda inhabitants use UN Avenue as one of the main access road to the neighbourhood. Residents and workers of Runda and Gigiri become the immediate beneficiaries of the project.

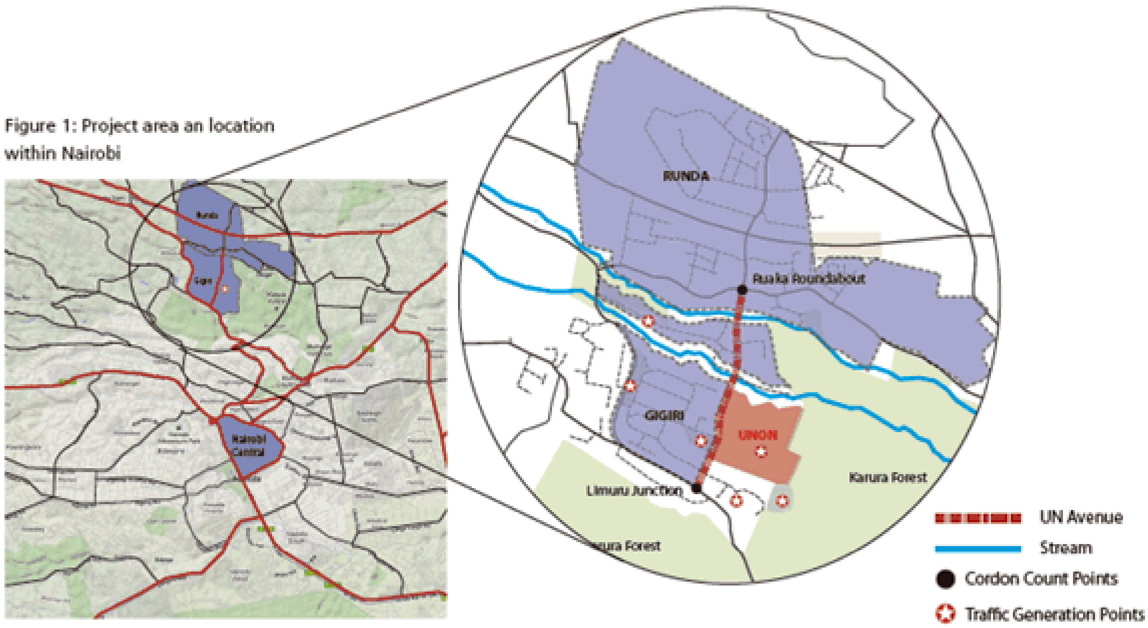


Figure 1: Project area an location within Nairobi

Based on estimations, and consistent with the topographic conditions most prevalent in Nairobi, approximately 50% of the terrain on UN Avenue can be classified as levelled with slopes of less than 5%, while the remaining 50% on the northern section after UN commissary, can be considered as a rolling terrain with slopes of greater than 5%. Two streams cross the north part of UN Avenue, and are the main pathway for rainwater. The topographic conditions on the avenue, make cycling a physically demanding form of transport.

1.2 Project Justification

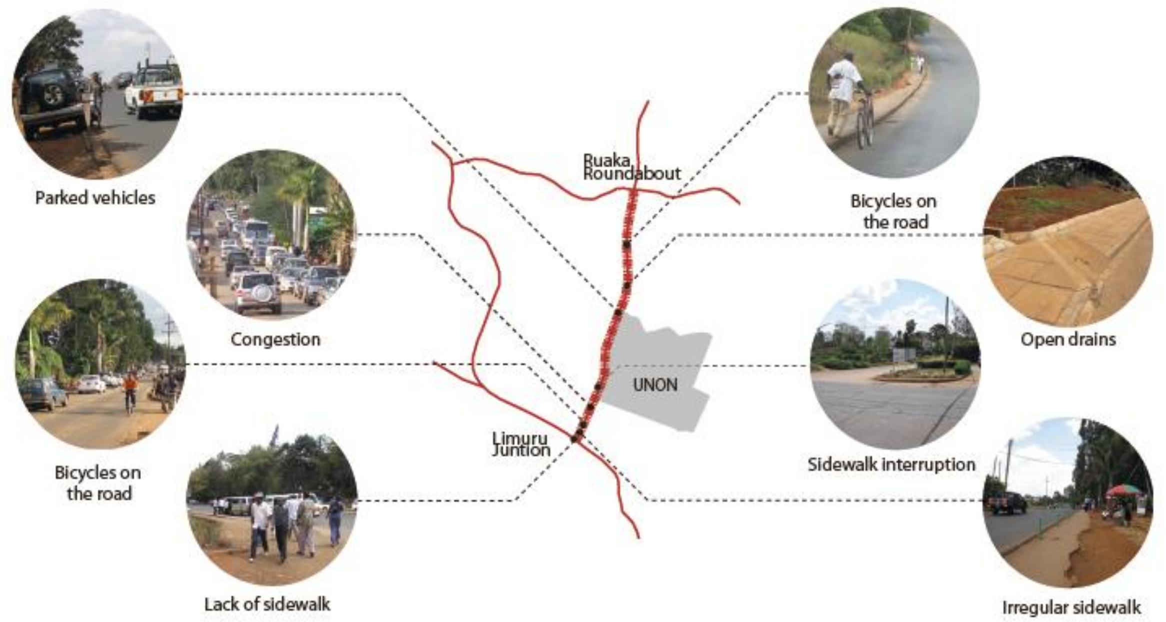
The criteria for selecting UN Avenue as a showcase included the availability of urban space and most importantly the high rate of accidents and road insecurity for pedestrians and cyclists along the avenue. The concern for road safety was a major force behind the project.

Prior to the intervention, several severe accidents involving non-motorised users occurred. The close interaction between motorised and non-motorised traffic, due to sharing a narrow road space without appropriate space for pedestrians and cyclists; coupled with road user's high speeds were recognised as major contributors to the accidents.

An additional justification for selecting UN Avenue as a non-motorised transport showcase road was the level of road congestion at the Limuru Junction during peak hours. This raised concern due to the air pollution caused by the congestion, as well as reduced accessibility to vital services and facilities.

Figure 2: State of area before the upgrade

protection from motor vehicles;



1.3 Project Description

Ideas for improving road conditions were developed by KURA and UNEP, and this led to the installation of new and improved non-motorised transport (NMT) facilities along the road, as well as the incorporation of drainage works.

After reviewing the respective benefits and considerations of different road sections and cycleway typologies (uni-directional cycle tracks on both sides of the road, vs. bi-directional tracks on one side), the final road improvements on UN Avenue included:

- Expansion and where necessary additional construction of three-metre wide pedestrian sidewalks, on both sides of the entire road;
- Construction of a three-metre, two-way cycling track, on the west side of the entire length of the road, with physical barriers for protection from motor vehicles; [1]
- Construction of raised pedestrian crosswalks at key points along the road and at the Limuru Junction, to ensure safe crossing points and traffic calming for motor vehicles;
- Construction of a slip lane for left-turning vehicles onto Limuru Road and relocation of the bus / matatu[2] terminus to the north side of the junction;
- Improvements and lateral stabilization of a drainage canal along the entire road length;
- Correction of the road horizontal and vertical alignment, in particularly at the vertical curve at the stream-crossing. Improvements of the bridge at both streams across the avenue;
- Installation of signage and road markings for pedestrians, cyclists and motorists;[3]

[1] Not all pedestrian crossings were built as raised crossings; some were painted-only crossings, while other proposed crossings were not installed. Other traffic calming mechanisms have been temporarily put in place, specifically a temporary security barrier at night, to reduce vehicle's speeds and for the neighbourhood's security.

[2] Matatu is the local word for a minibus or similar vehicle used as a para-transit mode.

[3] Signage and road markings' works have not yet been finalized at every point.

- Placement of solar-LED Street lights along the section of the road between United Nations and Limuru Road.

Part 2: Evaluation

2.1 Objectives

In order to evaluate the benefits, UNEP appraised the showcase road and the NMT road infrastructure through quantitative and qualitative analyses, including on-site observation and semi-structured interviews of users. The intended audience of this study is road and urban authorities undertaking, or wishing to improve facilities for walking and cycling. For this report the evaluation include the following methods:

- Stratified traffic count, ex-ante and ex-post;
- Qualitative survey;
- Behavioural analysis;
- Engineering analysis; and
- Video footage and documentary, including interviews with NMT users and senior civil servants.

There were multiple objectives of the evaluation:

(a) To demonstrate evidence of good practices that assist in the adoption of policies which ensure predictable and sustainable investment in NMT infrastructure. For example, the project has provided impetus for KURA, the National Road Safety Council, the Ministry of Transport and other government decision makers to adopt a “soft policy” approach to ensuring NMT infrastructure is provided on all major urban roads upgrades and new ones.

(b) To assess direct and indirect effects of road improvements in the use of non-motorised modes of transport at neighbourhood and sub-city level; and identify further obstacles and strategies for expanding its use. Including the necessity of provision of NMT networks;

(c) To adhere to the efforts of improving road safety on Nairobi roads, among them those by the International Road Assessment Programme (iRAP).

(d) To follow up on Kenya’s progress towards achieving certain objectives of the “Eastern Africa Regional Framework Agreement on Air Pollution (Nairobi Agreement-2008)”, that are specific to NMT, including the channelling of enhanced investments, the creation of enhanced interface between non-motorised and public transport, and to encourage attitude change.

Data and documentation on non-motorised infrastructure in Africa is scarce, and yet fundamental for ensuring that appropriate solutions are found for its advancement. The data and experience drawn from this Kenyan case study will serve to identify and highlight engineering, behavioural and policy issues, critical for the systematic promotion of investments in walking and cycling road infrastructure. Findings from the first Share the Road showcase project can be used to support educational activities among numerous stakeholders.

In order to meet the objectives outlined above, there are a number of key ‘focus areas’ that are addressed, consequently the study outputs section is divided into the following subsections:

- Area of Influence;
- Travel Patterns;
- Multimodality and Public Transport;
- Road Section and Design Elements;
- Road Safety and Security;
- Comfort, Satisfaction and Promotion; and
- Participation and Enforcement.

2.2 Methodology

Traffic counts and road user surveys were carried out for both the ‘before’ and ‘after’ improvement phases and approximate traffic volumes were determined. The choice of dates was dictated by KURA timelines and the need to synchronize the before- and after- improvement scenarios. Due to rehabilitation delays, the survey had to be postponed. Although originally the improvements were to commence in March 2011 for a period of eight months with completion slated for November 2011, by August 2011 only 60% of the work had been completed. This necessitated the ex-post traffic count to be pushed forward to April 2012.

Additionally, road users' opinions and comments on the road works were sampled in order to assess recognized benefits and their perspectives on the use of the road, before and after the improvements. The survey evaluated users' perception of the road; satisfaction with the works performed and the trip purpose.

Figure 3: Documentation of users' perceptions post-upgrade

Figure 4: Cyclist with a huge load on Limuru Road

Moreover, through data collection, interviews (figure 3), analysis and on-site observation of the use of the road, particularly the NMT facilities; the report provides contextual justification, design guidelines and recommendations that can be shared with a variety of programme stakeholders while undertaking similar projects. The results of the evaluation are expressed as lessons learned, and issues identified as outstanding.

Traffic Count

The traffic count and qualitative survey is the core portion of the evaluation, and was carried out in two phases. The first phase was done when the road works had just been commissioned. This was the ex-ante or before upgrading phase. The core works (involving road and drainage works, as well as the partial installation of road markings and removal of obstacles) took about five months to be completed. The second phase of the study, ex-post or after road improvements, was implemented in April 2012, just a few months after the cycle track was in operation. The exercise involved a count to determine changes in traffic volumes, directions and other traffic characteristics. A third phase of the traffic count study is recommended in the future, after the full completion of the road works and promotion campaigns are undertaken, and travellers have adapted to their trip patterns.

During the traffic counts, cordon points were set at the junction between the UN Avenue and Limuru Road and at the Ruaka Road Roundabout, the two edges of the intervention. Different road users were manually counted by assistants stationed at these points, counting through-traffic segregated by direction of travel (into / out of UN Avenue). The traffic count was conducted for 40 minutes every hour between 7 a.m. and 7 p.m. Due to the need to segregate between motorised traffic and non-motorised traffic,[4] 20 minutes in each hour were allocated to counting motorised traffic by an assistant and 20 minutes for counting non-motorised transport. The remaining 20 minutes in each hour was left as an allowance for synthesis and tallying of entries made. Figures obtained were assumed to be representative samples, and used for determining the estimated-per-hour traffic. The traffic count captured the following aspects:

- General road user type (e.g., motor vehicle, bus, etc.);
- Time of day: peak[5] / off-peak[6] (specific time);
- Location (Cordon point A or B);
- Tally / number; and
- Direction of travel (into / out of UN Avenue).

Road User Survey

The road user survey was done via stratified sampling; a sampling technique in which road users were divided into four categories (pedestrian, cyclist, motor cyclist and motor vehicle), and then randomly selected the surveyed subjects proportionally from the different strata.

[4] Classifications are defined on figure 5
[5] Peak hours: (1) morning peak: 7a.m. to 9a.m., (2) afternoon peak: noon to 2p.m., and (3) evening peak: 4p.m. to 6 p.m.
[6] Off-peak hours: (1) 10 a.m. to noon and (2) 2 p.m. to 4 p.m.

Figure 5: Road Users Stratus

Users	Description
Pedestrians	Persons travelling on foot or wheelchair
Cyclists	Persons travelling on bicycles segregated:
1. With loads	
2. Without loads	
Motor cyclists	Persons travelling on motorised two wheelers
Motor vehicles	Motor cars of any of the following categories
1. Large trucks and lorries	
2. Coaches and buses	
3. Small trucks and minibuses	
4. Cars / vans	

The survey targeted genders indifferently at varied points of the road and questionnaires were administered. The survey sample size was of 100 people for each phase. The proportion of targeted respondents comprised of 40% pedestrians, 20% cyclists, 20% motor cyclists and 20% motorists. Based on the ex-ante traffic count, the sample represented approximately 0.28% of daily users.

Figure 6: Sample of survey by percentage

Strata	Survey Sample	Percentage from Daily Population
Pedestrians	40	0.57%
Cyclists	20	1.77 %
Motorcyclists	20	0.74%
Motorists	20	0.07%

As the segregated cycling track is a new infrastructure element in Nairobi, special attention was put into its evaluation. Therefore, a second phase of the study included a semi-structured interview with selected regular users. This time, to counter the gender un-balance in the road use, female cyclists were interviewed on the outstanding issues when cycling along UN Avenue.

Part 3: Study Outputs

3.1 Area of Influence

To determine the geographic scope of the project and the probable origin / destination of the non-motorised users of UN Avenue, the area of influence of the intervention was delimited considering travel times for different transport modes.

From the two access points of the showcase avenue, radii representing 10, 20 and 30 minutes reach were established. Walking trips were calculated with a reference speed of 4.8 km/h. Following the street network, the reaching dis-tances for walking trips were set at 0.80, 1.60 and 2.40 km respectively. Whereas for cycling, a speed of 15 km/h was used to obtain reaching distances of 2.50, 5.00 and 7.50 km within 10, 20 and 30 minute trips respectively.

Due to the topographic conditions of the area, road network and urban connectivity, the actual trip does not reach the potential area of influence. The black dots on the graphics 5 and 6 mark the maximum distances for thirty-minute trips starting from Limuru Junction and Ruaka Roundabout.[7]

As a result, the pedestrian area of reach from UN Avenue remains mostly within Gigiri and Runda areas; while the area of influence for cyclists extends to Nairobi's north-west sub-region. Low and middle-low income residential areas that are great

[7] The method of calculation has been done over a map and does not consider he slopes and traffic conditions reducing actual travel speeds.

generators of non-motorised trips, such as Mathare, Eastleigh and Ngara; or smaller low-income pockets areas like Githogoro Village and Huruma are within the reach of a cycling trip. Peri-urban areas like Ruaka town, Gachie, Kiambu, as well as residential neighbourhoods like Parklands, Lower Kabete, Spring Valley, Kitisuru, etc., could potentially be reached on a bicycle within thirty minutes of travel.

3.2 Travel Patterns

The analysis of the traffic count results was used to determine travel patterns of road users. They showed that peak hours, particularly during the morning, were characterized by high numbers of both motorised and non-motorised traffic into the UN Avenue flowing at relatively low speeds. Off-peak hours recorded a lower but steady flow of both forms of traffic with very few, at times no cyclists using the road.

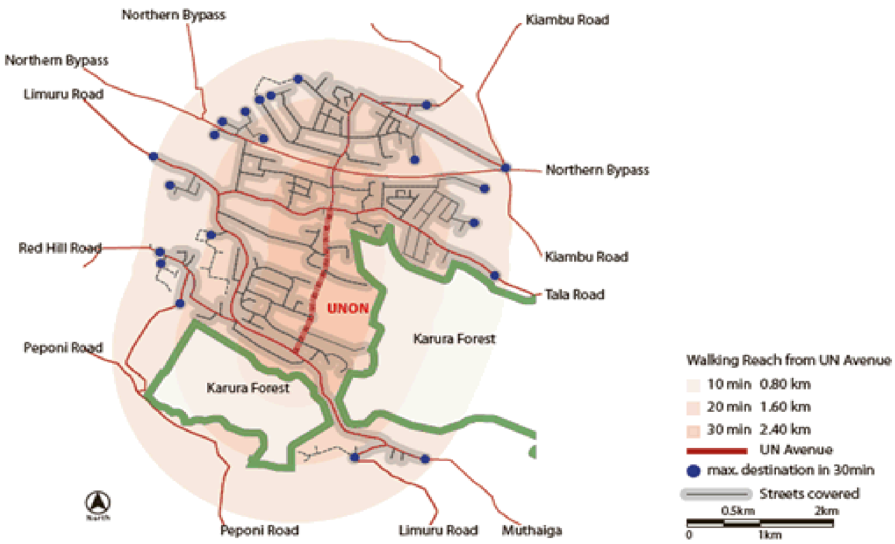


Figure 7: Walking Area of Influence

Pedestrians using the road had destinations within the survey area with common trip-ends being the United Nations Offices in Nairobi, foreign embassies within the area and the Kenya teachers training college. Motor vehicles using the road mostly comprised of small personal cars and vans with destinations within the UN Avenue, although a significant number used it as a through-road.

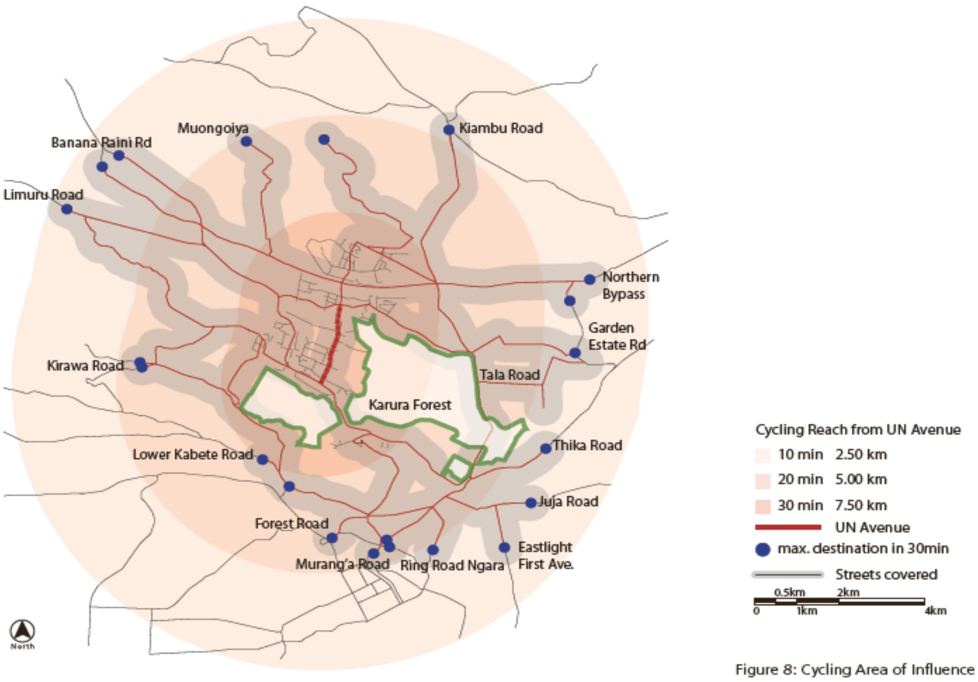


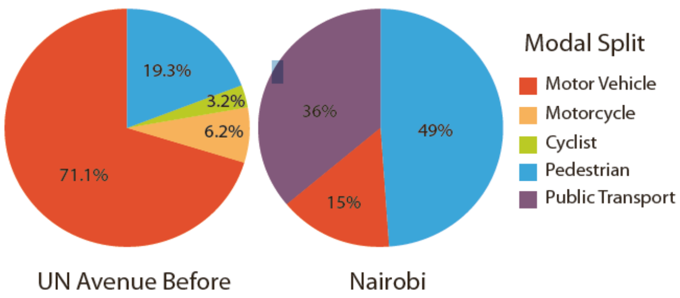
Figure 8: Cycling Area of Influence

In both traffic counts it was revealed that most of the traffic using the UN Avenue is motorised and that the average vehicular volumes are relatively constant throughout the day. The traffic composition on UN Avenue before the project constituted of: 19.6% pedestrians, 3.2% cyclists, 6.2% motorcycles and 71.1% motor vehicles. Compared to the average modal split in Nairobi Metropolitan Region (49% pedestrians, 15% private motorized modes and 36% public transport), the modal share within the study area has a very high use of private motor vehicles.

It was noted that most non-motorised traffic accesses and leaves UN Avenue through Limuru Road particularly in the morning and evening, as compared to that which uses the Ruaka Road Roundabout. Almost 2/3 of pedestrians captured during the traffic count (62-64%) use Limuru Road as an entry point, while only 1/3 of pedestrians (36-38%) walk through Ruaka Roundabout. This correlates with the location of the only public transport stop serving UN Avenue at Limuru Road Junction, which is an important mode for pedestrians.

It is worth noting that motorcycles represent 8% of the motor traffic on UN Avenue (ex-ante traffic count). Most of the motorcycles serve as motor-taxis or boda-bodas, and are present due to the lack of public transport serving the area, particularly Runda. In fact, approximately 72% of motorcycles were captured at the Ruaka Roundabout, mostly travelling towards Runda.

Figure 9: Modal Split in UN Avenue and Nairobi



The high number of motorcycles is presently one of the largest problems facing the new cycling infrastructure, due to the large numbers of motorcyclists riding along the cycle track. This causes safety risks to pedestrians and cyclists alike, and damages the surface of the cycleway.

Trip Purpose and Travel Direction

When asked about the purpose of their trip, majority of the respondents in the survey admitted to using the road for accessing their places of work.[8] The road also served as a through route for some, most of whom used it to access residential homes in Runda. Other users directly accessed their homes from the road while some carried out small informal businesses[9] on the road.

Figure 10 shows the purposes for which respondents used the road in both the before- and after-upgrade surveys; while figure 11 summarizes the average period of use of the avenue. The comparison shows increase in the use of the road by those accessing their places of work, for business and those using the road as a through road to access other destinations. It was also established that most of those that have been using the road for more than three years primarily use it to reach their homes, while majority of those who have been using the road for three years or less use it to access their work areas.

After the project, there was an increase in the proportion of cars / vans using the road. In the long term, the number of motor vehicles is likely to increase further as more people tend to prefer using well designed, more inclusive and safer roads; these factors make the road attractive due to improved road conditions. This increase will likely reflect on the rise in the motorisation rate of the country as a whole and the city in particular. With an increase in the number of motor vehicles, there will need to be continuous awareness on the use of facilities, respect for non-motorised facilities and adherence to signage; traffic laws and speeds in order maintain the benefits of the road rehabilitation.

The volumes and directions of travel of pedestrians, cyclists, and vehicles (before and after the road works) are as shown on figures 12 and 13.

In the mornings, as most people report to work by 8 a.m., motor vehicle volumes are quite high between 7 a.m. and 8 a.m. Although congestion during the morning peak is higher at the Limuru Junction, the number of vehicles captured was slightly higher at the Ruaka Roundabout, depicting that some of the morning traffic is comprised of through travel of Runda residents' coming from home on their way to work. During the evening peak, figure 13 shows a percentage of vehicles leaving their work places in Gigiri into Limuru Road and a steady number of through traffic from Limuru into Runda. The lower evening peak could be due to returning trips over a more spread lapse of time; residents coming back home after 7pm, or traffic that have destinations within the study area in the morning and leave before the afternoon and evening peaks.

[8] Work hereby refers to formal or office jobs.
[9] Business on the road refers to informal trading on the roadside and includes hawkers and peddlers among others.

Figure 10: Trip Purpose

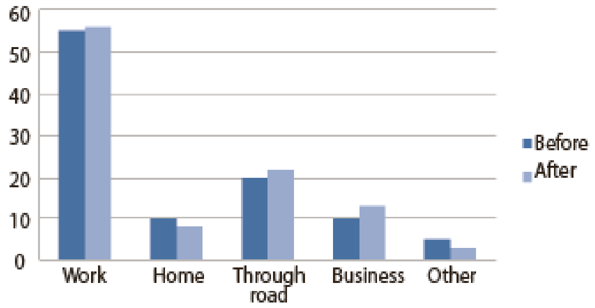


Figure 11: Average Period of Using UN Avenue

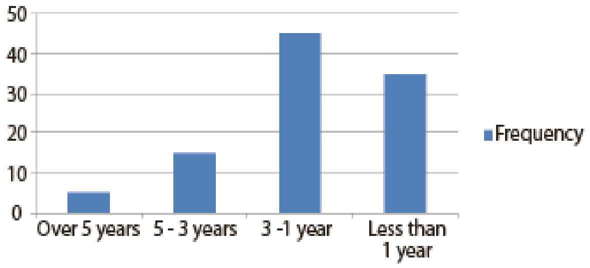


Figure 12: Total Traffic Volumes by Hour

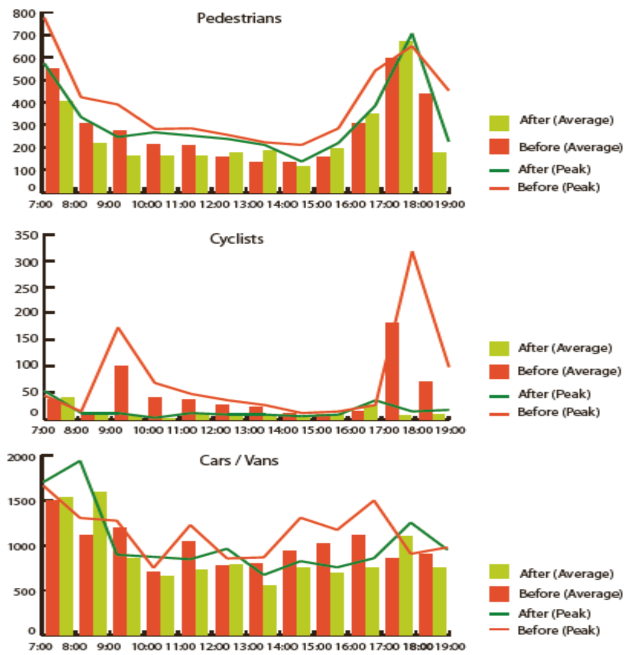
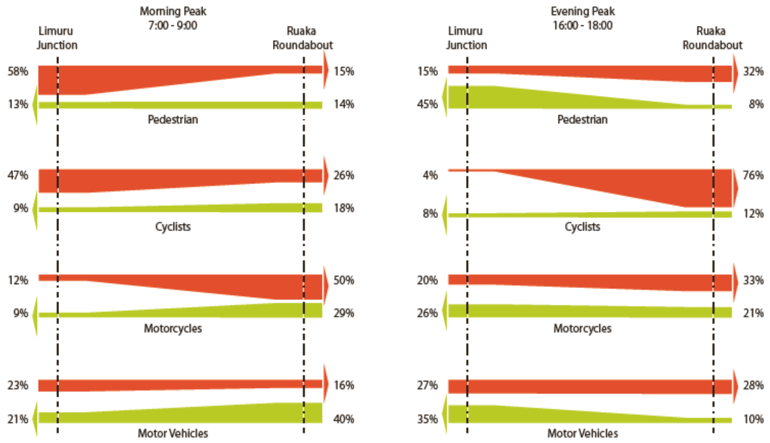


Figure 13: Direction of Travel During Peak Hours Before the Upgrade



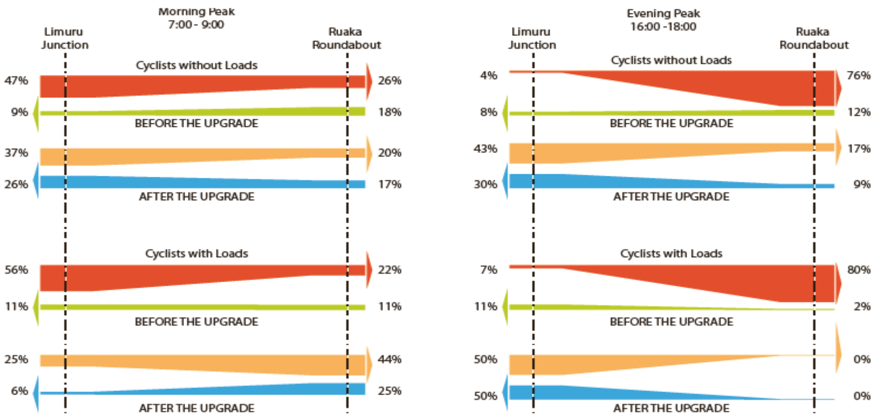
Motorcycles, on the contrary, have a very different travel pattern. As seen in the graphic, a distinct travel pattern towards Runda can be seen during the morning peak, while more diversified directions of travel (travel flows equally in and out of UN Avenue) in the afternoon peak. This probably responds to the widespread use of motorcycles as taxi service, and therefore motorcyclists keep doing trips back and forth in both directions of UN Avenue.

In comparison, pedestrian traffic has lower volumes and the majority are accessing work and other destinations during the morning peak between 7 a.m. and 8 a.m. and steadily leaves in the afternoon between 3 and 6 p.m. After 6 p.m. there is a sharp decline in the number of pedestrians on the road, as well as cyclists. Most pedestrians come in the morning from Limuru Junction, where the closest transit stop is located; and return back in the same direction. The pedestrian traffic at the Ruaka Roundabout is low during the morning but slightly higher during the evening peak.

It is assumed that some pedestrians who came by public transport in the morning use motorcycle taxis to reach destinations in Runda. Moreover, public transport users may use alternative means of transport while leaving work in the evening.

The ex-ante survey found out that cyclists, predominantly those with loads, mainly used the road as a through route to access other destinations outside the survey area. These users mostly used the road very early in the morning, before 7 a.m. and returned without their load late in the afternoons or early evening. At the time of the survey no cyclists using the road to access their areas of work or for sport and leisure purposes were encountered. Nevertheless, it has later been noticed an increase of this type of user and is expected to augment over time.

Figure 14: Direction of Travel



After road improvements, the proportion of bicycle trips in the modal split experienced a sharp decrease from 14% to 4.4% of the total non-motorised trips. This data is more critical when observed that bicycles carrying loads decreased from 30% to 20.7% of the total number of cyclists (between before and after the projects).

An explanation for this change may be found on the road works building the Northern Bypass during the same period of time. The construction of this new urban highway included a flyover that modified the mobility patterns of the nearby population. The different grades at the junction require cyclists to carry the bicycle uphill making this task insurmountable for cyclists carrying loads. Although this has created an urban barrier for both pedestrians and cyclists, pedestrians managed to overcome the obstacle.

As observed on figure 14, cyclists adapted their travel pattern. In the travel count before the project, most cyclists travelled towards Runda during the evening peak; after the road works, most cyclists and the all of those carrying loads used Limuru Road as return route to their destinations. Likewise, several cyclists that carried loads switched into walking, as we can observe a sharp increase of the pedestrian trips from 86.3% to 95.5% of the NMT trips.

The changes on the traffic patterns before and after the project show the influence that the net-work connections have over a trip choice. Cyclists and pedestrians will choose the most direct, convenient and safe route covering their entire trip, from origin to final destination. Interventions to improve non-motorised facilities need to maintain a city-wide perspective, while upgrading the sections and connections of the road network.

3.3 Multimodality and Public Transport

Multimodal travel is the capacity of combing different modes of transport on a single trip. Public transport use and quality of non-motorised infrastructures are closely interrelated. The ease of connection between public transport and pedes-trian facilities benefit urban mobility in general. In UN Avenue, this connection is expressed at the Limuru Junction, where the public transport station connects the central business district with Ruaka town.

Figure 15: Aerial image of the Limuru Junction before the upgrade in 2010

Figure 16: Aerial image of the Limuru Junction after the upgrade in 2013

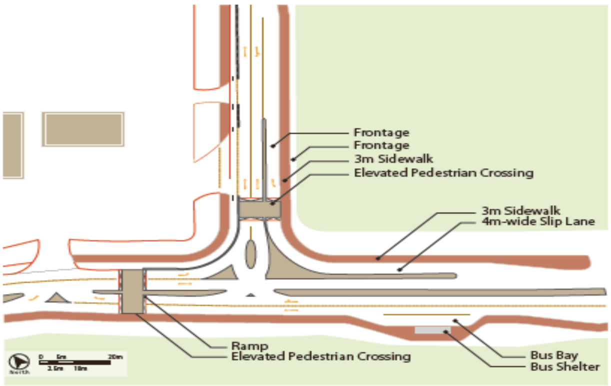


Figure 17: Redesign of the Junction

Junction Redesign

The majority of pedestrians using UN Avenue arrive to the area by public transport. Prior to the road upgrade, the matatu stage was a frequent factor of congestion at the Limuru Junction. The relocation of the bus terminus to the north side of the road, away from the junction, has led to reduced congestion for vehicles accessing Limuru Road. This is due to the incorporation of slip lanes for vehicles entering and leaving the UN Avenue. Slip lanes were design to be narrow and with a reduced radius. The design is a traffic-calming strategy that, together with a raised pedestrian crossing, keeps vehicle speeds low improving road safety. To reduce the risks for pedestrians when crossing to the bus stop on opposite side of Limuru road, additional raised pedestrian crossings and the necessary signage were also incorporated at about 100 metres from the junction. Details and images of the Junction can be seen in figures 18 to 20.

Figure 18: Slip-lanes with medians to facilitate pedestrian crossing

Figure 19: Bus bay on Limuru Road, direction to City Centre

Figure 20: Bus shelter and bay on Limuru Road, direction to Ruaka

Catchment Area and Walking Speeds

Although the ease of access to destinations within the UN Avenue largely remained the same for motorists, a major difference has been made for pedestrians and cyclists. Results from Share the Road's showcase project show increases in the average speed of pedestrian and cycling trips as road conditions improved. Better and more comfortable walking conditions (from an inadequate or non-existent walkway to a flat, unobstructed walking surface) resulted in a savings of 4 minutes per pedestrian kilometre. This corresponds to an increase in average walking speed from 3.5 to 4.5 km/h. Improved cycling conditions (the addition of a separate cycling lane) resulted in a savings of 2 minutes per riding kilometre, corresponding to an increase in the average riding speed from 10 km/h to 15 km/h. It now takes a rider (without load) an average of 3-4 minutes faster to ride from Limuru Road Junction to Runda Roundabout while the same distance would now save a pedestrian 7 to 10 minutes.

Faster and safer access to the area, result in greater productivity for people having their work places as the trip destination. It also enlarges the catchment area of public transport stops, by increasing the reach of a trip during the same travel time. Thus, extended catchment areas and better access to public stops with improved pedestrian facilities have the indirect effect of potentially increasing the usage of public transport.

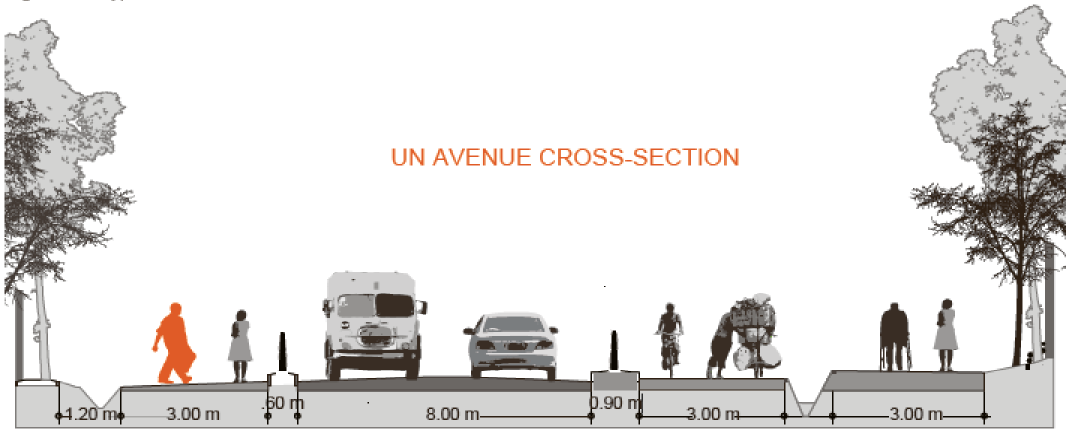
3.4 Road Section and Design Elements

UN Avenue is designed from edge to edge of the buildings following the principle of a complete street. By definition, complete streets incorporate infrastructure for walking and cycling, including signage, ramps and other facilities for the physically challenged. They comprise urban furniture like covered bus stops, street lighting, trees and vegetation according to the context as well as drainage works; sometimes they can incorporate rainwater harvesting facilities or retention ponds to avoid flood risks. Complete roads promote safety for all users and incorporate all of the principles of universal accessibility. The evaluation of UN Avenue against these principles took a close look at the road section (figure 21) and use of space, materials chosen and other relevant design elements that facilitate maintenance and social inclusion.

Universal accessibility refers to the adaptability of urban infrastructure and facilities to the widest range of potential users, including people with mobility and visual impairments, the elderly, people in wheelchairs, people walking with small children, pregnant women, and people carrying heavy loads such as water or firewood. Works on UN Avenue should compile with standards of universal accessibility in order to promote social inclusion. This is expressed in the design of elements, selection of materials and signage, as well as on the distribution of road space.

Kerb ramps need to be present at every intersection to increase usability for all. Although some sections of UN Avenue provide it; they are not incorporated in the design of every intersection. During the road improvement works, some drain channels were left open, preventing the use of the sidewalk by a person on a wheelchair. It is recommended to give more attention into features allowing accessibility during the design and construction phases, or to incrementally upgrade facilities if they do not yet comply.

Figure 21: Typical Road Section of UN Avenue



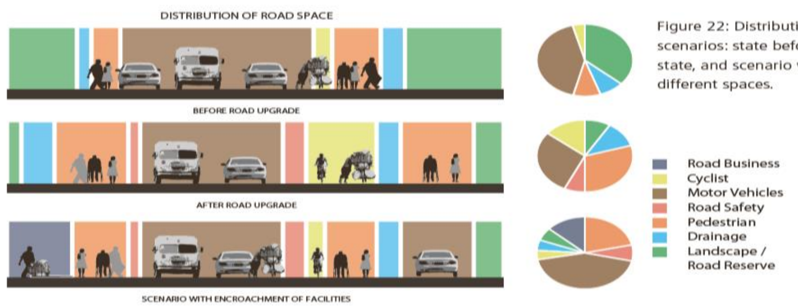


Figure 22: Distribution of road space under three scenarios: state before the upgrade, current state, and scenario with encroachment over the different spaces.

Distribution of Road Space

The new configuration of UN Avenue has achieved a more equitable distribution of road space among all users. In a comparison shown in figure 22, road space before the upgrade was mostly used by motorised vehicles; there was minimal pedestrian space and cyclist had to share the carriageway; after the road improvements, non-motorized users were allocated as much space as the motor vehicles, a zone is designated for road safety measures, and rainwater drainage is separated from pedestrian fluxes.

During both road surveys it was noted that in addition to those who use the road for movement, there are other users who use the road specifically for purposes of business. These include taxi cab operators, hawkers, newspaper and flower vendors, and shoe shiners who sell their products and services to other road users particularly targeting pedestrians. While their numbers are insignificant compared to the total number of other road users they take up part of the road space, particularly that used by NMT users. Hence, at certain points, they interfere with the streamlined flow of pedestrians and cyclists particularly at peak periods.

A third scenario of road distribution illustrated on the graphic shows the division of space when allowing the encroachment of vendors, and vehicles parked over the sidewalk, pushing pedestrians into the cycling lane, and cyclists back to the carriageway. The result of such concession over the upgraded space for non-motorised users is a return into the hegemony of motorised vehicles taking over the majority of the road.

Surface Materials and Maintenance

In general, the selection of materials is appropriate to their intended use and can be locally procured, reducing their transport-related energy. The cycle track has a tarmac surface, similar to the carriageway; while interlocked pavers were used for the sidewalk to allow permeability to the subsoil. Tarmac can provide a smooth riding surface, and pavers have the benefit of allowing rainwater to permeate.

Nevertheless, issues during construction have given rise to additional maintenance costs. In some areas, due to insufficient compression of the sub-grade layers and the uncalculated loads of parked vehicles, the surfaces have become uneven and deformed. This problem is more acute in sections bordering the drainage channel; where portions of the stabilized slope have collapsed. The cycle track will have similar problems in the near future, where the continuous use motorcycles over a surface intended for bicycles has created potholes. The lack of sufficient enforcement against cars and motorcycles' encroachment will incur in broader maintenance costs for the authorities.

Protection Elements

Protection elements such as kerbs and bollards have been very valuable in increasing actual and perceived road safety. The typical cross section of the road has a protected buffer area with a bollard and/or kerb between the bicycle track and the carriageway. In some areas a drainage channel separates the sidewalk from the bicycle track, while in others; the channel is in the far-end.

Along the project, three different typologies are used to separate the cycle track from the carriageway:

(a) Cycle track and carriageway at grade with raised kerb and U-shaped resin-coated-steel bollard as protection element;
(b) Cycle track at a higher grade than the car-riageway (15cm higher), and U-shaped resin-coated-steel bollard as protection element;
(c) Cycle track and carriageway at grade with only bollard as protection element (figure 25).

Figure 23: Sidewalk surface

Figure 24 : Damaged sidewalk

Figure 25: Bollard separator without kerb

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Each modality has different advantages, both from the maintenance and construction viewpoints. The use of prefabricated kerbs facilitate implementation, but are prone to be dislocated if they are not well anchored. When space is not abundant, the use of high kerbs requires extra buffer area to avoid interference with the pedal. As seen on figures 26 and 27, a weakly-anchored bollard and the kerb were fragmented with a minor impact from a vehicle. This has resulted in several bollards being knocked down. Nevertheless, each bollard damaged along the avenue, could have resulted in a pedestrian or cyclist casualty. Therefore, one could assess the accident prevention-potential of each element.

Figure 26: Broken bollards on UN Avenue due to a traffic accident.

Figure 27: Detail of the weak anchor and hollowness of bollard.

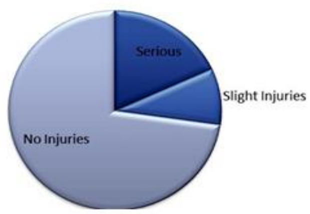
The lack of kerb, typologies (b) and (c), prevent garbage and stilt accumulation on the kerb side and facilitates water drainage. Raised kerbs must allow the flow of rainwater, either through separation between independent pieces, or by creating channels for the water. The absence of kerbs also facilitates the anchoring of the metal bollard into a harder surface, which would increase their durability.

In addition to the lateral bollards, located parallel to the cycle track, there are some located transversal, at intersections with road entrances and junctions. While these have the function of preventing the entrance of vehicles into the segregated cycle track, they do not prevent the use of sidewalks as parking places.

3.5 Road Safety and Security

Safety is perhaps one of the main benefits that can result from this and similar projects. Statistics show that in Nairobi, vulnerable road users- pedestrians, cyclists and motorcyclists- account for 54% of all road fatalities.[10] Road accidents' data obtained from Parklands Traffic Police Department covering the last six months of the year 2011 (i.e. representing accidents on the road before improvements) and January, February and March 2012 (representing the situation after road improvements) was used to assess the likely impact of road improvements on road safety. Whilst accidents affecting non-motorised transport users are mostly reported on roads with very high pedestrian volumes, the UN Avenue accounted a total of eleven accidents in the last half of 2011, with majority reporting no casualties. In the three months following the road improvement, there were only three slight accidents that involved motorists. This is an indication that the improvement of NMT infrastructure has led to improved safety for non-motorised users. The severity of accidents is summarized in figure 28.

Figure 28: Road Accidents After



Traffic calming measures and proper use of facilities, in addition to reduced traffic interaction due to segregation of users are likely to lead to a further decline in the number of accidents as well as their reduced severity. Nevertheless, with an increased use of the road, benefits of the improvements risk fading over time; particularly if road maintenance is not sustained. Therefore, additional efforts are required to ensure that traffic regulations (particularly speed limits) are respected in order to minimize the chances of accidents.

In the user satisfaction survey, most of the interviewed said they felt safe while using the road and had never witnessed any accident on the road. Most considered road behaviour to be good; and motorists were described as considerate of pedestrians and cyclists. Yet, in the before-upgrade survey some road users, particularly cyclists and pedestrians, reported that the stretch of the road between the United Nations Offices in Nairobi and Ruaka Road was notorious for high vehicle speeds and was a likely accident black spot. In the post-upgrading survey, those interviewed noted that with separation of pedestrians and cyclists, accident occurrence on the road involving pedestrians were unlikely. Some still mentioned the high vehicle speeds on that stretch as a remaining accident threat.

As regards to security, in both surveys most road users felt safe using the road at any time of the day due to the presence of security personnel and the frequent patrols by the neighbourhood security. Nevertheless, as shown in previous sections, most of the people use the road during the daytime. Of the few night-time users, most were motorists who liked the ambience particularly with the reflectors and markings. During further consultation with cyclists, they considered a risk to use the cycle track during beyond dusk, particularly due to the number of obstacles still present and lack of street lights on most of the avenue.

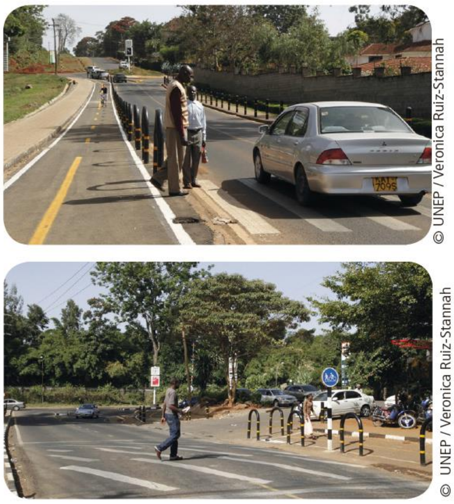
[10] Climate XL Africa 2009: Minimum Standards for safe, Sustainable and Accessible Non-motorised Transport Infrastructure in Nairobi

To increase the perception of security, Runda Association has been setting a temporary traffic barrier at nights (close to Ruaka Roundabout). This performs as a traffic calming mechanism and reduces vehicle speeds. In consultations, the association has expressed its wishes to be turned into a formal barrier.

Crossings

Another major contribution to the improved safety and ease of access to destinations has been the designation of crossing points and signage at specific points of the road, particularly to the renowned traffic generators. The rehabilitation works have had a big effect on reducing interaction between motorised and non-motorised traffic.

Figure 29: Raised zebra crossing vs. painted-only crossing. The second ones do not act as traffic calming devices.



The raised pedestrian crossings have been effective in allowing safer crossing, as vehicles reduce their speed. These also reduce the waiting time for pedestrians. At crossing points, road signage and marked pedestrian crossing points have made it easier for drivers to spot probable areas of interaction. However, those painted-only crossings do not succeed in reducing speeds and become more risky as they create a false sense of security for pedestrians. From the number of raised pedestrian crossings originally planned, only three of them were built. Crossing UN Avenue continues to be a threat on these points, particularly when the motorised traffic is at its lowest point, and the vehicles circulate at a higher speed: another risk factor for pedestrians.

Intersections and Vehicle Entrances

Cyclists' visibility to drivers is a prerequisite for preventing accidents. This is crucial at intersections and vehicle entrances. While the northern part of UN Avenue (from United Nations to Ruaka Roundabout) has very few intersections; the stretch between United Nations and Limuru Road has several intersections and entrances, which poses several risks. The most transited intersection is the junction with Gigiri Drive. Several vehicles turn without reducing their speeds and lacking a clear visibility to pedestrians or cyclists. The high-turning speeds are partially due to the high kerb radius of the intersection. A reduction of the turning radius of this junction would increase safety conditions.

The frequent number of entrances causes several interruptions to the cycle track (among them the entrances to the Embassy of the United States, Warwick plaza, UN Crescent Road, Gigiri Service Station, etc.). The numerous breaks to the cycle track interrupt the trip continuity, as cyclists must stop every few metres. Frequent entrances also provide an opportunity for vehicles to park on the cycle track or sidewalk.

Under such conditions, many cyclists choose or are forced to ride through the carriageway maintaining a continuous riding speed. Cyclists travelling in the opposite direction need to switch lane to go with the traffic flow and continue to ride on the vehicular lane. As this has shown, in road sections with several intersections or frequent entrances, it may be preferable to select a different cycleway typology integrated with the car flow. This can be done for a certain stretch of the road, but the transitions between different cycleway typologies require special attention to guarantee continuity. Transitions at the ends of the cycle track also need close examination to facilitate a smooth and safe incorporation into the traffic lane.

Another reason why some cyclists continue to use the carriageway may be the perception that the cycling lane is unidirectional, and when travelling in the opposite direction they use the carriageway. This can be improved through time, and targeted informative campaign to create awareness on the use of the new road facilities.

Figure 30: Large turning radius of intersection enlarge the distance for pedestrian and cyclist crossings, and facilitate cars turning at high speed.

© UNEP / Veronica Ruiz-Stannah

Lighting

Good lighting increase both safety and security. When located at intersections or crossings, it increases the visibility of vulnerable users. Kenya Urban Roads Authority (KURA) installed solar-powered LED road lighting on a stretch of UN Avenue, reinforcing the environmental benefits of the pilot program, as well as increasing road safety and security.

The lights have proved to be an efficient, reliable and cheap road lighting alternative that can potentially generate up to 100% energy savings. The use of energy-efficient lamps can bring significant environmental, safety and economic benefits. Funds invested in energy-efficient lamps can be recovered through savings in electricity, maintenance cost and longer lifespan of the equipment. A wider use of solar-lighting, along the avenue and on Nairobi roads in general, would be beneficial for road safety and personal security. It would extend the use of non-motorised facilities beyond dusk.

Figure 31: Solar-led lights provide environmentally friendly light

© Philips

Figure 32: Detour and different grade of sidewalk

© UNEP / Regina Orvañanos

Obstacles and Other Risks Factors

While the upgrade of the road implied an impressive improvement on travel conditions for pedestrian and cyclists, remaining obstacles on the sidewalk and the cycle track still create hazards. Some electric posts and potholes remain on the surface, creating risks, particularly for cyclists during dark hours. The height of bollards and other protection elements, particularly those located transversal to the riding direction, should maintain a height that will not interfere with the bicycle handlebars. A lower height would be equally effective for preventing car access, but more friendly with the needs of cyclists. Similarly, a minimum clearance of 1.20 metre-wide between obstacles is required to allow the pass of a wheelchair or a loaded bicycle without problems. The drainage channel adjacent to the cycle track creates a perception of un-safety. An un-experienced cyclist could lose control and fall into it. Further design should consider the addition of a small kerb to prevent potential accidents.

Besides infrastructure elements, obstacles can also refer to encroachment of facilities by vehicles parking on sidewalk, or motorcycles riding at a high speed. This is highly important, because, besides the risk they cause, it can be preventable through stronger enforcement of the traffic code.

3.6 Comfort and User Satisfaction

User comfort is defined by the design characteristics adequate to the human body's dimension, intended use, and the attractiveness and convenience of the trip. Climate comfort refers to the overall conditions that make a walking trip more comfortable, including during rainy season. Nairobi has a high precipitation level, for which good drainage is important; particularly for non-motorised travellers.

Given the conditions of the road before upgrade, the different categories of user had to share the paved road carriage during the rainy season when the pedestrian lanes were inaccessible because of the mud. In the dry season, pedestrians still preferred to use the carriageway to avoid dust as well as escape the congested road side which in addition harboured hawkers and peddlers. Congested traffic also meant higher levels of smoke and noise emissions from vehicles, making the road environment not attractive for many users particularly those who were walking or cycling.

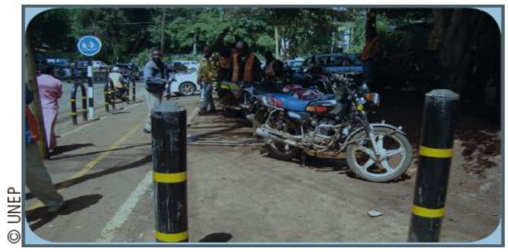
When asked about usability of the road, 74% of the pedestrians interviewed before the upgrade noted that the road was generally usable in dry weather, while 55% attested that the road was unsuitable for use during rainy weather because of mud on the sidewalk. In the post-survey, almost all the road users (particularly pedestrians and cyclists) felt comfortable using the road space despite the prevailing weather conditions thanks to the hard paved surface and the improved storm drains which minimized flooding. Motorists were also happy with the road upgrade particularly given the inclusion of driving controls (road markings, signage, lane delimitation, etc.), which have made driving on the road easier.

An important aspect of trip comfort is the directness and convenience of the route. Pedestrians will always have the preference of choosing the most direct route, on a straight line. Other aspects affecting pedestrian comfort are related to the surface condition. In certain sections, the cycling lane is more leveled than the sidewalk and has a more stable cross-slope, which creates more comfortable walking conditions. In other sections, the detours on the sidewalk to surround the drainage channel, or the lack of kerbs create small inconveniences for pedestrians.

Figure 33: Pedestrian choosing the most convenient path

As seen on in some stretches of UN Avenue, pedestrians tend to walk on the cycling track rather than on the sidewalk. This behavioural pattern is more evident when the drainage channel separates both areas, and when the sidewalk changes grade. Whereas when sidewalk and cycle track are side by side pedestrians tend to move back to the sidewalk (figure 33).This assessment recommends, future projects to have drainage channel between sidewalk and property line, instead of in between the two non-motorised fluxes.

Figure 34: Road business over the drain
Figure 35: Encroachement of Boda-boda drivers over the sidewalk.



3.7 Participation, enforcement and maintenance

As stated before, enforcement against the encroachment of pedestrian and cyclist space con-tinues to be a challenge. Until newly built facilities are utilized effectively and appropriately, the full benefits of having pedestrian infrastructure will not be achieved.

Enforcement is closely related to the participation and socialization of the project prior to implemen-tation. Stakeholder meetings were realised during the design phase. Yet, not all road users were included in the discussions since the early stages of the project. Although there is a recognized demand for the services of taxi and motorcycle-taxis; as well as business opportunities for street commerce, the conflict resides on their use of pedestrian facilities as parking space.

Their use of infrastructure has led to conflict with other road users. Their requests and considerations were not considered during the planning phase. There have been further consultation meetings with representative of taxi and motorcycle-taxi associations, but a final solution has not yet been found. An important lesson in this regard is need for continued and true stakeholder involvement.

Figure 36: Taxis and autos using sidewalk as parking plot

For future projects, the incorporation of the needs of other road users will be beneficial. Designing specific spaces for taxi or motorcycle-taxi operators could turn into an income-generating activity for the city. Likewise, the provision of space for commercial kiosks adjacent to the bus stage or at strategic points that respect the sidewalk can become an asset to the city. Participation and inclusion of all stakeholders can turn threats into opportunities.

Final and ongoing maintenance of the UN Avenue NMT facilities has also presented challenges towards the full success of the project. The mandate for NMT infrastructure maintenance is unclear amongst responsible government parties.

Gender-Sensitive Promotion

The use of bicycle within Nairobi in general and on UN Avenue in particular is done mostly by men. Out of the survey, no woman was found to use the bicycle. Nevertheless, there have been an increasing number of women cyclists among the employees of the international organizations. For further promotion, it is recommended to further research the physical and socio-cultural barriers preventing women to profit from the new infrastructure and discover appropriate gender-sensitive ways to encourage its use.

Promotional activities have been done in UN Avenue, such as half marathon and recreational runs have taken place during the past months. In result, the recreational use of the facilities is in rise, particularly among the residents of the area during weekends.

Part 4: Assessing UN Avenue results using ViDA

4.1 Introduction

The International Road Assessment Programme (iRAP) is a registered charity dedicated to saving lives through safer roads. iRAP works in partnership with government and non-government organisations to: inspect high-risk roads and develop Star Ratings and Safer Roads Investment Plans; provide training, technology and support that will build and sustain national, regional and local capability; and track road safety performance so that funding agencies can assess the benefits of their investments.

A road's Star Rating is based on an inspection of infrastructure elements that are known from extensive research to influence the likelihood of crashes occurring and the severity of those crashes that do occur. The focus of the Star Ratings is on the infrastructure elements which influence the most common and severe types of crash on roads for car occupants, motorcyclists, bicyclists and pedestrians. Each road infrastructure element is assigned to one of a number of categories by the raters according to its condition.

4.1.1 Methodology

iRAP currently uses two types of road inspections: drive-through and video-based. The type of inspection conducted depends on the availability of technology, the complexity of the road network and the degree to which a project is focused on building the capacity of road safety stakeholder organisations. Drive-through inspections involve at least two people: one driving a vehicle and a passenger recording road infrastructure elements as they travel using a Rapid Assessment Programme Inspection Device (RAPID). This type of inspection is technical and requires inspectors to hold iRAP accreditation. RAPID inspections are often used in situations where the road network is not overly complex or it is difficult or time-consuming to import a vehicle that is equipped for video-based inspections.

Video-based inspections differ from drive-through inspections because data is first collected by video and this is later used by raters to record road infrastructure elements. The videos are recorded with a specially equipped survey vehicle that records images of a road at intervals of 5–10 metres using an array of cameras aligned to pick up panoramic views (such as forward, side-left, side-right, and often, rear). The main forward view is calibrated to later allow measurements of key road infrastructure elements. The vehicle is also equipped with GPS that enables the video images to be correlated to precise locations on the road network. The vehicles can drive along the road at legal speeds while collecting this information. After the video data is collected, raters undertake desktop inspections of road infrastructure elements by conducting a virtual drive-through of the network. The raters use specialised software to make accurate measurements of elements such as lane widths, shoulder widths and distance between the road edge and fixed hazards, such as trees and large poles.

Although the drive-through inspections involve a continuous record of road infrastructure elements, and the video-based inspection records video images at 5-10 metre intervals, the Star Ratings are based on 100 metre long sections of road. At the completion of each type of inspection, it is possible to produce a detailed condition report that summarizes many roadway characteristics for the inspected network. The report contains information such as the proportion of the network that has paved shoulders and number of locations that have adequate pedestrian crossings etc. These data form the basis of Star Ratings.

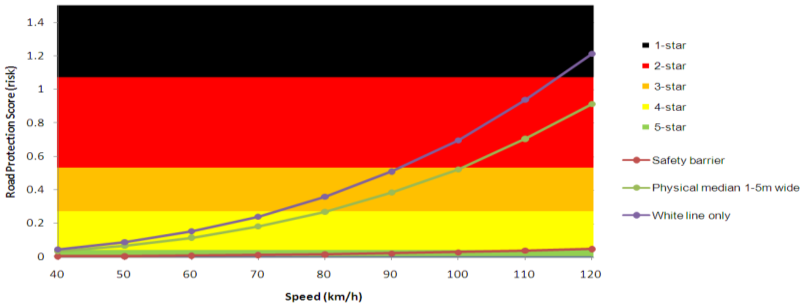
It was not possible to conduct a drive-through or video-based inspection for the UN Avenue due to financial constraints. Inspection of UN Avenue was done using photographs of the road before and after the rehabilitation process. Information obtained from the photographs was used to create a before and after dataset for the Avenue; this information was then uploaded on the Star Rating site ViDA, for determination of Road Protection Scores.

4.1.2 Road Protection Scores

Following the inspections of the road infrastructure elements, a Road Protection Score (RPS) is calculated for each 100 metre section of road using the iRAP software. The RPS is an objective measure of the likelihood of a crash occurring and its severity, based on an assessment of a road's infrastructure elements. The RPS forms the basis for generating the Star Ratings (and, in turn, Safer Roads Investment Plans). An important aspect of iRAP that shaped the development of the RPS is that it must be globally consistent, enabling its application in numerous countries, even when detailed, historic crash data is not available. It is also designed to provide a foundation for predicting the number of deaths and serious injuries that are likely to occur on a road network. This forms the basis for estimating the number of deaths and serious injuries and hence determining the countermeasures that might be applied.

Road Protection Scores (RPS) is calculated for each 100 metre section of road. These can plotted in a chart, with the distance in kilometres from the start of a road plotted on the horizontal axis and the RPS plotted on the vertical axis. To generate Star Ratings, each RPS is allocated to one of five Star Rating bands. The Star Rating system reflects the typical international practice of recognising the best performing category as 5-star (green) and the worst as 1-star (black). In principle, a 5-star road is one where the probability of a crash and death or serious injury is very low. The exact upper and lower RPS thresholds for the Star Ratings were set following significant sensitivity testing to determine how RPS vary with changes in road infrastructure elements. For example, figure 37 provides an illustration of the way in which the RPS for car occupant head-on crashes varies according to median-type and speed. It shows that a safety barrier will gain a 5-star rating (green) at all speeds, whereas the RPS associated with a median and centreline only increases rapidly as speed increases, such that Star Ratings decrease.

Figure 37: RPS, Star Rating and median options



4.2 ViDA

ViDA, iRAP's online analysis and reporting tool, is a suite of online tools for calculating, managing, analysing and presenting Road Assessment Programmes (RAP) Star Ratings and Safer Roads Investment Plans. By using state-of-the-art cloud-computing technology, ViDA provides tools, services and workflows to manage the RAP data lifecycle, from initial dataset pre-processing to on-screen and downloadable reports. ViDA also takes a new approach to reporting by allowing users to drill down through and analyse assessments using a flexible filter and search tool. Maps, tables and charts generated within ViDA are used in presenting the data. (See Annex 2)

4.2.1 Safer Roads Investment Plan (SRIP)[11]

Safer Roads Investment Plan generated within ViDa provides a list of the recommended countermeasures and a summary of the economic analysis. The summary includes:

1. Total FSI's Saved – an estimate of the total number of fatal and serious injuries (FSI's) that could be prevented over a 20 year period if all the recommended countermeasures were implemented.
2. Total PV of Safety Benefits – an estimate of the total present value of the economic benefits due to the fatal and serious injuries that could be avoided in the 20 year period.
3. Estimated Cost – estimated total cost of implementing the countermeasures over a 20 year period. Includes maintenance costs for countermeasures that have a shorter service life than 20 years.
4. Cost per FSI saved – cost of implementing the countermeasures per fatal and serious injury avoided.
5. Program BCR – the benefit to cost ratio of the Safer Roads Investment Plan for the roads filtered.

A strip plan is a tool used for producing a table that shows the relationship between the five countermeasures along a section of road. A strip plan can be created by filtering the data to a single section of road and then selecting up to five countermeasures. The strip plan shows a marker for each 100m of road where each of the countermeasures are recommended. The markers can be clicked to provide a map and details of the countermeasure at that specific 100m length of road.

The Safer Roads Investment Plan could not be generated for the UN Avenue due to constraints in data that hindered calculation of estimates such as, fatal and serious injuries that could be avoided and economic benefits that would be realized if countermeasures were implemented.

[11] The recommended countermeasures listed in the Safer Roads Investment Plan are automatically generated by the software. Each countermeasure proposed in the SRIP is supported by strong evidence that, if implemented, it will prevent deaths and serious injuries in a cost-effective way (i.e. it will have a BCR of greater than 1). Nevertheless, each countermeasure should be subject to additional investigation, prioritization, concept planning and detailed design before implementation.

4.3 Assessment Outputs: UN Avenue Star Rating

Star Rating results are presented for the pre-upgrade and post-upgrade of UN Avenue for three categories of road users: Vehicle occupants, pedestrians and bicyclists. The Star Rating Scores (SRS) were used to generate Star Rating tables and risk worms (charts that describe the level of individual road user risk for each 100m along the length of a road) to enable comparison of the pre-upgraded and post-upgraded phases of the Avenue. From the risk worms, it is possible to compare and determine if the safety conditions of the infrastructure for road users has improved after the upgrade.

4.3.1 Vehicle occupant 100m Star Rating

Star Rating provides an objective measure of the level of safety which is ‘built-in’ a road with five-star roads being the safest and one-star roads being the least safe. The Star Ratings measure the role of infrastructure within an individual road user’s risk, by considering the likelihood of a crash being initialized, and the severity of any crash that may occur.

The vehicle occupant Star Ratings considers three primary crash types: head-on, run off and intersection crashes. Table 1 shows percentage of the Star Rating for the sections of the road assessed. The table shows that the safety conditions of the vehicle occupants remained generally the same even after the upgrade of the infrastructure.

The majority (69% or 1.1km) of the road rated as 4-stars for both the pre-upgrade and post-upgrade, meaning that the level of vehicle occupant risk along the road is well managed for the prevailing traffic speeds. Factors that contributed to the rating included, good road conditions (minimal or no defects like potholes), adequate skid grip resistance and visible delineation centerlines and edge lines. The Detailed Conditions Report however shows that delineation of the road was judged as poor in the pre-upgrade due to worn out centerlines and edge lines. After the upgrade, there was adequate delineation because the center lines and edge lines were made visible.

The table also shows that 0.5km (31%) of the road rated as 3-stars before the upgrade and after upgrade. This suggests that these sections are of good standard, however they could further be improved by adding safety features such as street lighting and improving the quality of intersections. In the post-upgrade street lighting was installed for 0.1km (6%) of the road while in the pre-upgrade no street lighting was present. It is important to note that the solar-powered LED street lighting installed in the post-upgrade was as a result of a donation by Philips Lighting[12] . Street lighting was not prioritized from the outset of the upgrade. The quality of intersections was judged as poor due to inadequate delineation and the lack of signage. In addition, lack of protected turn lanes and wide turning radius at intersections increased the risk for the road users. In the post-upgrade, 1 out of 3 intersections has a protected turn lane.

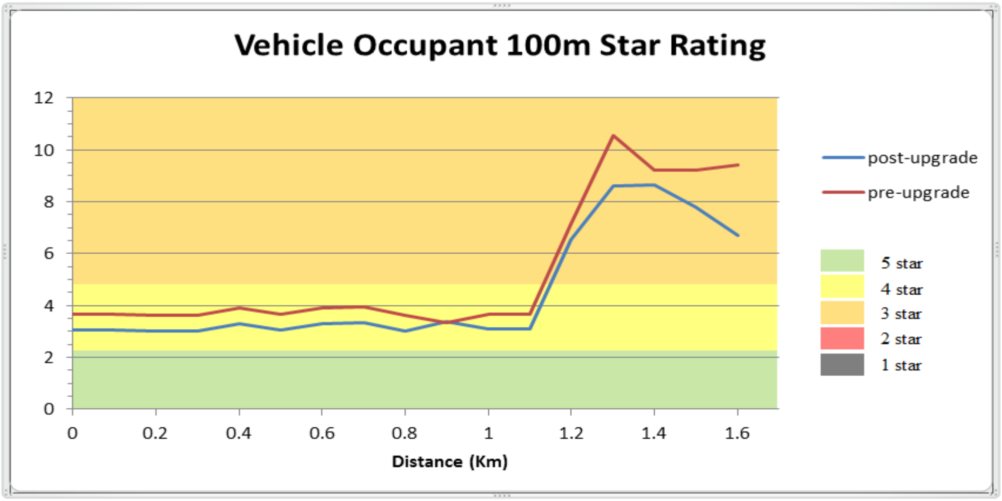
Table 1: Vehicle Occupant 100m Star Rating

Star Rating	Vehicle occupant 100m Star Rating			
	Pre-upgrade		Post-upgrade	
	Length (km)	Percentage (%)	Length (km)	Percentage (%)
5	0	0	0	0
4	1.1	69	1.1	69
3	0.5	31	0.5	31
2	0	0	0	0
1	0	0	0	0
Total	**1.6**	**100**	**1.6**	**100**

Figure 38 shows improved condition after the upgrade on the 1.3km and 1.6km stretch of the road. This is probably due to the protected turn lane which improves the safety conditions of the vehicle occupants at the intersection of UN Avenue and Limuru Road.

[12] Star (Kenya): Firm lights up UN Avenue with the solar power

Fig 38: Vehicle Occupant 100m Star Rating



However, the main focus of the upgrade was the non-motorized transport users.

4.3.2 Pedestrian 100m Star Rating

The pedestrian Star Rating considers two primary crash types for pedestrians, walking along the road and crossing the road. For example, dedicated walk ways and well-designed pedestrian crossing facilities improve the safety conditions for this user group. Table 2 shows a slight improvement of the road safety conditions for pedestrians after the upgrade with about 6% of the road being rated as 5-stars. This is primarily due to the pedestrian sidewalk facilities provided and the relative low operating speed (50km/h) of cars on the road.

Before the upgrade, the road had no crossing facilities for pedestrians. About 0.4km (25%) of the road was rated as 2-stars, while after the upgrade, 0.2km (13%) of the road rated as 2-stars. This is principally due to the addition of pedestrian crossing facilities at 4 sites along the road. Three of the crossing facilities are raised, marked crossings and the remainder is a marked crossing. These provide warning to drivers which enhance safety for pedestrians. There is no signage at the crossings. The Detailed Conditions report shows that the larger section of the upgraded road (1.1km of 1.6km) has no pedestrian crossing facilities, meaning that the crossing risk is still high for pedestrians.

Table 2: Pedestrian 100m Star Rating

Star Rating	Pedestrian 100m Star Rating			
	Pre-upgrade		Post-upgrade	
	Length (km)	Percentage (%)	Length (km)	Percentage (%)
5	0	0	0.1	6
4	0.5	31	0.5	31
3	0.7	44	0.8	50
2	0.4	25	0.2	13
1	0	0	0	0
Total	**1.6**	**100**	**1.6**	**100**

The Star Rating result presented in Figure 39 show that there was a slight improvement of pedestrian safety conditions after the upgrade with some deterioration at the 1-1.4km and 1.6km stretch of the road. This is contrary to what was expected of the upgrade. Some of the factors that were expected to drastically improve the safety of pedestrians include the dedicated walkway with physical barriers (bollards) that separate from motorized traffic.

The increase of risk after the upgrade for the section between 1.3km and 1.6km is mainly due to the increased number of lanes that pedestrians have to cross after the introduction of a filter lane at the intersection between UN Avenue and Limuru road. A pedestrian refuge at this point would have made it safer for pedestrians to cross, however the refuge installed is poor in design. For instance, the refuge does not have adequate pedestrian fencing to channel pedestrians to the appropriate crossing point. Another weakness is the increase in illegal vehicle parking in some sections of the pedestrian walkway. The design of the upgraded road did not integrate parking needs for the taxis and motorcycles which operate along UN Avenue. The taxi and motorcycle drivers therefore take advantage of the upgraded pedestrian walkways and cycling lane. In such sections, the pedestrians are pushed onto the carriageway or the cycling path which increases their risk.

Figure 39 also shows a slight improvement in the post-upgrade at the 1.5km mark which rated as 4-stars. This can be attributed to the raised and marked pedestrian crossing at this section.

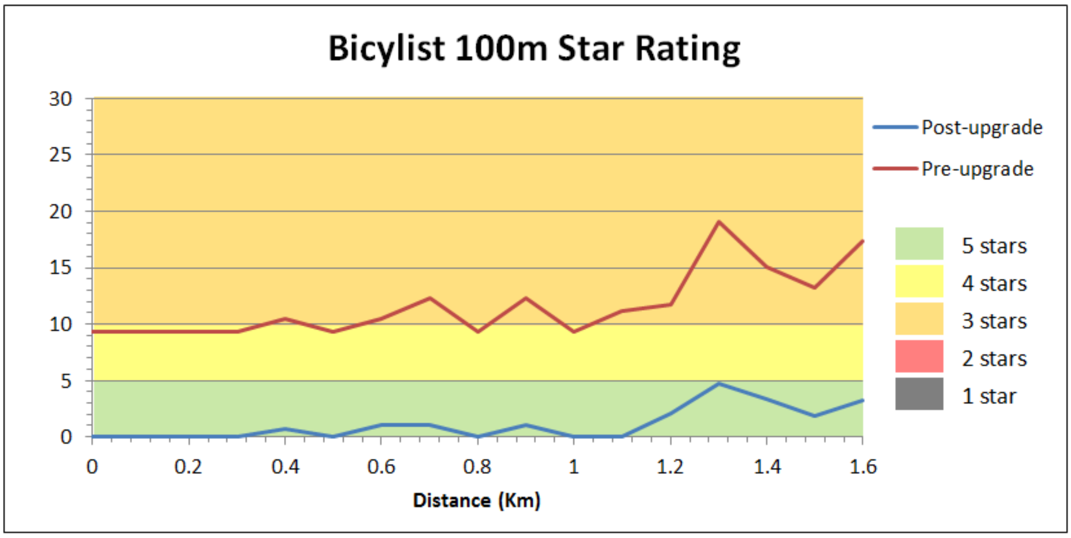
Fig 39: Pedestrian 100m Star Rating

4.3.3 Bicyclist 100m Star Rating

The Star Rating for bicyclists considered the provision of cycling infrastructure on the road. There was no cycling infrastructure before the upgrade resulting in bicyclists having to use the carriageway or existing footpaths. There was higher risk of cycling with more than half of the road (59%) before the upgrade rating as 3-stars while 41% rated as 4-stars as illustrated in Figure 40.

The figure shows a dramatic improvement for the bicyclists. All the sections of the road rated as 5-stars after the upgrade. This is attributable to the dedicated 2-way cycling lane constructed during the upgrade. The dedicated cycle path completely separates the bicyclists from motorized traffic, and dramatically reduces their risk.

Fig 40: Bicyclist 100m Star Rating



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Part 5: Conclusions

This first Share the Road NMT pilot project in East Africa, offers a great example of a new way of conceiving urban road infrastructure in Kenya, with replication already happening. Its evaluation has offered valuable lessons for future initiatives covering recommendation in road safety, accessibility and environment; the three pillars of the programme. Moreover, lessons have also been learnt regarding the methodology, which will be valuable for future evaluations.

Road Safety

Road safety was triggering key trigger for the project. The experience in UN Avenue shows a successful reduction in the number and severity of accidents on the road, achieved through an inclusive design of roads and segregation of road users as a fundamental principle for Kenya. Some elements incorporated have proven to be more efficient than others. Pedestrian safety has been enhanced by raised crossings and slip lanes, while painted crossings do not benefit nor reduce the risks of crossing the street. Raised and marked crossings improve the Star Rating Scores of the road. Star Rating results suggest that the crossing risk of pedestrians is however still high since a large section of the road does not have crossings. For cyclists, some design recommendation would increase their safety, such as improved visibility at intersections, and measures like reducing the kerb radius of streets crossing segregated tracks. Maintaining a smooth surface will be beneficial for both.

Figure 41: Vertical road signage

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Star Rating results showed that features such as adequate delineation and proper design of intersections provide warning to drivers and keep them within the driven lane, therefore improving safety for all road users. Proper signage keeps drivers aware of the conditions of the road and warns them of any sudden changes in road condition. It also makes them aware of probable interaction with other road users, making the road safer for all users.

Incorporation of a filter lane at the intersection of UN Avenue and Limuru Road greatly improved safety of the motorists. However, it increased the number of lanes to cross for pedestrians making it more risky. Infrastructure design should therefore integrate various needs of the different road users to ensure safety for all. This could also help curb encroachment of the upgraded cycling and pedestrian lanes by taxis and motorcycles.

Accessibility

In addition to safety, the study proved that general accessibility was improved. There was an average increase in the speeds for cyclists and pedestrians due to reduced obstacles; facilitating mobility on walkways and cycling lanes. The combination of accessibility with the improved comfort and aesthetics has not only shorten, but made more convenient the trips. The improved conditions of UN Avenue are expected to motivate those residents and people accessing home and work within the area to experience the use of non-motorised forms of transport in a safe and convenient way.

To extend the impacts beyond the direct area of influence, existing roads should be upgraded and new roads carefully planned with inclusive NMT facilities, in order to develop a city-wide network. This study has shown the relevance of network planning and the interconnection of actions at an urban scale. It has been very evident that making improvements or creating urban barriers has profound effects in the way people move through the city. By creating missing links to the pedestrian infrastructure and improving the conditions for cycling (more safe and more direct routs), more people will be attracted to walk and cycle in a dignified way. Accessibility is also enhanced when NMT infrastructure is properly linked to public transport facilities. Provision of safe and comfortable walking and cyling facilities can enable faster access to the nearest public transport.

Environment

Through the provision of infrastructure that makes walking and cycling convenient, safe and enjoyable, has multiple benefits for the environment, including the prevention of modal swift from non-motorised users into motorised modes. The incorporation of drainage and vegetation on complete streets also improves the urban general environmental conditions, making urban areas more livable and healthy.

Through this pilot case, creating a more ordered road environment and delimiting the road space for each user, has produced inherent benefits of reduced congestion and improved air quality; benefits which are mostly enjoyed by those who walk and cycle.

About the Methodology

During the process of data analysis, this evaluation encountered several challenges, recognizing the need for having effective methodologies and data collection mechanisms in place for transportation projects; e.g. variations during the day of the week of the traffic counts and surveys were not taken into account when establishing the methodology for the traffic counts, which affected the volume of counted users.

Additionally, user surveys could have included a broader scope of inquires; including more options to the trip purpose, inquires about intermodality and length of trip, question the origin and destination and more direct assessment of the cycling infrastructure. More rigorous methodologies for data collection will bring better quality data and therefore, better analyses for transportation projects. It is recommended to continue a periodical traffic count over the following years, which could be targeting cyclists in particular, to monitor the evolution in the number and user type.

Good documentation and dissemination of studies related with urban mobility and transport infrastructure in the region are needed to generate policies and guidelines for Africa based on local evidence.

Figure 42: User survey

5.1 Way Forward

As a showcase road, this project is just a start point, which has helped to trigger soft commitments and actions within Nairobi. Capacity has been enhanced among staff at the Kenyan Urban Roads Authority (KURA), for whom a new way of conceiving roads has already started. Future projects in Nairobi and other Kenyan cities can profit from the example; and take first hand observations to the pilot experience.

This evaluation helped to provide insight to the challenges of designing optimal pedestrian infrastructure. The experiences and observations on the ground will be useful to develop design standards at regional and city level. Further in site-observations will help determine what type of facilities adapt better to the local context, and respond best to the needs of the people of Nairobi.

Awareness raising and activation campaigns are still needed, including a stronger engagement and the creation of a civil society platform to advocate for pedestrians and cyclist's interests. Dissemination of the results will be important for the replication of the experiences.

Moreover, closer collaboration with partners doing valuable work on the non-motorised transport in Africa (such as Sub-Saharan African Transport Policy Programme SSATP, or the Transport and Environment Science Technology -TEST Network) is envisaged. UN Avenue will be part of iRap review of road safety measures in Nairobi towards safer and more accessible city-wide pedestrian and cyclist network.

Finally, this report looks forward to the replication of the initiative in other towns and other city roads, particularly those with very high numbers of pedestrians and cyclists because it is these roads that have high numbers of serious and fatal accidents. It encourages partners to find innovative ways to create pedestrian and cyclist-friendly cities around the continent.

UNEP will continue working on a triple approach to move towards a sustainable transportation by promoting better pedestrian and cyclist infrastructure, cleaner vehicles and more efficient public transport. Only by moving together on an integrated approach, will the environmental, accessibility and safety conditions improve for the majority of the people on the road.

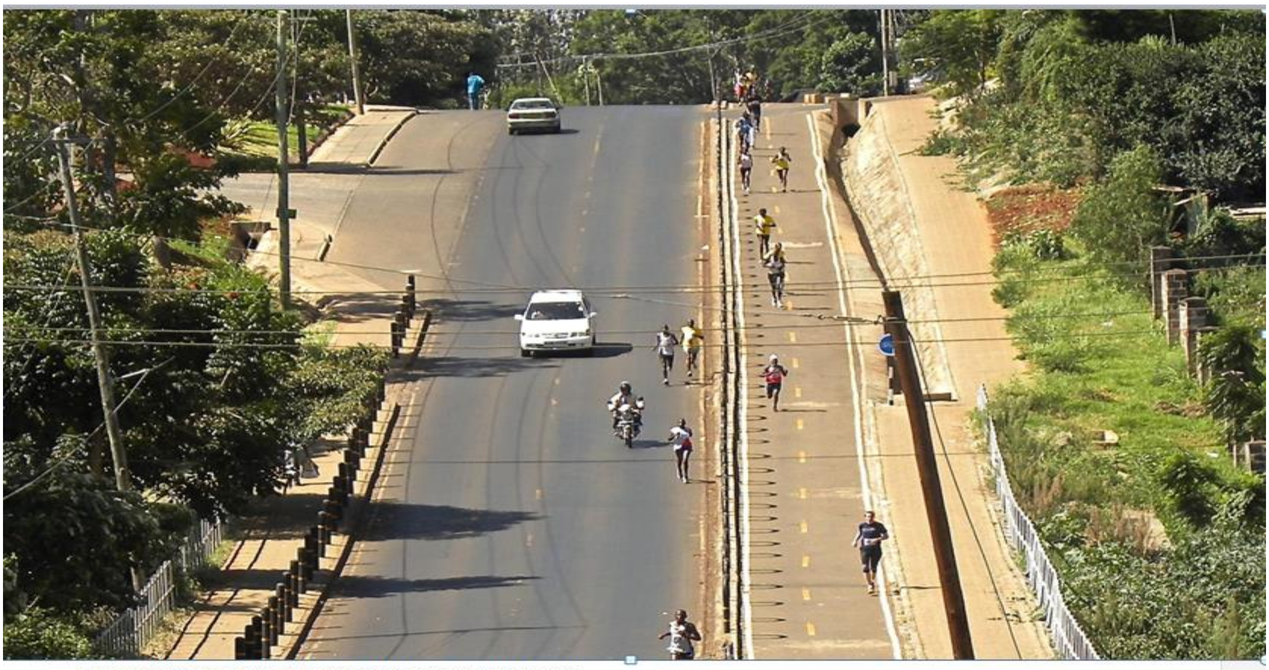


Figure 43: Runners of the UNEP Half Marathon on UN Avenue

Annexes

1. Indicators proposed by Share the Road Programme

Accessibility:

- Average speed for pedestrians and vehicles
- Number of destinations within transport modes, and travel times
- Size and numbers of inhabitants in catchment area

Environment:

- New users of NMT modes within area.
- Potential of increasing NMT users
- Percentage of trips for which people have the option to (realistically) choose for a sustainable mode of transport

Road safety

- Number of fatalities and serious injuries (total, per 100,000 inhabitants)
- Number of fatalities and serious injuries for NMT-groups (per 100,000 motor vehicles)
- Risks of NMT users of being involved in an accident.

2. ViDA Star Rating Reports

Maps

- *Star Rating* – provides a map of the Star Rating for different road user groups. This enables the user to see the change in risk along the road network. Star Ratings provide a simple and objective measure of the relative level of risk associated with road infrastructure for an individual road user.

- *Predicted Casualty Reduction* – shows a map of the predicted number of fatal and serious injuries that could be prevented if the complete Safer Roads Investment Plan were implemented. This map can help to prioritise the implementation of countermeasures by identifying specific locations or road sections where the potential to save lives is greatest.

Tables

- *Detailed Conditions* – The Detailed Road Condition tables provide the length and percentage of the filtered network for each category of recorded road attribute. The Detailed Conditions (After) report provides the schedule of road attributes as they would be if the complete Safer Roads Investment Plan was implemented. The Detailed Conditions report can be used to compare the infrastructure attributes of different roads or road sections and can help to provide an understanding of the Star Ratings of a given road section and the proposed countermeasures that will potentially alter the road attributes and reduce risk.

- *Star Ratings Tables* – The Star Rating tables provide the length (in kilometres) and the percentage of each star for each road user type for the filtered network. The Star Rating (After) table provides the same information except that the results presented relate to what the Star Ratings would be if the complete Safer Roads Investment Plan was implemented. In addition, the Star Rating (After) table provides the percentage change for each star relative to the original Star Rating.

Charts

- *Risk Worms* - the risk worm is a line chart that displays the Star Rating Score (the Star Rating Score or SRS is the numerical score that under pins the Star Ratings) along the length of a section. The risk worm is able to show the SRS for each of the road user types as either the 100m risk (raw data) or the smoothed risk. To generate a risk worm a single section of road must be selected. Comparison risk worms can be created if two matching datasets are available; this can be used to compare a proposed road design with the current (baseline) road, or between two different road designs.

- *Star Ratings* – this provides a percentage bar chart of the distribution between the Star Ratings for each road user type. This chart shows the raw or 'unsmoothed' data.

- *Star Ratings (Smoothed)* – this provides a percentage bar chart of the distribution between the Smoothed Star Ratings for each road user type.

In addition, all these charts are available as 'After' charts, showing the projected Star Ratings based on the recommendations within the Safer Roads Investment Plan.

Downloads

- *Core Data* – this file contains the road coding data for each 100m length of road along with the SRS (total and for each of the crash types) and the Star Ratings (raw and smoothed) for each road user type.

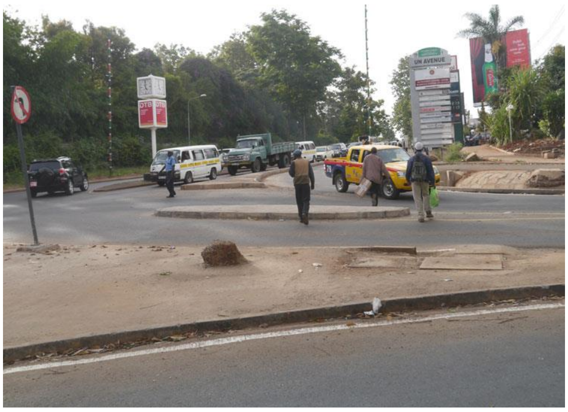
- *Fatality Estimation* – this file contains the fatality estimations every 100m for each road user crash type.

- *Countermeasures* – this file contains the details of each 100m countermeasure triggered by the model, whether each of the countermeasures made it through to the Safer Roads Investment Plan and the economics that justify each countermeasure.

- *Star Rating .kml files* – these are mapping files that are compatible with Google Earth and ArcGIS showing the Star Rating for each road user type.

3. Recommendations for UN Avenue Road

1. Relocation of KPLC poles that are obstructing the cycling path. Poles located near the US Embassy were relocated. However, there is still a pole that is obstructing the cycling path directly opposite the Whispers access road.



2. Erection of additional raised pedestrian crosswalks at the Limuru Road junction, around China Garden and UN Commissary area. The alternative would be demarcation of the road at these points with horizontal zebra crossing markings, to reduce the risk for pedestrians.

3. Horizontal signage (ground markings) on the pedestrian walkways and especially the cycling lane, including 'No Parking', is required for awareness raising and enforcement purposes.

4. A taxi parking rank could be provided with minimal restructuring of the road and signage. Due to lack of parking space for the taxis, they tend to eNcroach the walkways and cycling lane.

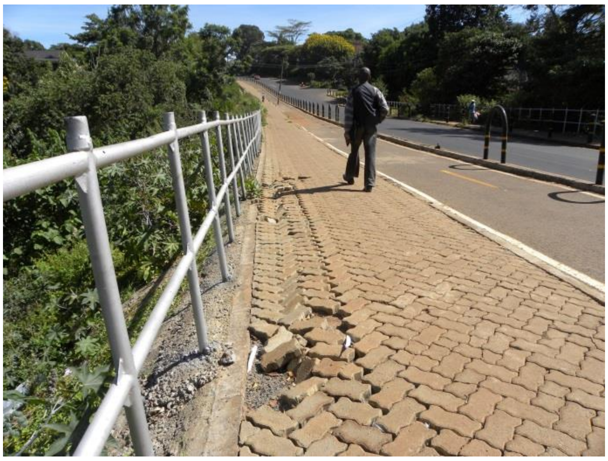
5. Provision of adequate street lighting along the Avenue. Consultation with cyclists during the post-upgrade phase revealed that they consider it a risk to use the cycle track after dusk, particularly due to lack of street lighting and numerous obstacles present on the track.

6. Repairing of worn out underground cable boxes that result in un-even cycling and walking surfaces, including unprotected (uncovered) manholes.

7. Kerb ramps need to be present at every intersection to increase usability for all. Although some sections of UN Avenue provide it, they are not incorporated in the design of every intersection.

8. During the road improvement works, some drain channels were left open, preventing the use of the sidewalk by persons on wheelchairs. It is recommended to give more attention into features allowing accessibility during the design and construction phases, or to incrementally upgrade facilities if they do not yet comply.

10. Replace/re-install damaged vertical signage and physical barriers. The bollards and vertical signage are currently damaged due to impact from motorists during accidents meaning that the bollards and kerbs were weakly anchored, and also due to low quality materials used during the rehabilitation process.



11. In some areas, due to insufficient compression of the subgrade layers and the uncalculated loads of parked vehicles, the surfaces have become uneven and deformed. This problem is more acute in sections bordering the drainage channel; where portions of the stabilized slope have collapsed. The cycle track will have similar problems in the near future, where the continuous use by motorcycles of a surface intended for bicycles has created potholes.

12. Painted-only crossings do not succeed in reducing speeds and become more risky, as they create a false sense of security for pedestrians. From the number of raised pedestrian crossings originally planned, only three were installed. Crossing the avenue continues to be a threat at these points, particularly when motorized traffic is minimal, with vehicles circulating at high

13. The stretch between United Nations and Limuru Road has several intersections and entrances, which pose several risks. The most transited intersection is the junction with Gigiri Drive. Motorists lack clear visibility of pedestrians and cyclists, and turn without reducing their speeds. The high-turning speed is encouraged by the wide kerb radius of the intersection. A reduction of the turning radius of this junction would improve safety.

14. The height of bollards and other protection elements, particularly those located transversal to the riding direction, should maintain a height that will not interfere with the bicycle handlebars. A lower height would be equally effective for preventing car access, but more friendly to the needs of cyclists. Similarly, a minimum clearance of 1.20 metre-wide between obstacles is required, to allow wheelchairs or loaded bicycles to pass without problems. The drainage channel adjacent to the cycle track is also not safe. An un-experienced cyclist could lose control and fall into it. Further design should consider the addition of a small kerb to prevent potential accidents.

15. Congested sidewalks especially near the Limuru road junction due to motorcycles and hawkers. Provision of parking spaces for motorcycles are required, and the regulation of hawkers by city authorities.

4. Sample Road User Survey

Location		Respondent type	Motorist / motorcyclist Pedestrian Cyclist		
Data Capturer:		Time:		Date:	
Note: This is with reference to your experience in using this road before the reconstruction.					
1. For how long have you been using this road?					
A) >5 years	B) 5-3 Years	C) 3-1 Years	D) Less than 1 Year		
2. What times of day do you frequently use the road?					
2 (1). For what purpose					
A) Access to work	B) Access to home	C) Through road	D) Other (specify)		
3. What has been your experience in using the road in the following conditions?					
Rainy weather:	1. Very good	2. Good	3.Indifferent	4. Bad	5. Very bad
Dry weather:	1. Very good	2. Good	3. Indifferent	4. Bad	5. Very bad
4. How do you rate the on-road behaviour of other road users					
A) Motorised traffic:	1. Pleasant	2. Modest	3. Unpleasant		
B) Non-motorised traffic:	1. Pleasant	2. Modest	3. Unpleasant		
5. How do you rate the security while using this road?					
1. Very safe	2. Safe	3. Unsafe	4. Very unsafe		
6. Have you been involved / witnessed an accident while on this road?					
A) Yes			B) No		
6. (1). If yes, who were involved?					
A) Motorist- Motorist	B) Motorist- pedestrian	C) Motorist- Cyclist	D) Cyclist- Pedestrian	E) Other (Specify)	
6. (2) If yes in 6 above, what was the nature of the accident?					
A) Fatal	B) Serious	C) No casualties			
7. Given the current traffic situation, how easy is it to access your destinations in terms of convenience and time?					
1) Not Easy	2) Easy	3) Difficult	4) Very Difficult		
7 (1) Please explain why:					
8.What is your assessment of the likability (with reference to smoke / noise pollution) of this road?					
9.What improvements could be made on the road with reference to:					
A) Road design					
B) Safety					
C) Access to destinations					
D) Any other					

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