STUDY ON EFFICACY OF RING ROADS FOR URBAN DEVELOPMENT, BY USING JAPANESE'S EXPERIENCES. "CASE OF KINSHASA''

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Abstract - Kinshasa, one of the biggest cities in Africa, is in need to start changing its condition and function of the roads. The last study on the Transportation Master Plan sets out the traffic congestion and the estimation of the future population. These elements bring many difficulties with useful urban function. To decongest traffic and meet the future demand, by improving roads network, remains the primary idea. Our Research-Based on analysis of the efficacy of the Ring Roads by using Japanese experiences and point out vital and necessary results . From the inspection on the fields, in Nagoya, Utsunomiya, Sapporo, and the usage of some documentation, we found that the beltway plays a crucial role to reduce the cross traffic flow in the city core and secure the shape of the metropolitan area, that will be useful as a solution.

Keywords - Roads Network, Traffic Congestion, Transport Mode, Traffic survey.

I. INTRODUCTION

As a capital city of the Democratic Republic of the Congo ''D.R.C'', Kinshasa supposed by 1960 to receive the population of 400,000 people on the total area of 9,965 km², for the first evolution of the city with its major transportation infrastructures and the same Central Business District ''C.B.D'' [1]. This metropolitan had an inappropriate development in term of the master plans, from the end of the 19th century up to the early 21st century. Subsequently, in the year of 2018, the population was more than 12.50 million. This situation brought some problems in economics, land-use planning, transportation planning, transportation facilities projects, and construction. The roads network is insignificant and unsuitable compared to the total land area, and the traffic condition is not good. Sometimes, the traffic congestion average reaches 2.3 hours, that permits the city to lose several million a day. The master plan of the Strategic Orientation Plan of the Agglomeration of Kinshasa ''S.O.S.A.K'', made in 2014, gives the general strategies of sustainable development. The Project of Urban Transportation Master Plan of Kinshasa ''P.D.T.K'' realized in 2018, where the OD traffic examination on four-step model flow method gave 72,506 inbound vehicles per hour into the city center [2]. The purpose of this research is to find a solution to the traffic circulation by improving the roads network. To adapt this roads network systematically to the expanding need of the city, with smooth traffic and reduction of the traveling time. In this study, the Ring Road ''R.R'' is used for two significant functions of traffic and spatial, to improve and make viable the utility of the city. Furthermore, the R.R will prepare the combination of the multimodal transportation plan. Then, the Japanese experiences of riding R.R, discussion of the results with some municipal responsible, and the traffic survey in Kinshasa constitute the significant methods to come up with the final project result. The body of the paper will be organized as follows: The Influence of the R.R in the City, Methodology, Japanese R.Rs, Traffic Survey, and Roads in Kinshasa, Results, discussion, and conclusion.

II. THE INFLUENCE OF THE R.R IN THE CITY

A. Overview

The R.R or Beltway often indicates a circumferential route from one or a series of roads within a city or a town, as an express transportation infrastructure. It plays a crucial role in the urban planning system. Then, the traffic does not have to pass through the city center. This type of road is one of the keys to solve the chronic traffic congestion as made in several world cities. The system has a variety of functions, which are roughly classified into those for handling traffic flow, and for supporting urban structure. The best effectiveness start after it is full opening for service.

B. Effects of the R.R

It serves both as a support for a high-capacity transport system and a fast-track route to connect the main functions of the city (city center, industrial zone, universities, airport, port, etc.). Hence, the type of a town, which necessities a R.R system to handle increasing traffic volume, is said to be a town with a population of 200,000 people or more [3]. Some analysis of the R.R effects:

- With the new way of establishing the simulation model to analyze the scheme of R.R traffic systems; the results for the unique situation are concluded, and it is useful for optimizing the current traffic system [4].
- The change of the socio-economic environment in

the society, this situation is relatively better and
- social interaction with the group of people [5].
- The study of the traffic circulation determined that the current roads network is inadequate for the present volume of traffic and as well the impossibility to widen the road [6].
- The RR project of Addis-Ababa pleased the residents due to the motion of heavy vehicles that enter the city from the significant radial routes to bypass segments of the metropolis; then, it brought the possibility to avoid the city center. The scheme increased accessibility, mobility in the city, and cut down traffic congestion in the area and connected neighborhoods with market places, schools, churches, and clinics. The reduction of traffic congestion, in turn, condensed the risk of motor accidents [7].

Hereafter, Table 1 of some R.Rs purpose over the world:

Continent/ Country	City/Name of Ring Road	Length (Km)	Purpose
Africa / Morocco	Rabat, Rabat R.R	41.7	Open since 2016, to relieve Rabat and Salé from passing through traffic.
Asia / Singapore	Singapore, ORRS (Outer R.R System)	–	Open in 2009, to reduce the traffic volume on the city-bound roads.
America / United States	Arizona, Loop 101 Phoenix Metropoli- tan area	98.15	Completed in 2001, to facilitate communication and ensure exchange in the city.
Europe / Belgium	Brussels, Brussels Ring	76	Ended by 1978. It allows contact with some Europe roads and national roads.
Oceania / New Zealand	Auckland, Western R.R	48	Completed in 2017. To end decades-long delays and divert the massive traffic.

Table 1 Some R.Rs over the World[1]

Concerning the R.Rs around the world, the principal target is the smooth traffic over the city and diverts the traffic that has no business in the city core to the peripheral areas. This study aims to include some added values on the R.R functions, to sum up, the Japanese upsides of the beltways, shaping the city to limit the unplanned expansion, to create new CBDs relative to the Master Plan of Kinshasa city. On the other hand, to make a plan of 2050 for the incensement of the population and the number of OD traffic estimated to be respectively 32.51 million and 199.065 inbound vehicles per hour.

III. METHODOLOGY

Related to the situation of the Kinshasa city, it has been essential to select the technical and scientific methods to come up with relevant data. The RR is a new project never been done in D.R.C, the reason for the quantitative and qualitative methods combined. Based on the S.O.S.A.K, that gave much information on the problems of the city and projective development strategies. First, the data collection has been realized about the history, evolution, and the future plan, of the transportation system in Kinshasa [1]-[2]. Next, the Japanese skills of the R.R realized from the inspection and riding of Nagoya R.R that connected the Kanto region and the Kansai region. After that, the Utsunomiya R.R with the same technique; this is the surface R.R with an upgrade at several junctions. The step ended with the in-depth analysis of the Sapporo R.R, by a discussion with road department members at City hall, and riding inspection. The improvement of these data made during different exchange besides Japanese academics societies. Next, the P.D.T.K that allows the analysis on the traffic circulation and the evaluation of the plan and population. The knowledge of the Kinshasa condition and future plan; the Japanese experiences with three selected R.Rs, and previous studies are the

[1] https://en.wikipedia.org/wiki/list_of_ring_roads, may 30 / 2019 at 12:32 (UTC)

elements which helped to realize the Kinshasa R.R proposal plan and alignment.

IV. JAPANESE RING ROADS

In Japan, the national government, prefectural government, municipal government, and expressway companies, administrate many types of road, respectively. Furthermore, the roads described by road act, there are a bunch of ways where R.R is included [8].

A. Basic of Ring Road Functions in Japan

By creating an R.R, the traffic bound into the city center supposed to divert. Then, the reduction in traffic volume would be useful to mitigate traffic congestion. Therefore, the effects of this road are as follow:

- To put an end to the traffic flow transit into the city core;
- To distribute streams of traffic from the peripheral area to the urban focal point;
- To have direct motion between neighboring areas;
- To move on time even during the discontinuance of some road sections due to disasters or traffic accidents.

B. Ring Roads Efficacy in Japan

After being informed about Japanese roads network, the rides for inspection on Nagoya, Utsunomiya and Sapporo R.Rs give these following details for the effectiveness:

Nagoya R.R: Owned and operated by the Nagoya Expressway Public Corporation, The Nagoya Expressway R.R (Nagoya kousoku douro toshin kanjou-sen) is an urban expressway. In the downtown of the Nagoya city, the R.R forms a rectangular loop that is one-way only and flows clockwise with 2 to 4 lanes of traffic [9]. The Nagoya RR is a bypass of 66 km, situated at less than 10.3 km of the city core that existed since 1985 to present. The opening section about 59 km (with temporary two lanes road) due to the opening sides of East, Southeast, and north-south in mars 2011 [9]. Fig1. This Infrastructure contributes to cut down the traffic volume, especially in the city core and develops socio-economic activities by sharing and detour inappropriate way the vehicles that bound in the downtown and remain for diverse reasons. On the other hand, The National route 302 that is also shaped as R.R, is a surface road with the same direction than Nagoya RR, from 15 km east-west and 20 km north-south, and approximately 66 km extended length in Nagoya city (Fig1 and Fig.2). The standard widths are 50 m, 60 m, and 72.5 m. The Land readjustment (L.R) system is used to connect the entire route as designed. This road is increasing the number of access possibilities north to south and east to west, from 2 in the year of 1999 to 2430 by the year of 2020.



Fig.1 Nagoya R.R and others Roads in 2018

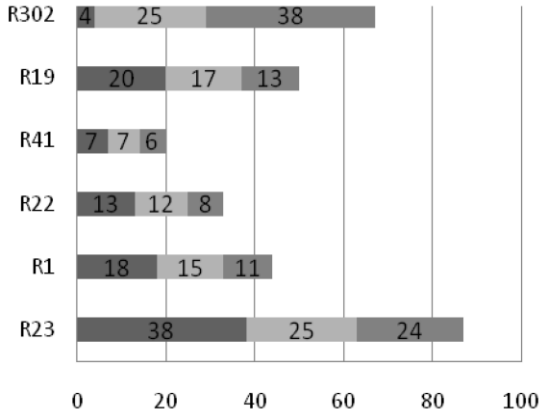


Fig. 2 Evolution (%) of RR302 efficacy in 1985, 1999 and 2015 compared with radial roads

The national RR302, contributed to a vast effective traffic congestion reduction in the Nagoya area, with the sharing traffic of 4% in 1985, 25% in 1999 and 38% in 2015. Compared to R322, the radial roads R19, R41, R22, R1, and R23 decrease progressively on the different periods. Concerning the Expressway RR, where the construction percent is estimated, about 89% has the sharing traffic of 18% compared to the total traffic of the region.

Utsunomiya R.R: is included in the urban development area of Tokyo and belongs to the 100 km² area of the same metropolitan. The Utsunomiya R.R has been adopted since 1958 to improve the

decline of urban functions, due to the mixture of heterogeneous transportation in a conventional one-point concentrated type (radiation pattern) [10].

There are two R.Rs; the Inner R.R located in the center of a small area qualified like a loop road. The Outer R.R, the most useful for the city condition, is located in the big area of the region. This local Outer RR is composed of four roads, the national highway n°4 as the bypass, the provincial roads 3, 119 and 121 as mentioned in Fig.3. This project (Inner R.R) is about 8 km east-west direction of the outline of Utsunomiya city with a total extension of 34.42 km. The structure is shaped to accept 19 crossing national and highway prefectural roads. It is a simple R.R, but the function is crucial due to no traffic jam with a speed range from 50 km/h to 60 km/h. After opening to the public, on the inner cross-section, the total traffic volume from the city center to the suburbs is 3% (137,770 vehicles /12h to 131.2.903 vehicles/12h) [10]. On the contrary, to the outer cross-section, for each direction, the amount of straight-ahead traffic decreases by about 11% (11, 487 vehicles/12 h decrease)[10].

The traffic volume flowing in the right and left turns on the ring road increases by about 19% (6,620 vehicles / 12 h Increase)[10]. The land use got much value because of the presence of the R.R that contributes to the development of the city for the exchange and commercial activities. The estimated total traffic reduction in the city core is about 11%.

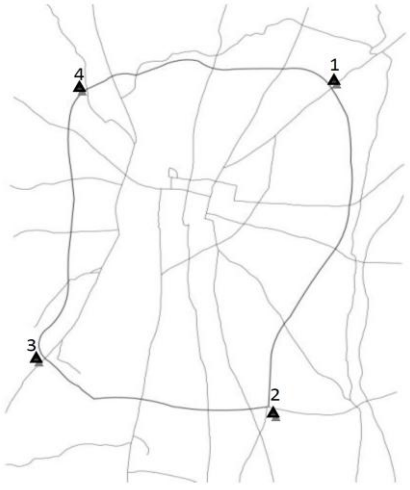


Fig. 3 Utsunomiya Outer RR

Reference box

Radial Roads

Outer RR (NR4=1-2; PR121=2-3; PR3=3-4; PR119=4-1)

Sapporo R.R: The observation covers the period from August 27 to August 31, 2018. Sapporo city has an appropriate transportation system included beltways that contribute utterly to the smooth traffic around the city core and the peripheral zones. Sapporo has a grid pattern design from the city center, with a bunch of radial roads, around 13 that crossing the central area from east to west and north to southern zone [11]. There are many types of roads existing in the internal of the city. Currently, Sapporo has two ring roads, Inner ring road, and Outer ring road. The Inner beltway was planning for a long time ago and was the main ring road to assure the smooth movement of the road in the city center. After that, the second ring road has been initiated to play almost the same function for different effects due to the increase of the population and the extension of the Land use.

The following are the information of these R.Rs: The Inner Ring Road, completed in 2001, also calls Sapporo Annular Passage. This track is an urban planned road that extends 22.7 km with four lanes to 6 lanes depending on the specific areas. It was the first in Japan like the full-scale R.R [11]. The Outer R.R, evaluated in 2016 with 85% for the evolution and total project of 66.4 km. There are some sections where the width should be improved for an extension [11]. This second ring road on the same broad area is planned due to the augmentation of the traffic noticed by the number of vehicles. Also, the extension of land use and the population. Not only of the Sapporo but also for the neighboring cities (e.g., Otaru, Kitahiroshima,etc). There are also the main effects that justified the construction of the Outer R.R.

This road is located about 4 km to 9 km (maybe more in the South-East of the city) from the center point as the city. Table 2 shows the effects of Sapporo R.Rs.

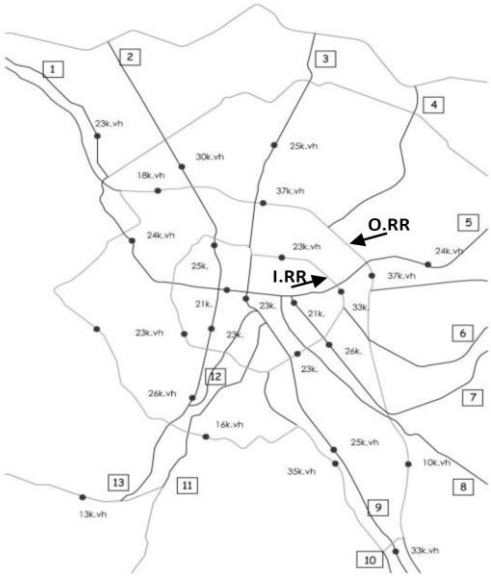


Fig. 4 Sapporo Inner RR and Outer RR

Reference box

Radial Roads (1-13)

Inner and Outer R.Rs

	Traffic/unit (Veh/12h)			
Radial roads	Before RRs	RR1	RR2	% of Reduction
1	23,203	24,105	21,984	5
2	30,342	_	25,709	15
3	25,817	_	23,961	7
4	_	_	_	_
5	24,725	_	21,984	11
6	_	_	_	_
7	_	26,032	21,638	17
8	_	_	_	_
9	33,106	25,503	23,961	28
10	_	_	_	_
11	_	_	_	_
12	_	_	_	_
13	_	26,974	23,337	13
The average percentage of traffic reduction 14				

Table 2 Traffic's Effects of Sapporo R.R

C. Findings in Japanese R.Rs

- Give the shape of the city and secure against the unexpected expansion of the town;
- Have a structure relative to the scale of the city (Population and total area);
- Be used to divert the cross-traffic in the city core, share and distribute traffic flow with some reduction of traffic congestion (10% or more) [12];
- Have some alignment problems that are solved by the land readjustment (LR) method [9];
- Have a national road or expressway as one section of RR alignment;
- Contribute to the reduction of the traveling time due to augmentation of the speed (smooth traffic);
- Have the overpass and underpass in the important junctions with the possibility to turn right and left;
- Facilitate the communication of two extremity cities by using central city R.R.

V. TRAFFIC SURVEY AND ROADS IN KINSHASA

Located in the west of the country, limited by a vital length of Congo River, Kinshasa lacks a provision of adequate infrastructures. The road traffic survey focused on the census of Kinshasa primary roads traffic volume and the OD traffic for road planning [2].

A. Analysis of the OD traffic

The Kinshasa OD traffic examination applied by the P.D.T.K gives 72,506 for inbound vehicles per hour [2]. The population of Kinshasa will be 1.6 times in 2030 and 2.1 times in 2040, relatively to the estimation for the future [2]. I am assuming that the growth rate of the future gross domestic products ''G.D.P'' of Kinshasa is the same as the growth rate of the last ten years of 7%. The G.D.P per capita will be 1.5 times in 2030 and 2.3 times in 2040; this analysis gives data on column 2030 and 2040 in Table 3. Deduction and progression for the OD traffic, in 2020 and 2050, the situation will be as shown in table 4. The results will be usable in 2050, then all analysis back by the simulation to the traffic study from 2017 up to 2050.

	2017	2020*	2030	2040	2050*
Pop. (Million)	12.50	13.76	20.00	26.00	32.51
GDP (USD)	725	865	1,093	1,654	1.953

Table 3 Future population and G.D.P [2]

*2020 and 2050 are the value calculated in this study.

T/t (h)	2017	2020	2030	2040	2050
W+C	4455	5314	6713	10157	11995
MC	2958	3528	4457	6744	7964
Car	28988	34578	43682	66091	78049
Van	23010	27447	34674	52462	61954
Bus	9800	11690	14768	22344	26386
Others	3295	3984	4965	7512	8872
Total	72506	86489	109259	165311	199065

Table 4.Future OD traffic from Population and G.D.P.

With T/t(h)= Traffic/time per hour; W+C= Walk + cycling; MC= Motorcycle.

B. Roads in Kinshasa

The main problems of the road network in Kinshasa are as follows: the discontinuous primary roads, disconnected secondary roads, and unbalanced network density (Fig.5). According to the geographical view, the new urban area will be divided into three zones, by two rivers (N'djili and Nsele) [1]. The Western division, the Central Division, and the Eastern division, where the first zone is the evaluation sector for our urban development strategy. In Kinshasa, there three types of roads, primary, secondary and tertiary roads separated by National, provincial and urban roads. The road density index of the arterial roads is insignificant of 0.02, using (1), due to the total length of 205.23 km, the total area of 9965 km², and 12.5 million of population.

$$RDI = \frac{L}{\sqrt{(P \times A)}} \quad (1)$$

Where RDI= Road Density Index
L= Road length in Km
P= Population in 1,000
A= Land area in Km²

C. R.R proposal (Results)

For the future land use plan, the method of establishing R.Rs that will enclose the planned urban divisions is strategically detailed as follows:

Western Division: As the main sector of the development, this zone has the major C.B.D in the municipality of Gombe with 18% of urban employment share [2]. The Western Inner R.R and the Western Outer R.R are two structures for urban development, as using Fig.6. This area is connected to Kongo Central province that is a coastal region. The daily traffic volume divided by directions D1, D2, D3, and D4 of passenger car unit per day (pcus/day) from/to different areas, as demonstrated in Table 6.

Central division: this area, located between N'djili River and Nsele River, will have the Central R.R that will be passing by the International airport of N'dlili. The new C.B.D in the sub-center will be developed, as shown in Fig 7.

Eastern division: To be populated of 6 million of inhabitants by 2040. The eastern R.R is Important to connect to the Brazzaville city and the city of Kikwit, as using in Fig.7.

It health mentioned that the geometric design of these R.Rs is Expressway and Arterial Road, as shown in Table 5. The speed design is ranged between 80-100 km/h with 4 to 6 lanes, and the total length of all expected roads and future access roads by 2050 is 2000 Km. Then the Road Density Index will be improved to 0.11, as operated in (1).

Type	Design speed (Km/h)	No. of lanes	Carriage-Way (m)	Right of way (m)	Others elements (m)
Expressway	100	4	3.50	40	26
		6	3.50	50	29
Arterial road	80	6	3.50	40	19
		4	3.50	35	21

Table 5 Proposed Geometric Design of R.R [13]

Direction	Traffic flow (000 pcus/day)			
	Normal	Between O.R.R &I.R.R	After I.R.R	%
D1	319	299	270	16
D2	374	336	317	15
D3	240	224	213	11
D4	144	133	124	14
The average percentage of traffic reduction 14				

Table 6 R.Rs expected effects in Western Division

The R.Rs in the western division will divert the traffic from the junctions with the existing road network, and then the estimation with the road junction design justifies the 14%.

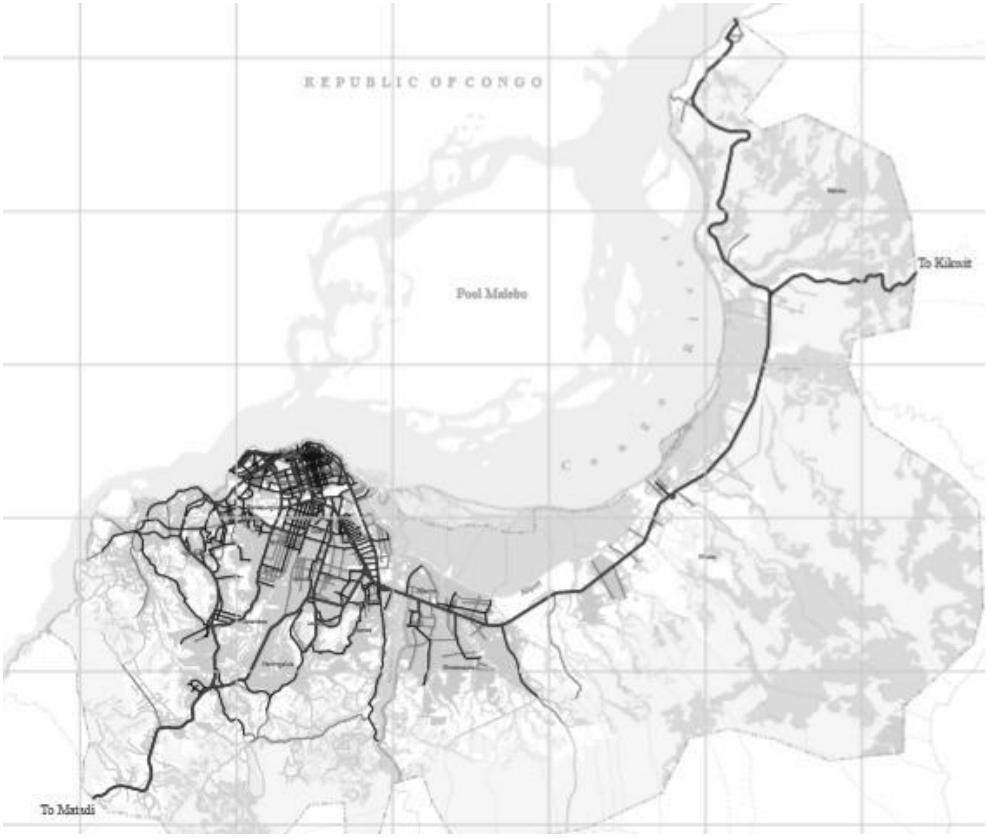


Fig. 5 Kinshasa Existing Road Network Map

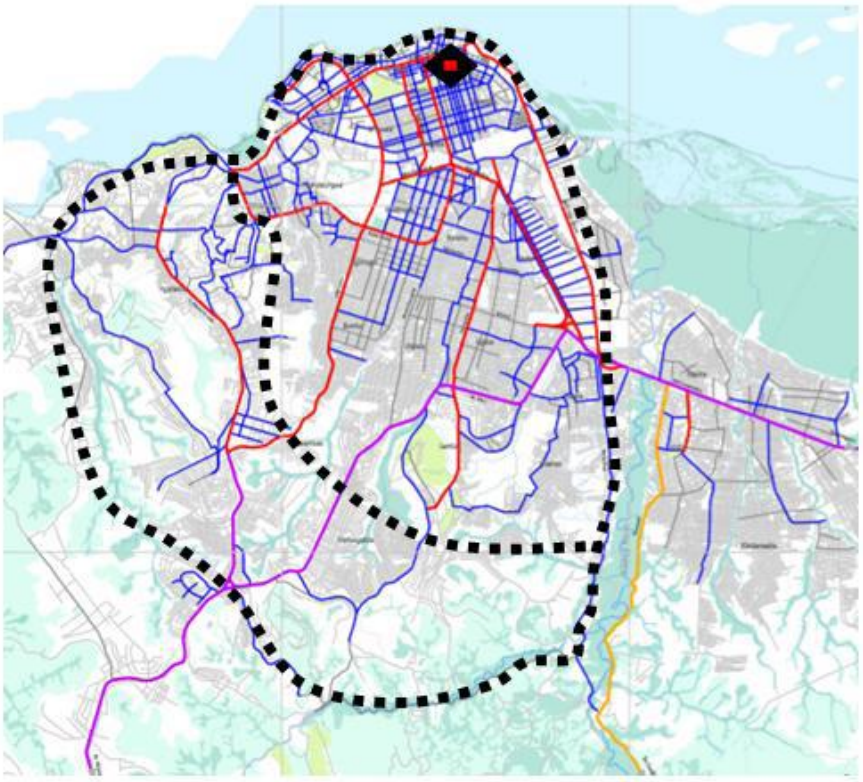


Fig. 6 Western Division Road network

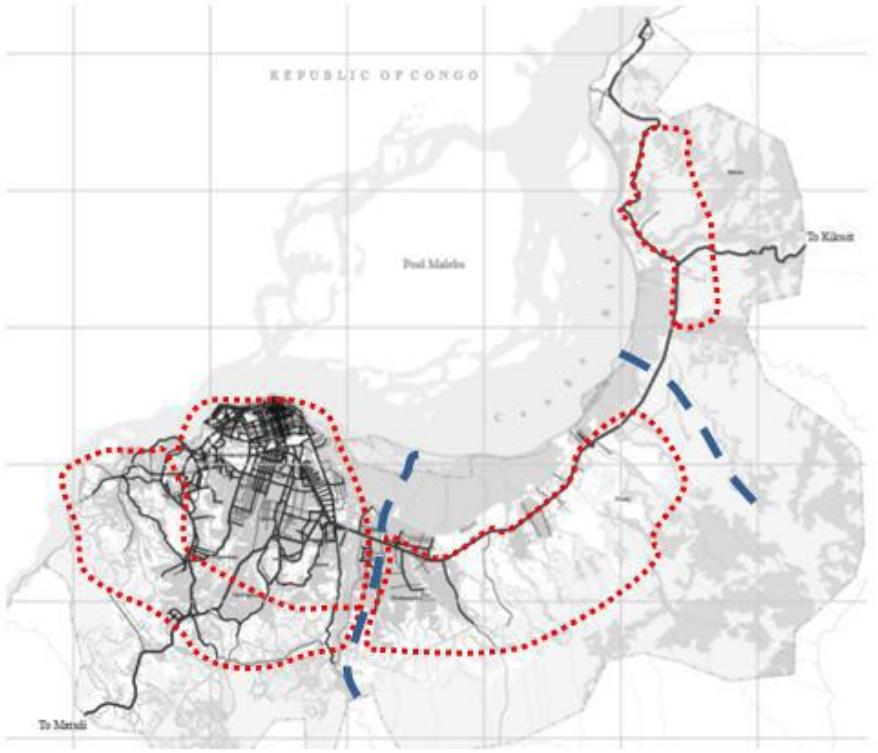


Fig. 7 Ring Roads Alignment

VI. CONCLUSION

The proposal R.Rs over the city offers new development value alongside the structural alignment and reduces the traffic volume into/through the current urban area. However, for the future roads plan, the national road number 1 (NR1) should be connected to three development divisions for the relevant function of the city. To prevent the increase of the cars, the BRT and MRT will be the keys by including the road pricing system and improve the level of service for the vehicle operation. The project remains more vital, but it will be costly and technically a great challenge to be realized. Finally, the R.Rs as a transportation system links and the land use will add to the accessibilities over the different neighborhoods, which contribute to urban development with environmental impact.

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