4.3 A Basic Strategy for Infrastructure Development

4.3.1 Road and Transport

(1) Basic Policy

1) Road Network Development

Due to the rapid motorization and increase of population, road traffic demand in Vientiane Capital has been increasing and traffic congestion becomes a real problem in the peak hours in the city center area. In general, traffic congestion is caused by imbalance between the traffic demand and the capacity of the infrastructure. It is important to improve the road network by improving the surface condition of roads, clearing bottlenecks of the road capacity, completing missing links, and constructing new roads in accordance with transport demand of Vientiane Capital.

DPWT is said to have a plan to construct three ring roads; an inner ring road, a middle ring road, and an outer ring road, as a main frame of network in Vientiane Capital. An alignment of the outer ring road seems to be still just an idea, however, and the plan of ring roads was changed as urbanization has been gradually expanded toward the northern area. One of roles of an outer ring road is to make an outline of a city.

2) Improvement of Public Transport

The current public transportation system in Vientiane Capital consists mainly of bus service operated by Vientiane State Bus Company (VSBC), taxi that provides service on demand, Tuk-tuk that provides transportation in the CBD not covered by the bus service, and Sonteo providing service in the suburban area.

Focusing on the service level of buses, the number of vehicles required to provide enough level of service accommodating passengers' demand was estimated at 264 fleets in 2013 by JICA UTMP. However, the number of buses owned by VSBC is only 127 vehicles and 20% of those are old and insufficient for operation at present. As a result, it appears to be difficult for the bus transport to compete with private vehicles such as a passenger car and motorcycle under the current condition.

On the other hand, the role of public transport in Vientiane Capital shall become more important to alleviate traffic congestion in urban area. Therefore it is urgently necessary to provide an attractive public transport system having competitive ability with private vehicle users.

3) TDM and Parking Policy

One of transport problems found extensively at present in the central area of Vientiane Capital is illegal parking. Illegal parking not only decreases the capacity of a road section by occupying shoulders of the section but increases traffic accidents by blocking lanes for motorcycles and making them to weave in and out. Moreover there are some cases that vehicles are parked on a sidewalk and impede pedestrians' movement.

Most of illegal parking in the congested area or the central area is caused by lack of parking space. Therefore, it is necessary to establish a parking policy to build appropriate parking

space accommodating parking demand. On the other hand, over-supply of parking space sometimes induces people to use vehicles and it causes traffic congestion in turn. Therefore, it is necessary to specify areas where parking space should be provided and areas where public transport promotion measures are introduced in accordance with a city plan.

4) Traffic Safety Improvement

In general, most of traffic accidents are attributable to human errors of vehicle drivers such as carelessness and violation of traffic rules. Therefore, traffic safety education programs for vehicle drivers would be effective to decrease the number of traffic accidents and improve traffic safety. On the other hand, there are factors that arise from the hardware, such as vehicle maintenance, road surface conditions, a blind corner, etc.

Vientiane Department of Public Safety (VDPS) and the traffic police seem to collect traffic accident data and have a database. The Study team will collect these data and analyze it. The existing traffic accidents recording system shall be improved so that a database can be established as part of urban transportation master plan to enable a proper action to reduce traffic accidents.

5) Environmental Mitigation

Air and noise pollution caused by the increase of motor vehicles and over-aged cars has been intensifying especially the central area where a lot of traffic concentrates. These problems should be minimized through strict enforcement of emission standards of vehicles, promotion of public transport use, and introduction of traffic demand management, especially in the congested area. The introduction of new vehicles will help to reduce emission from vehicles. Noise pollution will be also mitigated through frequent and appropriate vehicle maintenance and improvement of driving manners.

(2) A Strategy for Road Network Development

1) Functional Road Classification

The road classification in Vientiane Capital relies mainly on the administrative responsibility rather than functional use. At the moment, six types of roads exist; namely, the national road, provincial road, district road, urban road, rural road and special road. The national road is under the control of MPWT, and the provincial, district, urban and rural roads are managed by DPWT of each province except the roads in the urban area of Vientiane Capital that are controlled by VUDAA.

On the other hand, there is no functional classification and design guideline which can be applied in the whole Study area, and each authority has standard for road development. For the formulation of road network development in the Study area, road classification scheme should be determined for both existing and future roads, taking functional hierarchy into consideration first.

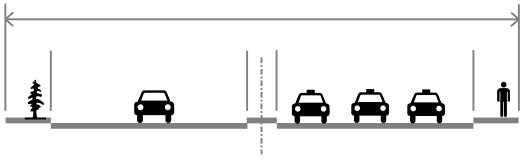
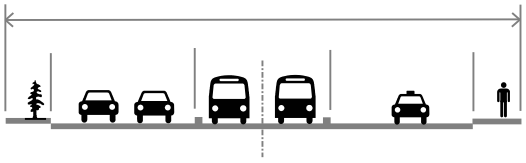
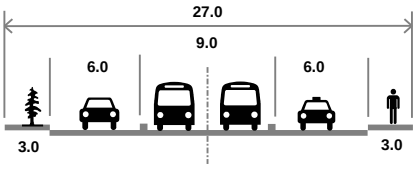
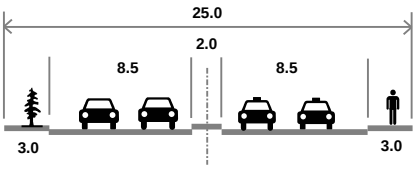
A newly defined scheme is proposed that consists of the primary arterial road, arterial road, and collector road. The main characteristics of each functional class can be summarized in Table 4.3.1. The functional elements of the proposed road classification embody not only considerations of traffic characteristics but also various aspects on mobility and connectivity between elements. Table 4.3.2 describes examples of cross section by the element of road classification.

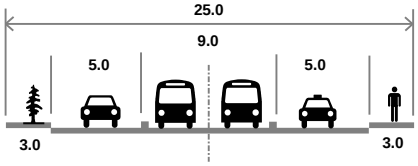
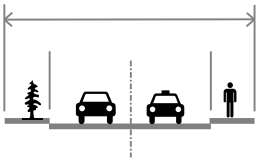
Table 4.3.1: Proposed Road Functional Road Classification

Classification	Application	Intent
Primary Arterial Road	Entire province Link to trunk roads outside of the province	- Form structure of province - Link to international road - Connect major attractions (Airport, sub-center, and urban cluster) - Accommodate longer trips and freight trips - Introduce BRT lanes
Arterial Road	Between districts Link to primary arterial road	- Link to primary arterial roads - Accommodate travel demand between cities and villages - Provide bus services
Collector Road	Between neighboring cities and villages Link to primary arterial road and arterial road	- Provide access to major roads - Accommodate local demand circulation - Can be used for public transport feeder service

Source: JST

Table 4.3.2: Typical Examples of Cross Section by Road Classification

Classification	Number of Lanes	Cross Section (meter)	Note
Primary Arterial	6 lanes		Six lanes with 3.5 meter of width each lane; 2.5 meter shoulders; 2.0 meter median; 3.0 meter footpaths
	6 lanes including BRT		Four mixed traffic lanes with 3.5 meter; 2.5 meter shoulders; 3.0 meter footpaths; two BRT lanes with 4.5 meter in median
	4 lanes including BRT		Two mixed traffic lanes with 3.5 meter; 2.5 meter shoulders; 3.0 meter footpaths; two BRT lanes with 4.5 meter in median
Arterial	4 lanes		Four mixed traffic lanes with 3.25 meter; 2.0 meter shoulders; 2.0 meter median; 3.0 meter footpaths

	4 lanes including BRT		Two mixed traffic lanes with 3.25 meter; 1.75 meter shoulders; 3.0 meter footpaths; two BRT lanes with 4.5 meter in median
Collector	2 lanes		Two lanes with 3.25 meter; 2.0 meter shoulders; 3.0 meter footpaths

Source: JST

2) Traffic Demand

a) Motorization in Existing and Future

Table 4.3.3 shows the estimated vehicle ownership of each district. The household vehicle ownership was obtained on the result of the social survey conducted by JST. By multiplying these ratios with the population, the vehicle ownership of the passenger car and motorcycle is estimated at 54,500 and 274,900 respectively.

Table 4.3.3: Estimated Number of Vehicles Owned in 2010

District No.	District Name	Vehicle Ownership Ratio (veh./1,000 pers.)		Household Vehicle Ownership (%)			Population (2009)	Estimated No. of Vehicles Owned	
		Passenger Car	Motorcycle	No owning	M/C owning	Car owning		Passenger Cars	Motorcycle
1	Chanthabouly	110.8	429.4	2.3	61.3	36.3	78,407	8,700	33,700
2	Sikhottabong	76.6	376.2	5.1	66.7	28.2	113,763	8,700	42,800
3	Xaysetha	70.1	374.6	5.0	67.0	28.0	111,037	7,800	41,600
4	Sisattanak	78.6	388.6	6.0	67.0	27.0	78,211	6,200	30,400
5	Naxaithong	28.6	305.5	10.0	77.2	12.8	66,462	1,900	20,300
6	Xaythany	64.6	337.2	5.4	68.2	26.5	171,705	11,100	57,900
7	Hadxaifong	78.0	329.3	10.3	60.3	29.4	89,202	7,000	29,400
8	Sangthong	4.2	174.0	38.0	60.0	2.0	27,573	100	4,800
9	Maypakngum	59.3	273.3	4.0	71.0	25.0	51,287	3,000	14,000
Total		69.3	349.1	7.0	66.7	26.3	787,647	54,500	274,900

Source: JST

On the other hand, Table 4.3.4 describes the number of registered vehicle by type through the years of 2000 and 2009. The increase of registered vehicles from 2000 to 2009 counts about 60,000 for passenger vehicles and 189,000 for motorcycles. Assuming that this increase continues in future, the number of vehicles owned by household can be estimated as shown in Table 4.3.5. The number of passenger car becomes 223,500 in 2030, which is about four times of the existing, and motorcycles become 620,700, which is 2.3 times. The ownership of passenger car becomes 155.3 vehicles per 1,000 people in 2030, while 69.3 in 2010.

Table 4.3.4: Trend on Increase of Registered Vehicles

Type of Vehicle	2000	2005	2006	2007	2008	2009
Motorcycle	83,468	144,507	171,504	201,608	241,808	272,211
Tuk-tuk	2,445	3,695	3,675	3,721	3,581	3,584
Sedan, Pickup, Van	19,574	43,220	49,580	61,559	65,675	79,095
Heavy Truck	6,210	5,405	6,419	7,747	7,521	10,086
Large Bus	1,130	665	691	838	926	927
Total	112,827	197,492	231,869	275,473	319,511	365,903

Source: MPWT

Table 4.3.5: Estimated Future Vehicle Ownership

	2010	2020	2030
Passenger car	54,500	166,800	223,500
Motorcycle	274,900	463,300	620,700
Total	329,400	630,100	844,200
Ratio		1.91	2.56

Source: JST

b) Number of Trip Production and Modal Share in the Future

Based on the future population discussed earlier and the motorization trend discussed above, the future travel demand can be estimated as shown in the following table. The estimation utilized a model that consists of four steps: namely, trip production, trip distribution, modal share, and assignment, which was developed in JICA Urban Transportation Master Plan Study.

This model estimates total number of trips generated in the Study area by inputting demographic information into the model first. Then the travel demand between areas, which is compiled in a form of a matrix, is estimated and each element of demand can be divided into trips by each mode with the modal share model considering future vehicle ownership by areas.

The total number of trips generated in the Study area is 2,548,000 in 2020 and 3,435,000 in 2030. The growth of trip generation is almost in proportion to the increase of population because of the model's characteristics. However, the motorized trips by private vehicles such as motorcycle and passenger car become 1.7 times of the existing in 2020 and 2.3 times in 2030; the increase of passenger car trips is particularly large.

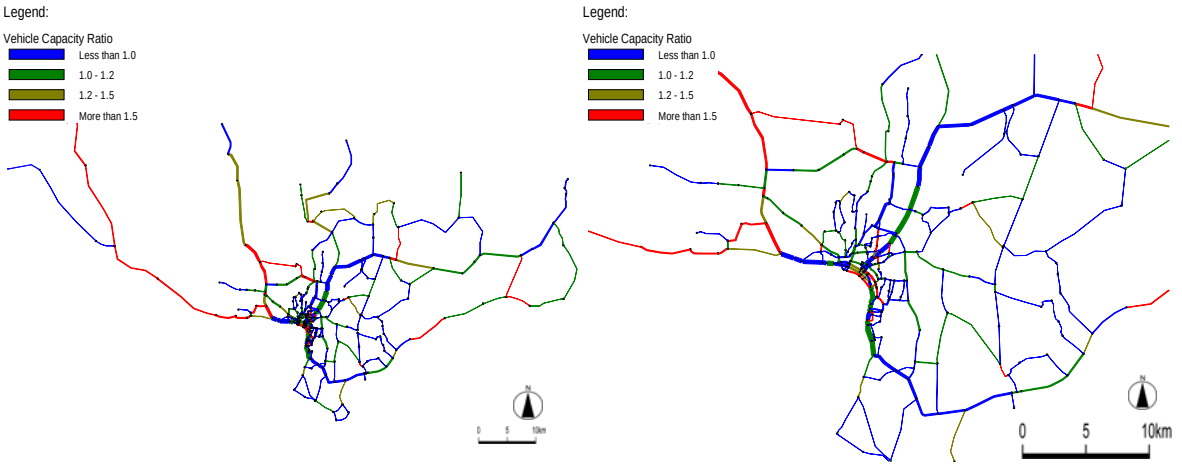
Table 4.3.6: Trip Production in the Future

Mode	2009		2020		2030	
	No. of Trips (1,000)	Modal Share (%)	No. of Trips (1,000)	Modal Share (%)	No. of Trips (1,000)	Modal Share (%)
Walk	729.6	39.2	698.7	27.4	932.2	27.1
Motorcycle	825.4	44.3	1,215.7	47.7	1,637.2	47.7
Passenger car	168.0	9.0	459.7	18.0	636.9	18.5
Bus	140.1	7.5	174.0	6.8	228.8	6.7
Total	1,863.1	100.0	2,548.1	100.0	3,435.1	100.0

Source: JST

c) Estimated Traffic Demand

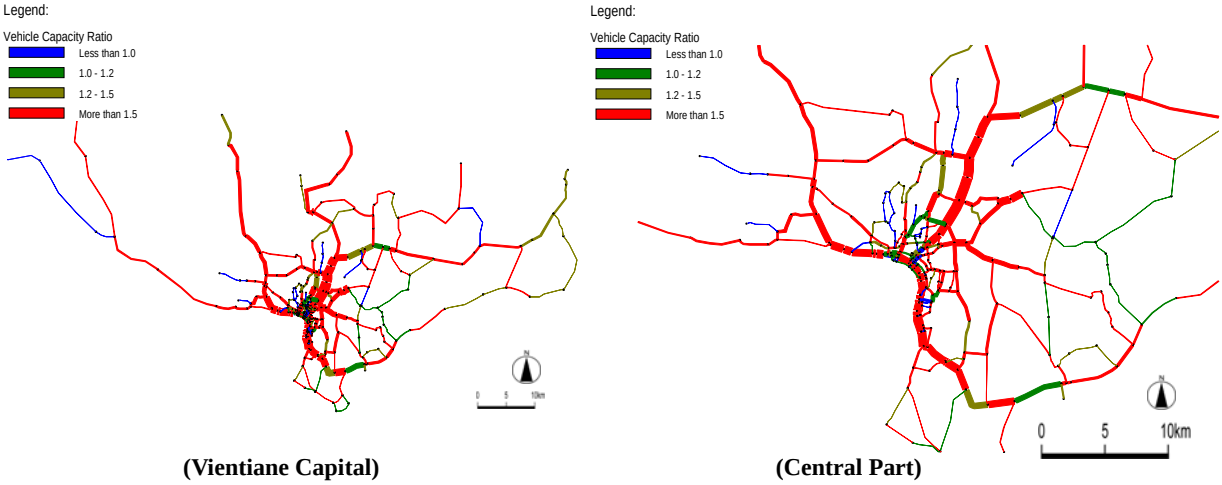
The travel demand estimated above is loaded on a network so that traffic volume on each road section can be obtained. For this methodology, a road network should be prepared representing the existing road condition. Figure 4.3.1 illustrates the traffic flow band with level of congestion shown by color for the existing situation. This is a result after the traffic volumes are calibrated by the traffic count survey result for the existing situation. Figure 4.3.2 shows a result of the exercise on an imaginary case that the future travel demand is loaded on an existing network. This suggests potential needs of travels on each road section.



(Vientiane Capital) **(Central Part)**

Source: JST

Figure 4.3.1: Estimated Traffic Demand on Existing Road Network



(Vientiane Capital) **(Central Part)**

Source: JST

Figure 4.3.2: Estimated Traffic Demand on Existing Road Network with Future Demand

3) Road Network Master Plan

Due to the ongoing rapid motorization, the road traffic demand in the Study area can be estimated to increase rapidly. In order to cope with the increasing road traffic, road

development should be accelerated to expand a capacity of road section. However, it is important to take the following points into consideration for the future road network development.

- (a) Conceptual network structure based on functional scheme
- (b) Efficient network development to cope with travel demand

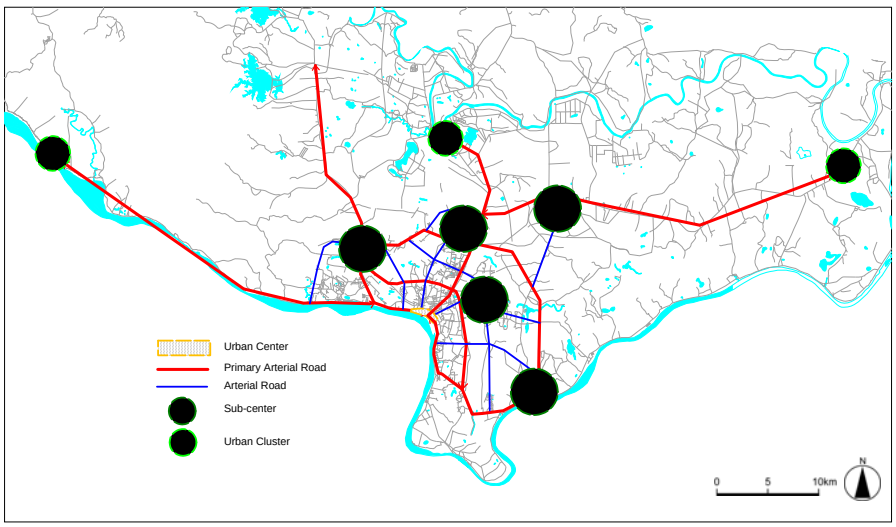
a) Conceptual network structure

The existing road network in the Study area consists of five major radial roads, namely, National Road 11, National Road 13 North, National Road 10, National Road 13 South, and National Road A12. Basically, these corridors seem to be served with high level of road standard. However, a capacity and road surface condition of some sections are found to be insufficient in these corridors. Besides, there are missing links in the ring roads and it does not seem to be well structured.

Taking the current situation into consideration, conceptual network development policy is summarized as follow:

- Fundamental five radial roads and two ring roads (outer and inner) should be formed with primary arterial roads, and the arterial and collector roads complement the fundamental primary arterial road network structure.
- Sub-centers and urban clusters should be connected by primary arterial roads and/or arterial roads. Some of these connections might be necessary to accommodate public transport lanes (BRT) according to traffic demand.

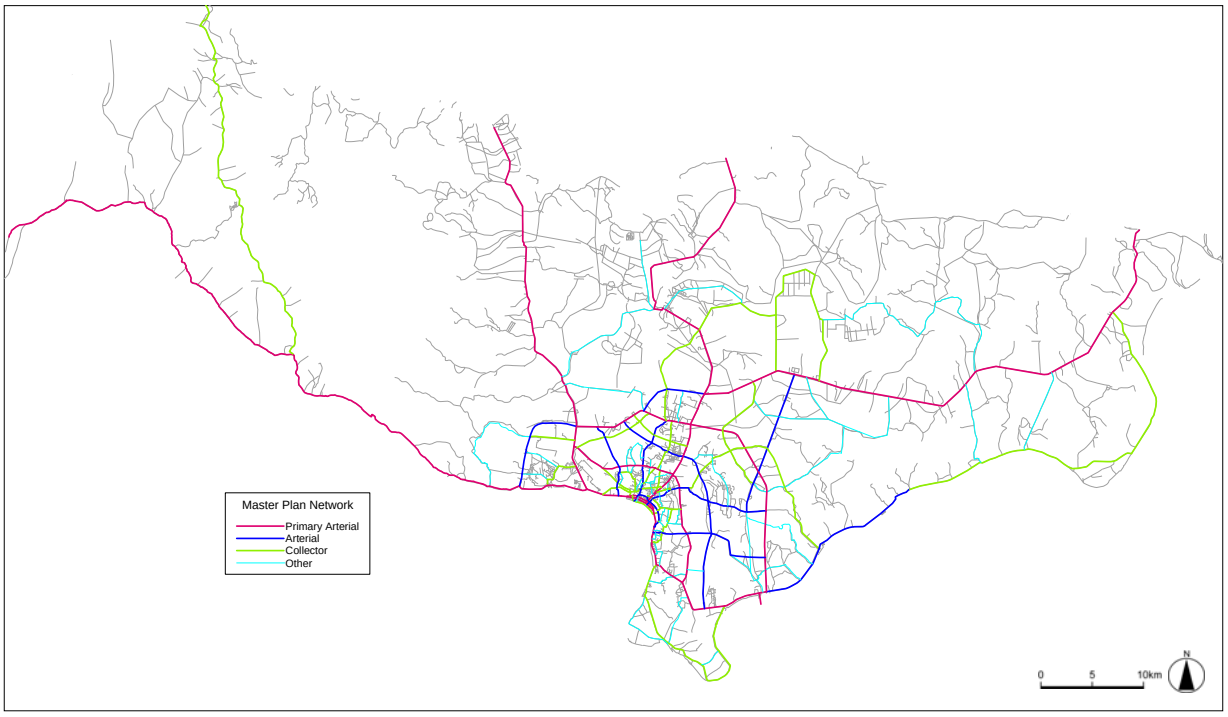
A conceptual network development policy is illustrated in Figure 4.3.3.



Source: JST

Figure 4.3.3: Concept for Road Network Master Plan

The hierarchy of road network development based on this discussion can be realized in the following figure.



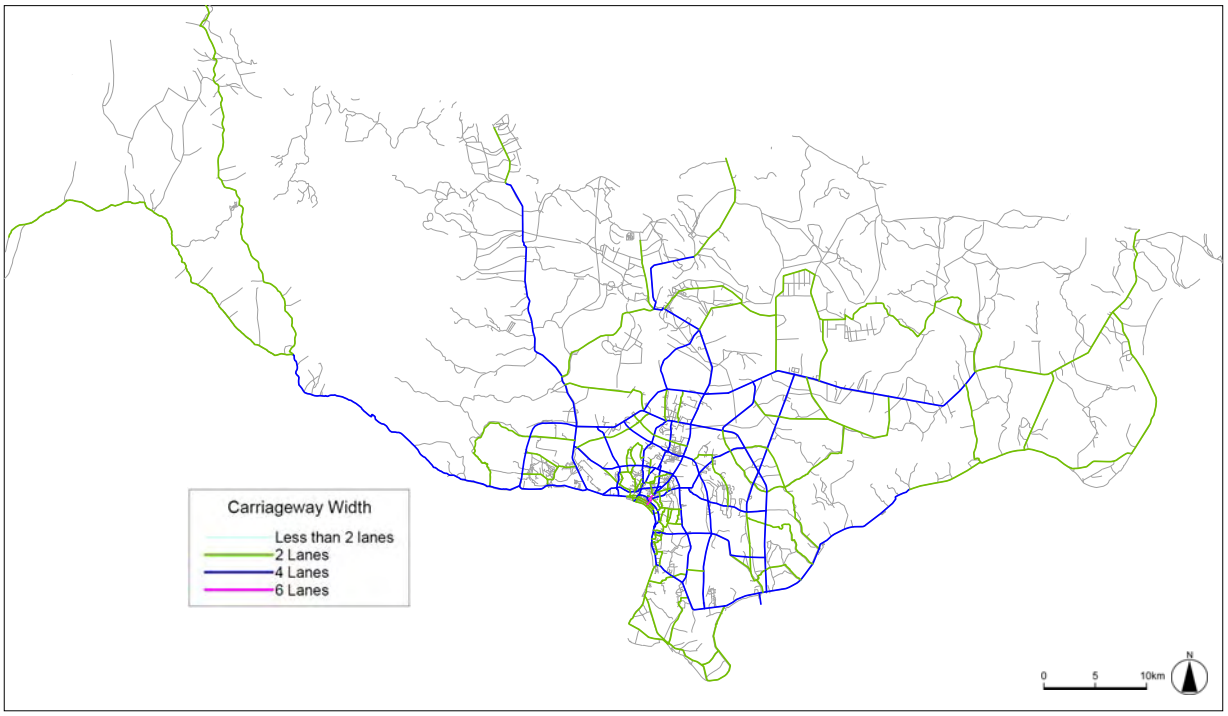
Source: JST

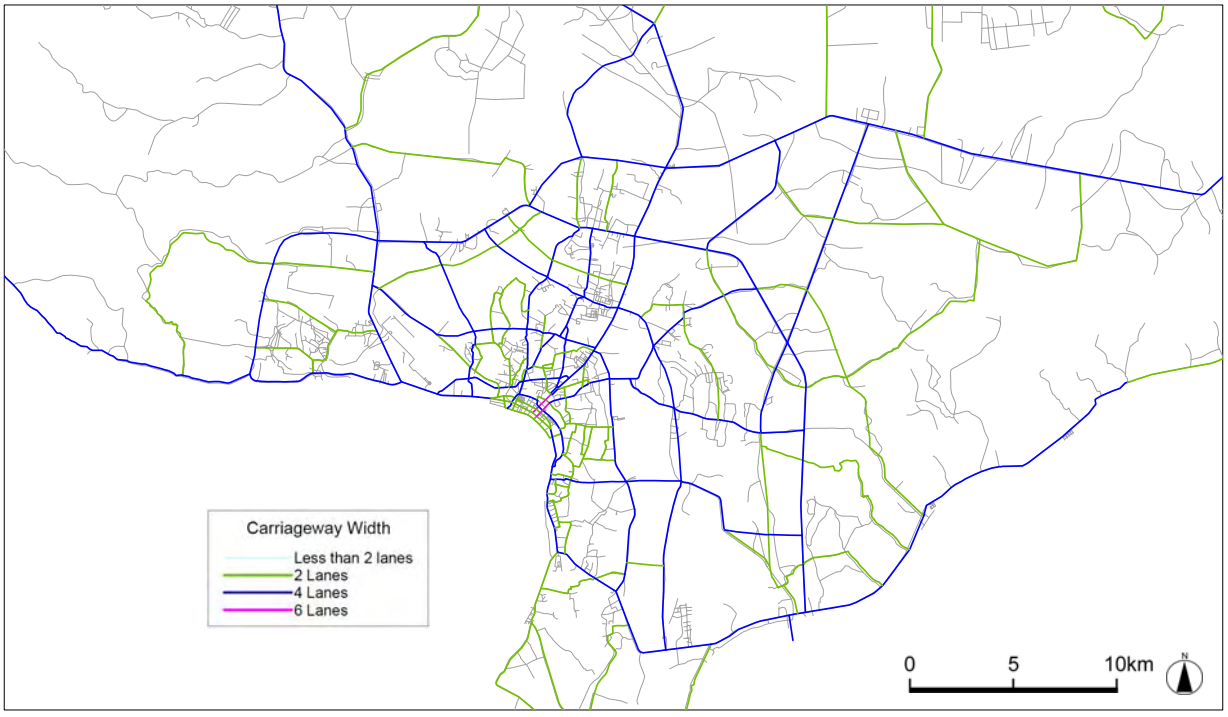
Figure 4.3.4: Proposed Hierarchy of Road Network

b) Travel Demand Based Service Level

An efficient transportation system should be developed to strengthen urban functions, to sustain economic growth, and to enhance the quality of people's life in the Study area. It is significant to reduce negative impact such as economic loss of travel time and travel cost in order to establish an efficient transportation system. The efficiency in transportation can be achieved with balancing the travel demand and supply of transportation infrastructure.

Figure 4.3.5 shows the proposed road network accommodating the travel demand discussed in Figure 4.3.2, which is the result of traffic assignment of travel demand in 2030 on an existing network. If the future road network will provide the capacity indicated in the figure, most demands can smoothly travel with certain level of quality and economic loss of travel can be reduced. A performance of the road network will be discussed in the later section.





Source: JST

Figure 4.3.5: Master Plan Network

4) Road Development Program

In the previous section, the future road network is proposed based on the conceptual structure and travel demand in 2030. It is also indispensable to determine a development program in

harmony with a phase of urban development. For this purpose, exercises on balance check between travel demand that is estimated with the population based on the urban development plan and supply of a network infrastructure has been done by the models.

Consequently the following road development program is established.

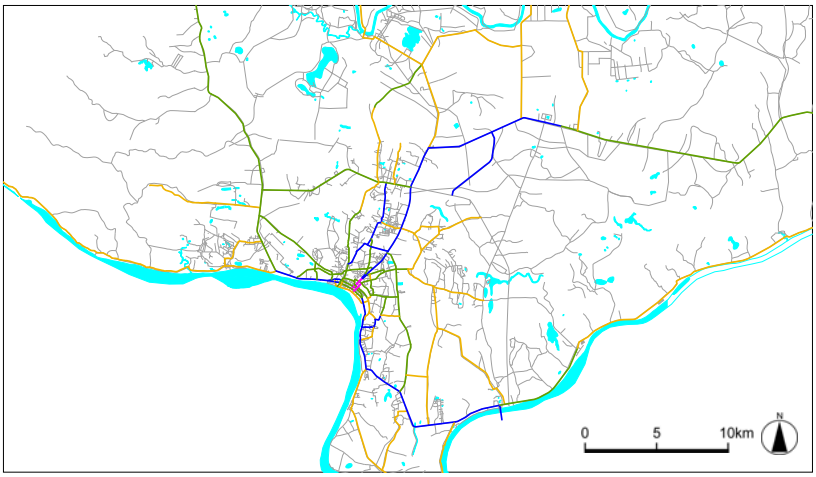
a) Road Development Program between 2010 and 2020

- Existing resource must be used efficiently. Thus, the original capacity of the road must be restored. If there are factors disturbing smooth flow of traffic such as encroachment, illegal parking, and the deterioration of road surface, the condition should be improved to restore the capacity.
- Two important ring roads should be completed. The 450 Year road has been constructed and this will be completed by the end of year 2010. On the other hand, Dongdock Road now provides two lanes capacity. The latter should be improved with four lanes capacity and let these two roads form the outer ring road with four lanes capacity from Sikeu to Thanaleng.
- Another ring road which should be constructed until 2020 is the inner ring road connecting National Road 13 North and National Road 10 and bypassing central area of the City. For the completion, the road section between Phongsavat and Nong Dong Road should be newly constructed and road section on Nong Dong Road be improved with four lanes capacity.
- In the eastern area, a new radial road should be developed. This corridor will provide an important access link to the Vientiane railway station that is planned for development with Thai assistance.

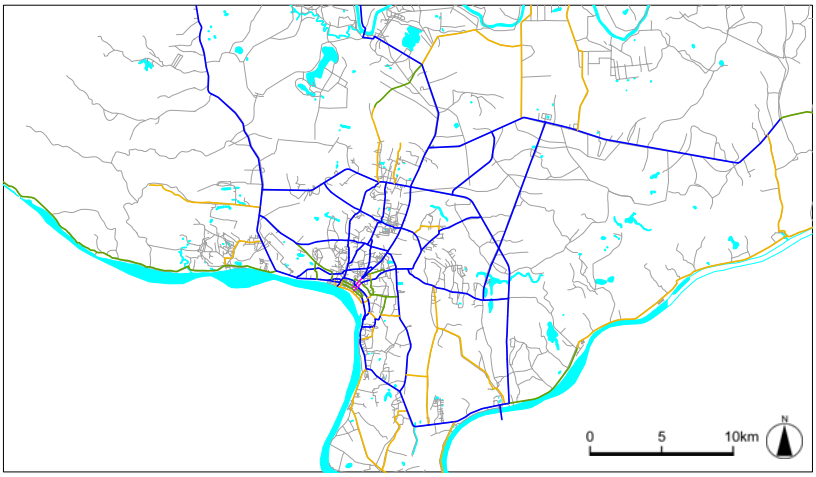
b) Road Development Policy between 2020 and 2030

- A new ring road should be constructed between the inner and outer ring roads to formulate newly developed urban area. This ring road connects Dongdock Road and Tadeua Road and providing four lanes capacity is desirable.
- Two important radial roads should be newly constructed. One is a radial road linking the urban center and the 450 Road in Thanaleang. Another is connecting Dongdock Road with the urban center. Both radial roads are desirable to be served with four lanes capacity.
- Two arterial roads; one north of Dongdock and the other west of Phonsavat area, should be newly constructed. These will play a role as an ultimate urban development boundary so that the areas outside of these roads should not be used for urban function.
- Other small roads will be constructed as a feeder route to link primary arterial and arterial roads.

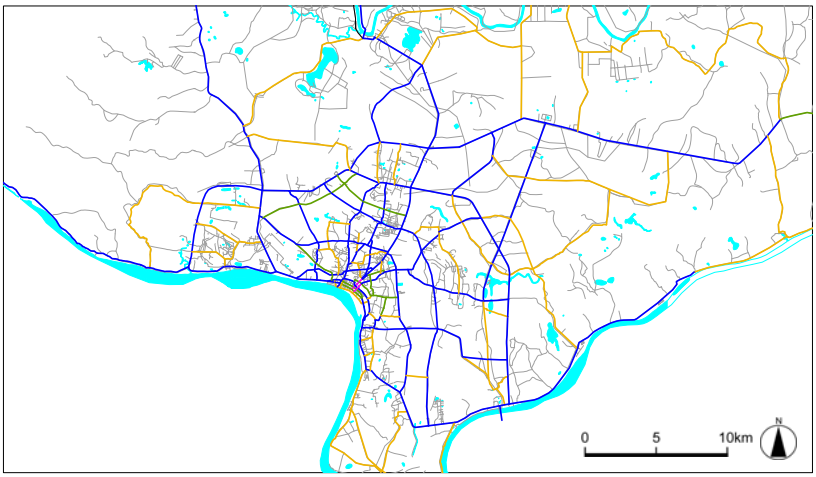
The above-mentioned program is displayed in Figure 4.3.6 and the results of traffic assignment are displayed in Figure 4.3.7.



2010



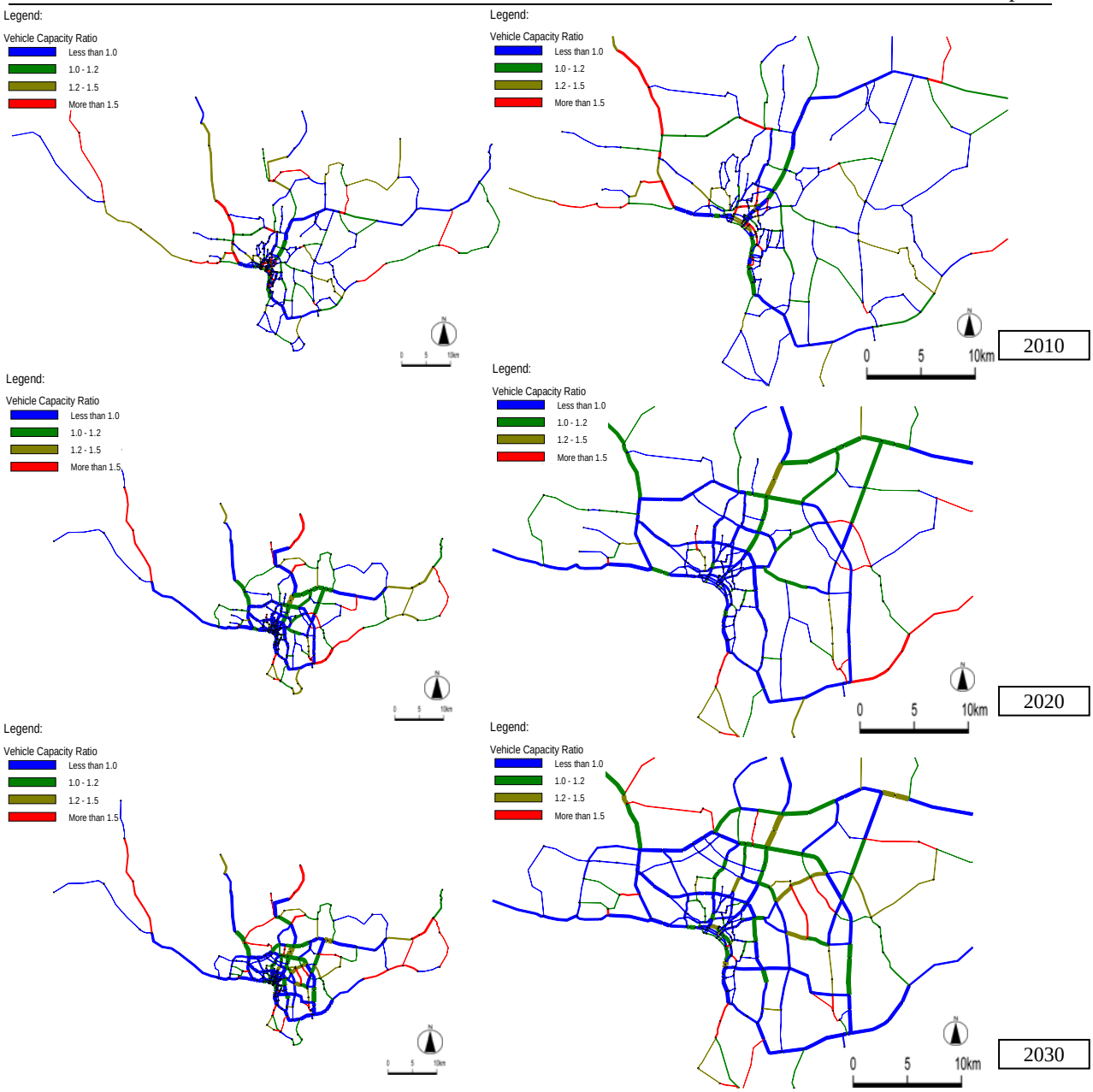
2020



2030

Source: JST

Figure 4.3.6: Road Development Program



(Vientiane Capital) **(Central Part)**

Source: JST

Figure 4.3.7: Traffic Assignment Results

5) Performance of Proposed Road Development Program

The performance of road network can be evaluated by indicators such as average travel speed, daily vehicle distance, daily vehicle time, and average congestion that are estimated by the traffic assignment. Table 4.3.7 summarizes the performance of each case:

- Existing Case in 2010
  assigns the existing travel demand on the existing road network. This will be the basis on which the change of other alternatives can be evaluated.

- Multi-Core Structure Case (Adopted Master Plan) in 2020
  assigns the future travel demand estimated for 2020 based on the Multi-core structure adopted for the Master Plan on the proposed road network in 2020.

- Single-Core Structure Case in 2020
  assigns the future travel demand estimated for 2020 based on the Single-core Structure case of urban plan on the proposed road network in 2020.

- Multi-Core Structure Case (Adopted Master Plan) in 2030
  assigns the future travel demand estimated for 2030 based on the Multi-core structure adopted for the Master Plan on the proposed road network in 2030.

- Single-Core Structure Case in 2030
  assigns the future travel demand estimated for 2030 based on the Single-core structure of urban plan on the proposed road network in 2030.

The average vehicular travel speed is estimated at 25.4 km per hour for the existing case, which will be improved to 35.6 km per hour in 2020 and at 34.3 km per hour in 2030 if the road development will be completed as the program, even though average vehicle capacity ratio in the future will be higher than the existing value. The difference between the cases of Multi-core and Single-core is impact on cost saving according to infrastructure development.

Table 4.3.7: Summary of Network Performance

	Travel Distance (1,000 pcu*km)	Travel Time (1,000 pcu*h)	Capacity*km (1,000 pcu*km)	Road Length (km)	Average VCR	Average Travel Speed (km/h)
2010 Existing Case	6,240.4	245.2	8,054.1	739	0.77	25.4
2020 Multi-Core Structure Case	12,844.6	361.2	15,517.4	784	0.83	35.6
2020 Single-Core Structure Case	13,542.4	391.7	15,517.4	784	0.87	34.6
2030 Multi-Core Structure Case	15,830.2	461.8	18,394.7	835	0.86	34.3
2030 Single-Core Structure Case	17,398.4	518.1	18,394.7	835	0.95	33.6

Source: JST

(3) A Strategy for Improvement of Public Transport

1) Existing Modal Share

The existing public transport in Vientiane Capital seems to be insufficient to accommodate potential demand and meet the requirements of public transport users because of limited availability of fleets and routes and poor quality of service. Table 4.3.8 shows the modal share surveyed in 2007 in JICA Urban Transport Master Plan Study. The share of public transport is indicated at 3.9%. In particular, public transport use by school commuters, which are generally target potential user of public transport in many countries, is extremely low in Vientiane Capital.

Table 4.3.8: Modal Share by Trip Purpose

Mode	Home		Work		School		Others		Total	
	No. of Trips	Share (%)	No. of Trips	Share (%)	No. of Trips	Share (%)	No. of Trips	Share (%)	No. of Trips	Share (%)
Walk	117,838	25.0	27,085	15.9	58,627	34.3	37,718	26.0	241,268	25.2
Motorcycle	283,177	60.1	110,680	65.0	101,853	59.6	77,029	53.1	572,739	59.8
Private car	51,670	11.0	25,998	15.3	8,429	4.9	20,092	13.8	106,189	11.1
Public Transport	18,786	4.0	6,501	3.8	1,845	1.1	10,295	7.1	37,427	3.9
Total	471,471	100.0	170,264	100.0	170,754	100.0	145,134	100.0	957,623	100.0

Source: JICA Urban Transport Master Plan Study

2) Public Transport System Planning

The public transport service and preference of users have been in something of a vicious circle. Poor service of public transport discourages users to use it and the consequent decrease of revenue by decreasing rider-ship will further deteriorate the quality of public transport service. To break this vicious circle, a better comprehensive public transport system should be planned and implemented in harmony with the road network development and urban development plan.

A comprehensive public transport system has not been studied in this Study because of the limitation of the study period. Therefore, only policy for public transport system development is discussed in this section.

All successful public transport systems need to include the following:

- (a) Demand oriented services
- (b) High level of services to shorten travel time of users
- (c) Efficient route design

a) Demand oriented services

For public transport users, an experience of public transport use is more than just a bus trip. It might be a total journey from door to door and users may evaluate its service in terms of access, travel time, travel cost, convenience, and comfort. Network design in the planning process should take these into account and consider all aspects of route planning, waiting

facilities, inter-modal facilities, ticketing, the quality of fleet, service quality, and comfort and convenience.

b) Services to shorten travel time

Traffic congestion is a severe and detrimental factor to threaten viability of public transport services. Maintaining good travel speed for buses in their routes is an essential issue to ensure productive public transport service. Principal measures to improve the bus operating speed are as follows:

- Introduction of bus rapid transit system (BRT)
- Bus exclusive lane/bus priority lane
- Public transport priority signal system
- Improvement of accessibility (low-floor fleet, barrier-free at bus stop, etc)

c) Efficient route design

A design of bus routes is an important aspect to improve accessibility of public transport users. However, route design should be carefully done in consideration of a balance between two ideas that provide direct door-to-door travel options and develop an efficient system. The principle of efficient route design involves the following:

- Simple and easy to understand design
  BRT as trunk, secondary, and feeder
  Intuitive route numbering/naming system
  Reduce the number of routes and duplications
- Network integration
  Integration of bus and paratransit
  Fare integration
- Accessibility and coverage
  Linkage between dwelling place and attractions
  Access to the center of the city
- Demand oriented design
  Provide direct service to high demand route
  Provide easy transfer for low demand route

3) Reasonable Modal Share

If we employ Multi-core structure as the Development Master Plan for 2030, the average VCR on the whole network will be 0.86, which is worse than the existing, 0.77 as shown in Table 4.3.7. This means that congestion worsens compared with the existing condition even though the Master Plan road network will be developed. Therefore, modal shift from private vehicle use to public transport will be necessary to mitigate the congestion.

Table 4.3.9 shows the mitigation of congestion according to the assumed modal shift from private mode to public transport mode. As shown in the table, the average vehicle capacity

ratio becomes less than the existing values, if 20% of the users of passenger car and motorcycle switch their travel mode to public transportation. This exercise suggests that transport policies are necessary to promote the modal shift of private vehicle users to public transport mode, if VCR is expected to be less than the existing condition.

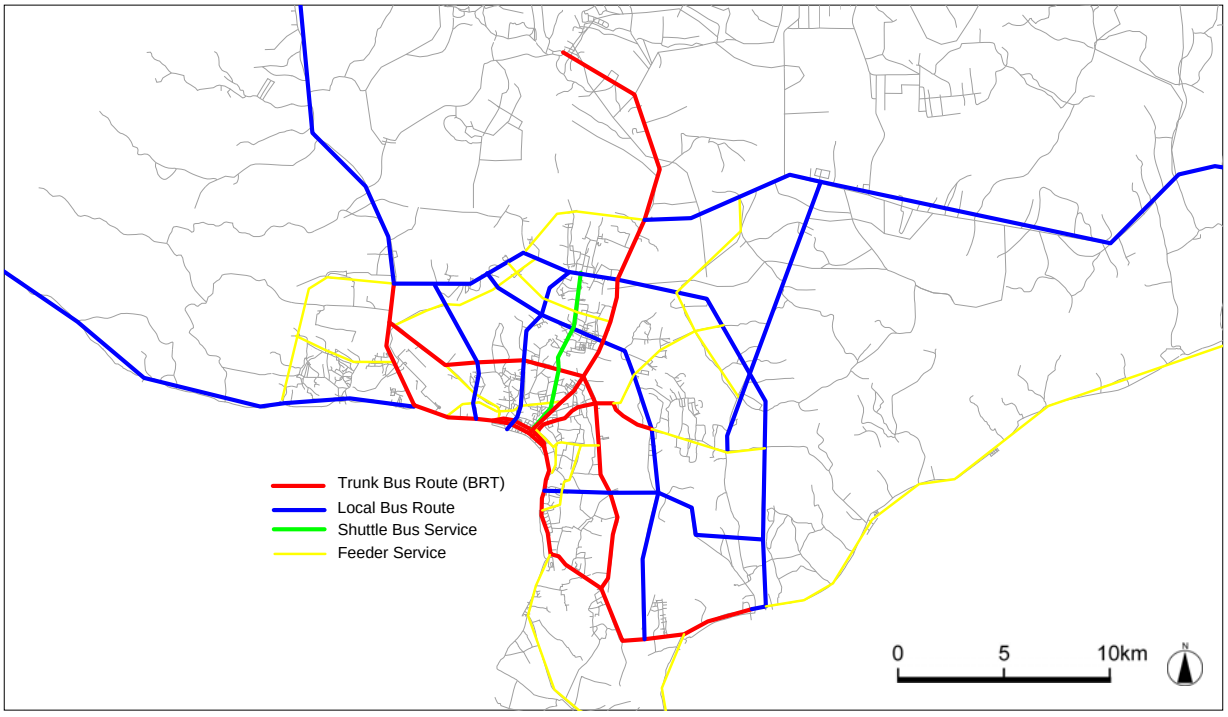
Table 4.3.9: Exercise on Reasonable Modal Share

	Modal Share (%)				Average VCR
	Walk	M/C	Car	Bus	
0%	27.1	47.7	18.5	6.7	0.86
10%	27.1	42.9	16.7	13.2	0.80
20%	27.1	38.2	15.0	19.7	0.74
30%	27.1	33.5	13.1	26.2	0.67
40%	27.1	28.8	11.4	32.7	0.61

Source: JST

4) Proposed Public Transport Network

An example of public transport network is proposed based on the traffic demand discussed in the previous sections. Road sections of arterial roads with higher demand should provide trunk bus route serving BRT, with bus priority lanes or bus exclusive lanes. BRT lines are introduced in three radial corridors and the inner ring road. Local buses will be provided on the rest of arterial roads such as the outer ring road, the middle ring road, national roads, and two radial roads that will be newly constructed. Paratransit modes; *Tuk-tuk* and *Sonteo* will play a role as a feeder service to provide access to the trunk bus routes and local bus routes for the bus users.



Source: JST

Figure 4.3.8: Proposed Public Transport Network

One of BRT corridors in the proposed public transport network shown in Figure 4.3.8 is a route between Phongsavate and Thanaleng passing in the historical area of the urban center. This route may involve measures on traffic management in the central area discussed next.

(4) A Proposal of Traffic Management in the Urban Center

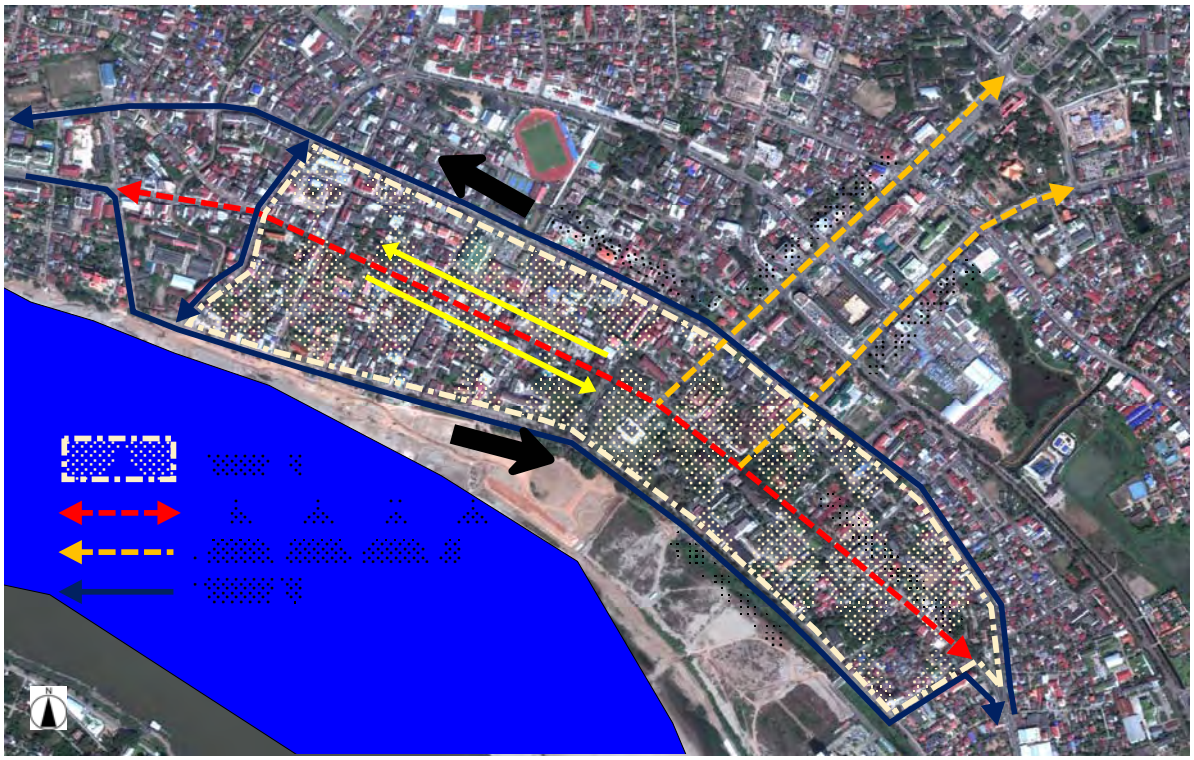
One of the most difficult problems in the field of urban transportation planning is the congestion of motor vehicles in urbanized area and the urban center. Congestion gives negative impact on private activities and imposes social costs, losses in travel time, road accidents and environmental damages.

In this Study, public transport network including several BRT corridors is proposed and one of the corridors passes through the urban center such as Historic Conservation Zone of Vientiane Capital. To avoid the congestion caused by the introduction of BRT corridor in the central area, the corridor should be carefully designed together with supporting measure to enhance public transport use which decreases the congestion.

A representative measure in the traffic demand management (TDM), which is to control travel demand and reduce congestion, is electric road pricing (ERP). This is a measure to specify vehicle-free area and vehicles that enter this area will be charged and allowed to enter the area. This system imposes travelers not to use private vehicles to enter the area so that alternative mode such as public transport should be provided for them.

In this Study, TDM measures are proposed in the urban center of Vientiane Capital as shown in Figure 4.3.9. The area between Samsenthai Road and Fa Ngum Road will be specified as private vehicle free area and private vehicles except the following are not allowed to enter this area in principle.

- Vehicles of residents
- Permitted vehicles with payment of charge
- Emergency vehicles
- Paratransit vehicles with operation license in this area



Source: JST

Figure 4.3.9: Traffic Management in Urban Center

One way system will be applied on Samsenthai Road and Fa Ngum Road as counter-clockwise. These two roads formulate the boundary of the private vehicle free area. Settha Thirath Road will be a public transport corridor which consists of exclusive lanes (both ways) for bus and paratransit modes and this corridor forms a main section of BRT network system in Vientiane Capital.

Paratransit modes include *Tuk-tuk* and taxi of existing public transport mode. The existing *Tuk-tuk* vehicle is mostly timeworn and it is expected to be renewed. Moreover, the negotiating-fare system should be replaced with an explicit fare system so that even visitors can use them easily and without trouble of payment. Some of *Tuk-tuks* will be used as feeder service to complement trunk bus and ordinary bus in outside the area.

ERP is based on the idea to use electric charge system. However, this advance system requires not only initial cost of total system but a settlement by credit card of private vehicle users. Therefore, a pre-paid sticker on the private vehicle to allow entry into the restricted area is a primitive but economical measure for the introduction.

4.3.2 Water Supply

(1) Basic Policy and Target

The national target of water service ration is set by DHUP MPWT at 80% of the total population by 2020 in urban area, while in Vientiane Capital it is set by DPWT, Vientiane Capital at 100% by 2015 for urban area and 90% by 2015 and 100% by 2020 for rural area.

The present water service ratio in 2009 is estimated at 92% in Vientiane Capital as the served population is 372,906 estimated by NPVC and the population in service area is 404,175 estimated by this JICA Study Team as the total population of core urban area and Tha Ngon of Urban Cluster as shown in Table 4.3.10 and 4.3.11.

Based on the National policy, the Vientiane Capital policy and in consideration of the present conditions, future service ratio is proposed and planned as shown in table 4.3.10.

Table 4.3.10: Water Service Ration

Item	Area	Detail Area / Remark	2009	2015	2020	2030
Planning Policy in this Master Plan	Urban Area	Core urban area of Vientiane Capital including Tha Ngon	92%	97%	100%	100%
		Khok Hae and Ban Phao of Urban Clusters, excluding Tha Ngon	0%	-	80%	100%
National Policy	Urban Area	-	-	-	80%	-
Vientiane Capital Policy	Urban Area	-	-	100%	-	-
	Rural Area	-	-	90%	100%	-

Source: DHUP under MPWT, DPWT under Vientiane Capital and JST

JST sets a target of water service ratio of urban area in the city center of Vientiane Capital as 97% in 2015 and 100% in 2020, although DPWT, Vientiane Capital, set the target 100% in 2020, for it normally takes more time to increase the ratio in the last 10% from 90%. The planned target will overcomes the national policy.

Khok Hae and Ban Phao Urban Clusters have no water supply system at present, and as they will be developed as Urban Clusters these two sites are considered to become urban area. The water service ratio of the two sites is set 80% in 2020 to match the National policy.

Development of rural water supply is proposed to expand from the present water supply system, utilizing mainly ground water from wells or boreholes for households or individual users. Some center of districts or villages could have water supply network as same as village of Phialath and Houaykham in Sangthong District.

(2) Water Demand Projection

1) General

Water demand projection is prepared based mainly on the population forecast. JST prepared the population forecast as shown below,

Table 4.3.11: Population of Vientiane Capital (Past and Future Trend)

			Past Population		Base Year Population	Population Framework		Remark
			1995	2005	2009	2020	2030	
(a) Inner Urban Zone			185,453	203,930	220,051	225,000	230,000	SA
(b) Outer Urban Zone and Outskirts Zone			87,435	145,481	178,342	382,000	665,000	SA
	Sub-Centers	KM21	16,562	18,701	19,632	45,000	150,000	SA
		Thanaleang	3,215	3,809	4,076	16,000	35,000	SA
		Dongdack	11,723	19,163	23,326	56,000	80,000	SA
		Naxaithong	1,799	2,531	2,901	7,000	20,000	SA
		Railway Town	2,858	3,796	4,252	16,000	30,000	SA
		Total	36,157	48,000	54,188	140,000	315,000	SA
	Residential Area		51,278	97,481	124,155	242,000	350,000	SA
(c) Outside of Core Urban Area			241,194	342,320	389,254	467,000	544,000	SA / Not SA
	Urban Cluster	Tha Ngon	3,888	5,162	5,782	13,000	20,000	SA
		Khok Hae	854	848	955	2,000	8,000	SA
		Ban Phao	1,686	2,137	2,350	4,000	7,000	SA
		Total	6,428	8,147	9,086	19,000	35,000	SA
	Agricultural &Conservation Area		234,766	334,173	380,167	448,000	509,000	Not SA
Total (a+b+c)			514,082	691,731	787,647	1,074,000	1,439,000	-

Note: SA= Water service area by water supply network
Source: JST

Generally water supply from the network is provided only in urban area as shown in right column of table above as "SA", and groundwater from wells or boreholes is provided in rural area if the quality of the groundwater is good.

The urban planning area of the Vientiane Capital is (a) Inner urban zone including historic conservation zone, (b) Outer urban zone and outskirts zone and (c) Urban clusters. Water demand forecast is prepared below by i) Core urban area with Tha Ngon, ii) Khok Hae and Ban Phao and iii) outside of urban planning area.

2) Water Demand at Core Urban Area with Tha Ngon

The present water supply system in the urban area covers (a) Inner urban zone, (b) outer urban zone and Tha Ngon. For this area, the past water supply information has been provided by NPVC and water supply master plan was conducted by JICA in 2004 (water MP).

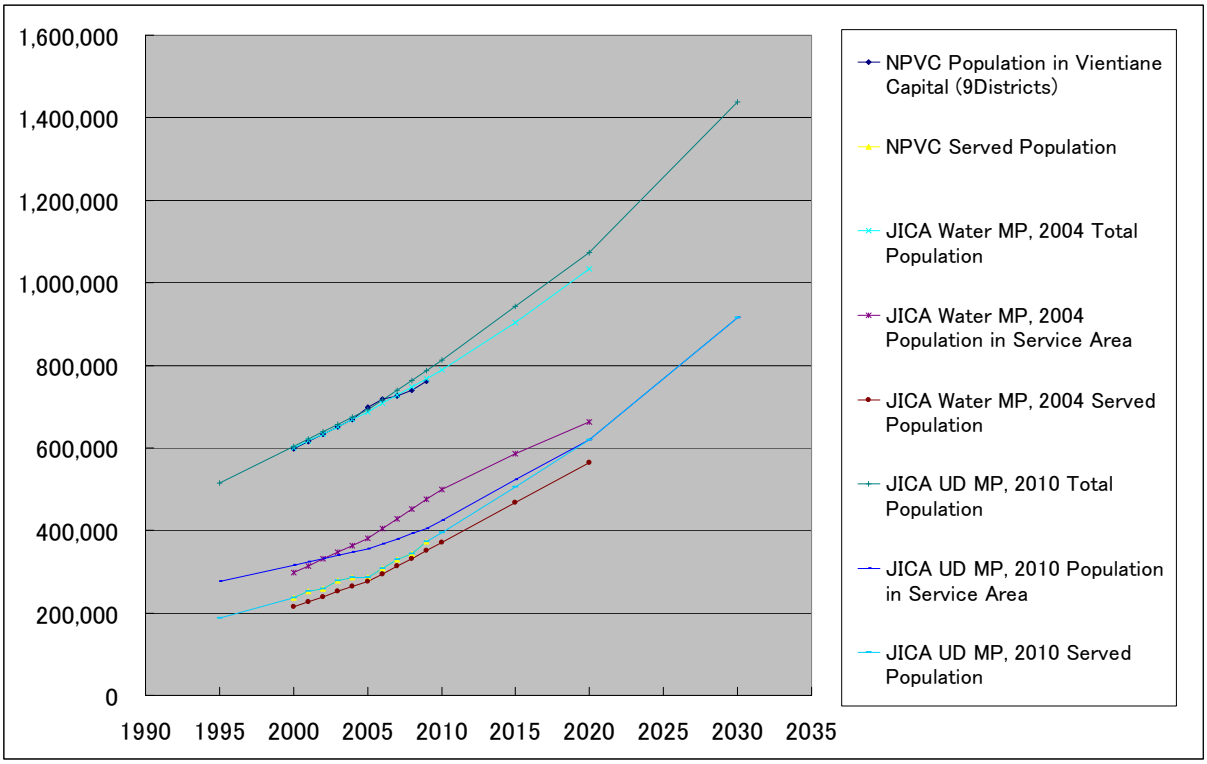
Water demand of the area is estimated based on the past trends and the projection in water MP and the new population data. Summary of the past trends, the projection in water MP and this Urban Development Master Plan study (UD MP) results are tabulated in table below,

Table 4.3.12: Comparison of Past NPVC data, JICA MP in 2004 and this Study

NPVC, Water MP, UD MP	Unit	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2015	2020	2030
NPVC																
Population in Vientiane Capital	Person		597,800	616,000	633,100	650,600	669,467	698,318	718,569	725,820	740,010	760,730	-	-	-	-
Served Population	Person		237,042	252,312	258,558	277,884	285,678	286,935	308,347	328,895	343,640	372,906	-	-	-	-
Per Capita Water Consumption (Domestic)	Lpcd		182	174	176	178	169	186	174	182	174	175	-	-	-	-
Domestic Water Demand	m3/day		43,226	44,024	45,597	49,584	48,216	53,365	53,653	59,859	59,826	65,231	-	-	-	-
Non-Domestic Water Demand	m3/day		25,247	32,235	33,387	36,306	35,304	32,963	33,140	37,572	39,291	43,556	-	-	-	-
Total Water Demand	m3/day		68,472	76,258	78,984	85,891	83,520	86,328	86,793	97,431	99,117	108,786	-	-	-	-
NRW	m3/day		30,906	28,890	34,346	34,705	35,675	33,869	32,221	37,357	37,270	52,027	-	-	-	-
NRW Rate	-		31%	27%	30%	29%	30%	28%	27%	28%	27%	32%	-	-	-	-
Water Production	m3/day		99,379	105,148	113,330	120,595	119,195	120,197	119,014	134,788	136,387	160,813	-	-	-	-
JICA Water MP 2004																
Population in Vientiane Capital	Person		599,000	616,617	634,234	651,850	669,467	687,084	707,300	727,516	747,733	767,949	788,165	902,716	1,034,521	-
Population in Service Area	Person		297,575	314,128	330,682	347,235	363,789	380,342	404,221	428,100	451,979	475,858	499,737	586,710	662,441	-
Served Population	Person		215,522	227,531	239,540	251,549	263,558	275,567	294,507	313,448	332,388	351,329	370,269	466,981	564,648	-
Service Ratio	-		72.4%	-	-	-	-	72.5%	-	-	-	-	74.1%	79.6%	85.2%	-
Per Capita Water Consumption (Domestic)	Lpcd		174	-	-	-	-	172	-	-	-	-	170	170	170	-
Domestic Water Demand	m3/day		37,501	-	-	-	-	47,398	-	-	-	-	62,946	79,387	95,990	-
Non-Domestic Water Demand	m3/day		30,361	-	-	-	-	37,781	-	-	-	-	47,015	58,505	72,803	-
Total Water Demand	m3/day		67,862	-	-	-	-	85,179	-	-	-	-	109,960	137,891	168,793	-
NRW Rate	%		33	-	-	-	-	28	-	-	-	-	25	25	25	-
NRW	m3/day		33,424	-	-	-	-	33,125	-	-	-	-	36,653	45,964	56,264	-
Water Demand with NRW	m3/day		101,286	-	-	-	-	118,304	-	-	-	-	146,614	183,855	225,057	-
Day Maximum Water Demand, (= Water Demand with NRW x 1.1)	m3/day		111,415	-	-	-	-	130,134	-	-	-	-	161,275	202,241	247,563	-
JICA Urban Development MP 2010																
Population in Vientiane Capital	Person	514,082	602,907	620,671	638,436	656,201	673,966	691,731	715,710	739,689	763,668	787,647	813,679	943,840	1,074,000	1,439,000
UP MP Population in service area	Person	276,776	315,675	323,454	331,234	339,014	346,793	354,573	366,974	379,374	391,775	404,175	423,796	521,898	620,000	915,000
Service Ratio	-	68%	75%	78%	78%	82%	82%	81%	84%	87%	88%	92%	93	97	100	100
Served Population, till 2009 NPVC, after 2010 UD MP	Person	187,149	237,042	252,312	258,558	277,884	285,678	286,935	308,347	328,895	343,640	372,906	394,000	506,000	620,000	915,000
Per Capita Water Consumption (Domestic), till 2009 NPVC, after 2010 UD MP	Lpcd	179	182	174	176	178	169	186	174	182	174	175	175	175	170	170
Domestic Water Demand	m3/day	33,000	43,000	44,000	46,000	50,000	48,000	53,000	54,000	60,000	60,000	65,000	69,000	89,000	105,000	156,000
Non-Domestic Water Demand	m3/day	17,531	25,247	32,235	33,387	36,306	35,304	32,963	33,140	37,572	39,291	43,556	46,000	57,000	70,000	109,000
Total Water Demand	m3/day	50,531	68,247	76,235	79,387	86,306	83,304	85,963	87,140	97,572	99,291	108,556	115,000	146,000	175,000	265,000
NRW Rate	%	31	31	27	30	28	29	28	27	28	27	32	30	25	20	15
NRW	m3/day	23,000	31,000	28,000	34,000	34,000	34,000	33,000	32,000	38,000	37,000	51,000	49,000	49,000	44,000	47,000
Water Demand with NRW	m3/day	73,000	99,000	104,000	113,000	120,000	117,000	119,000	119,000	136,000	136,000	160,000	164,000	195,000	219,000	312,000
Peak Factor	–	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Day Maximum Water Demand, (= Water Demand with NRW x 1.1)	m3/day	80,300	108,900	114,400	124,300	132,000	128,700	130,900	130,900	149,600	149,600	176,000	180,400	214,500	240,900	343,200

Note: Shade color of population is prepared in the studies and figures between the years are interpolated.
Source: NPVC, JICA Water MP 2004, and JST

The served population of UD MP follows NPVC data till 2009, and after 2010 it is prepared by UD MP to match the target of 100% in 2020 as described before. Populations of the past trend by NPVC, water MP forecast and this UD MP forecast are shown below, and it is understood that the UD MP forecast which is based on the past trends almost matches the water MP forecast.



Source: NPVC, JICA Water MP 2004, and JST

Figure 4.3.10: Comparison of Population related to Water Supply in Core Urban Area with Tha Ngon

After setting the served population, a unit water demand for domestic, non-domestic water demand, non-revenue water (NRW), a peak factor are set as follows to estimate the water demand.

- Unit Water Demand for Domestic water demand:
  Till 2009 applying past data of NPVC (about 170-185 Litter/capita/day, hereinafter Lpcd), after 2010 applying 170-175 Lpcd based on the water MP 2004

- Non-domestic water demand:
  Till 2009 applying past data of NPVC, after 2010 applying 43,556 x (1+4.47/100)^(year-2009) based on the water MP 2004, this is about 60-70% of domestic water demand

- Rate of NRW:
  Till 2009 applying past data of NPVC, after 2010 applying figures to achieve the target of 15% in 2030

  Present NRW rate is about 30% in 2010 and water MP proposed 25% in 2020. The target of 15% in 2030 is challenging figure to reduce the NRW.

- Peak factor:
  Applying 1.1 based on the NPVC data and water MP.

The water demand is estimated as below based on the above conditions for (a) Inner urban zone + (b) Outer urban zone and outskirts zone + (c) Tha Ngon as Urban Cluster.

Table 4.3.13: Water Demand Estimation in Core Urban Area with Tha Ngon

Item	Unit	1995	2005	2009	2020	2030
Population in Service Area	Person	276,776	354,573	404,175	620,000	915,000
Service Ratio	-	68%	81%	92%	100%	100%
Served Population	Person	187,000	287,000	373,000	620,000	915,000
Per Capita Water Consumption	Lpcd	179	186	175	170	170
Domestic Water Demand	m3/day	33,000	53,000	65,000	105,000	156,000
Non-Domestic Water Demand	m3/day	17,531	32,963	43,556	70,000	109,000
Total Water Demand	m3/day	50,531	85,963	108,556	175,000	265,000
NRW	%	31	28	32	20	15
Water Demand with NRW	m3/day	73,000	119,000	160,000	219,000	312,000
Peak Factor	-	1.1	1.1	1.1	1.1	1.1
Required Water Production	m3/day	80,300	130,900	176,000	240,900	343,200

Source: JST

As shown above, the required water production shall increase from 176,000 m^3/ day in 2009 to 343,200 m^3/ day in 2030.

3) Water Demand at Khok Hae and Ban Phao

Outside of core urban area, Khok Hae and Ban Phao Urban Clusters will be developed as urban area and water supply system will be introduced there. Population and the service ratio are set as described earlier, and the unit water demand, NRW, and a peak factor are set as follows to estimate water demand.

- Unit Water Demand:
  Total unit water demand for domestic and non-domestic use is applied as 200 Lpcd, as the non domestic activity is not so active compared to the center of Vientiane Capital. The figure is referenced to the unit water consumption of Kaysone Phomvihane and Pakse in JICA Study of "Preparatory Survey on Formulation of Basic Strategies for Regional Core Cities Development in Lao People's Democratic Republic".

- Non-domestic water demand:
  It is included in the above unit water demand 200 Lpcd.

- Rate of NRW: Applying 15% from beginning of the commencement

- Peak factor: Applying 1.1 based on the NPVC data and water MP.

Water demand is estimated as below based on the above condition for Khok Hae

Table 4.3.14: Water Demand Estimation in Khok Hae

Item	Unit	1995	2005	2009	2020	2030
Population in Service Area	Person	854	848	955	2,000	8,000
Service Ratio	-	0%	0%	0%	80%	100%
Served Population	Person	0	0	0	1,600	8,000
Per Capita Water Consumption	Lpcd	-	-	-	200	200
Water Demand	m3/day	0	0	0	320	1,600
NRW	%	-	-	-	15	15
Water Demand with NRW	m3/day	0	0	0	380	1,880
Peak Factor	-	-	-	-	1.1	1.1
Required Water Production	m3/day	0	0	0	420	2,070

Source: JST

As shown above, in Khok Hae the required water production is 420 m^3/ day in 2020 and 2,700 m^3/ day in 2030.

Water demand is estimated as below based on the above condition for Ban Phao.

Table 4.3.15: Water Demand Estimation in Ban Phao

Item	Unit	1995	2005	2009	2020	2030
Population in Service Area	Person	1,686	2,137	2,350	4,000	7,000
Service Ratio	-	0%	0%	0%	80%	100%
Served Population	Person	0	0	0	3,200	7,000
Per Capita Water Consumption	Lpcd	-	-	-	200	200
Water Demand	m3/day	0	0	0	600	1,400
NRW	-	-	-	-	15	15
Water Demand with NRW	m3/day	0	0	0	710	1,650
Peak Factor					1.1	1.1
Required Water Production	m3/day	0	0	0	780	1,820

Source: JST

As shown above, in Ban Phao the required water production is 780 m^3/ day in 2020 and 1,820 m^3/ day in 2030.

4) Water Demand at Outside of the Urban Planning Area

In the rural area outside of the urban planning area, basically water is supplied individually from groundwater using wells or boreholes. Population served by this system is the remaining population from the total population minus the served population with water network system described before.

The unit water demand, a peak factor are set as follows to estimate water demand.

- Unit Water Demand:
  Total unit water demand of domestic and non-domestic use is applied as 70L/cday,

based on the information from JICA Senior volunteer, who is in charge of water leakage investigation in Vientiane Capital.

- Rate of NRW: Applying 0%
- Peak factor: Applying 1.1

Water demand by groundwater is estimated as below based on the above condition for (a) Inner urban zone + (b) Outer urban zone and outskirts zone + (c) Tha Ngon as Urban Cluster.

Table 4.3.16: Water Demand Estimation in Core Urban Area with Tha Ngon by Groundwater

Item	Unit	1995	2005	2009	2020	2030
Population in Service Area	Person	276,776	354,573	404,175	620,000	915,000
Service Ratio	-	32%	19%	8%	0%	0%
Served Population with Groundwater	Person	90,000	68,000	31,000	0	0
Per Capita Water Consumption	Lpcd	70	70	70	70	70
Domestic Water Demand	m3/day	6,300	4,760	2,170	0	0
Non-Domestic Water Demand	m3/day	0	0	0	0	0
Total Water Demand	m3/day	6,300	4,760	2,170	0	0
NRW	%	0	0	0	0	0
Water Demand with NRW	m3/day	6,000	5,000	2,000	0	0
Peak Factor		1.1	1.1	1.1	1.1	1.1
Required Water Production	m3/day	6,600	5,500	2,200	0	0

Source: JST

Water demand by groundwater is estimated as below based on the above condition for the other rural area,

Table 4.3.17: Water Demand Estimation in Outside of Urban Planning Area

Item	Unit	1995	2005	2009	2020	2030
Population in Service Area	Person	234,766	334,173	380,167	448,000	509,000
Service Ratio	-	100%	100%	100%	100%	100%
Served Population with Groundwater	Person	234,766	334,173	380,167	448,000	509,000
Per Capita Water Consumption	Lpcd	70	70	70	70	70
Water Demand	m3/day	16,000	23,000	27,000	31,360	35,630
NRW	%	0%	0%	0%	0%	0%
Water Demand with NRW	m3/day	16,000	23,000	27,000	31,360	35,630
Peak Factor		1.1	1.1	1.1	1.1	1.1
Required Water Production	m3/day	17,600	25,300	29,700	34,500	39,190

Source: JST

Phialath Village and Houaykham Village in Sangthong District, categorized as rural area, are supplied water by network system and the served populations are 1,700 and 860 respectively at present. Total population of the rural area is 380,167 in 2009 and the population of the two

villages is less than 1%, almost negligible. So, they are not counted in this plan. Water demand in the other area of rural area is prepared for showing the magnitude size of water demand.

(3) Facility Plan

1) General

JST prepared a list of required major water supply facilities till 2030 such as water treatment plants (WTP) and expansion of water network. This is a rough estimation and they shall be studied in detail on water supply master plan expected to be carried out in near future. The plan described below is prepared roughly, so detail shall be studied by the water master plan.

2) Water Treatment Plants (WTP)

The required water production capacity corresponding to the daily maximum water demand is estimated first and future WTP development plan are tabulated below together with the past demand and WTP capacity,

Table 4.3.18: Development Plan of Water Treatment Plant (WTP)

Item	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2015	2020	2030
Daily Maximum Water Demand	80,300	108,900	114,400	124,300	132,000	128,700	130,900	130,900	149,600	149,600	176,000	180,400	214,500	240,900	343,200
Capacity of WTP															
Chinaimo	40,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000
Kaoleo	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	60,000	60,000	60,000	60,000	60,000
Dongmakkai	-	-	-	-	-	-	-	-	-	-	20,000	20,000	40,000	60,000	100,000
Thadeua	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600
Tha Ngon	660	660	660	660	660	660	660	660	660	660	660	660	660	660	660
Don Ban												20,000	40,000	40,000	40,000
Sendin													20,000	20,000	20,000
New Tha Ngon															60,000
XayfongTai, Hatsaifon															15,000
Total WTP Capacity	61,260	101,260	101,260	101,260	101,260	101,260	101,260	101,260	101,260	101,260	161,260	181,260	241,260	261,260	376,260
Extra capacity or Deficiency		-7,640	-13,140	-23,040	-30,740	-27,440	-29,640	-29,640	-48,340	-48,340	-14,740	860	26,760	20,360	33,060

Note: Yellow color figures are capacity of WTP after newly construction or expansion.
Source: JST

As shown above, in 2009 the daily maximum water demand or the required water production capacity is 176,000 m^3/ day and total WTP capacity is 161,260 m^3/ day, which means that water is in shortage even at present. In 2030, it will be 343,200 m^3/ day and 376,260 m^3/ day respectively, meaning that the water supply will be secured if the above WTP development plan to supply additional water demand is achieved.

Urgently required are the expansion of Dongmakkai WTP, expansion of Don Ban WTP and new construction of Sendin WTP.

- Expansion of Dongmakkai WTP is planned to be 40,000 m^3/ day in 2015 and 100,000 m^3/ day till 2030. The site has enough area to expand the facilities but inlet facilities will be required from the Nam Ngum River.
- Expansion of Don Ban WTP is planned to be 40,000 m^3/ day in 2015 at the same site.
- New construction of Sendin WTP is planned to be 20,000 m^3/ day in 2015. The location is not identified yet in detail, so it shall be studied.

The above three (3) WTP expansion and new construction are set as a high priority in NPVC.

Additionally, a new Tha Ngon WTP of 60,000 m^3/ day will be required till 2030. This new Tha Ngon WTP was proposed by water MP in 2004 but the candidate site is now occupied by a private company. So the site of the New Tha Ngon WTP shall be studied again.

Xayfong-Tai, Hatsaifon WTP of 15,000 m^3/ day is proposed here but the requirement shall be studied in detail in a master plan.

The location of the WTP is shown in Figure 4.3.12.

Location of Sendin WTP is distant from center of Vientiane Capital, so this implementation shall be studied carefully although NPVC set this plan high priority. Further expansion of Dongmakkai WTP or construction of new Tha Ngon WTP in early stage could be higher priority plan in stead of the Sendin WTP construction in early stage.

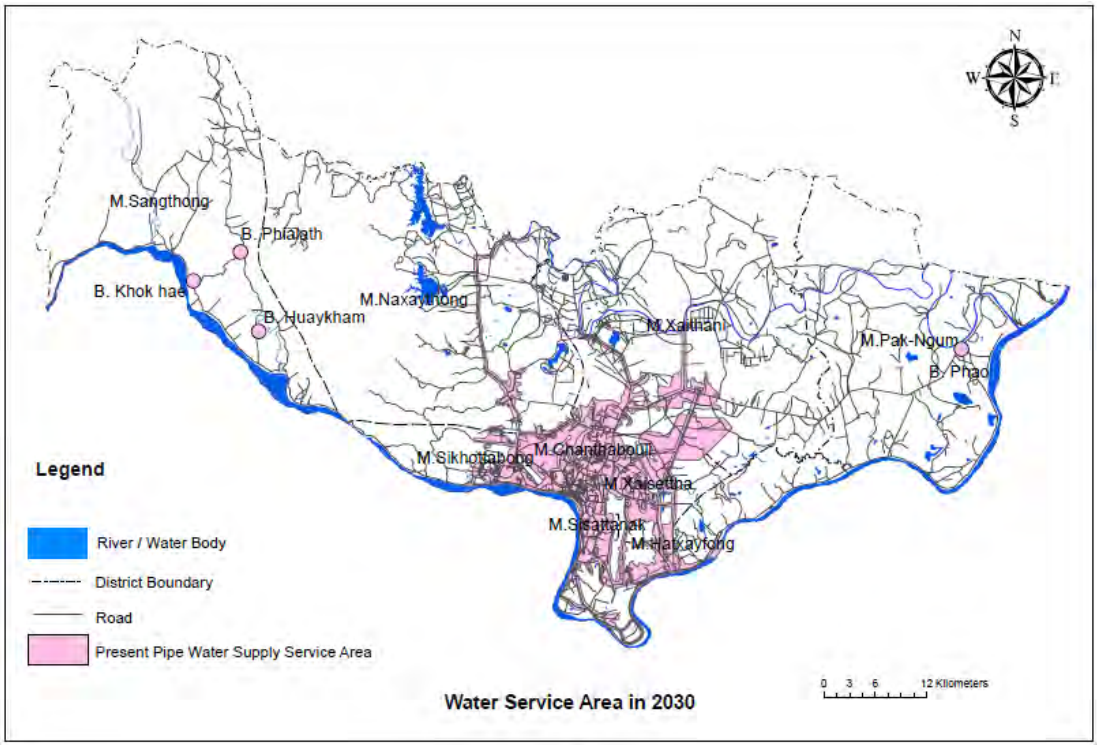
3) Other Water Supply Facilities

a) Water Service Area

The water service area is prepared based on the future land use map in 2030 prepared in this study.

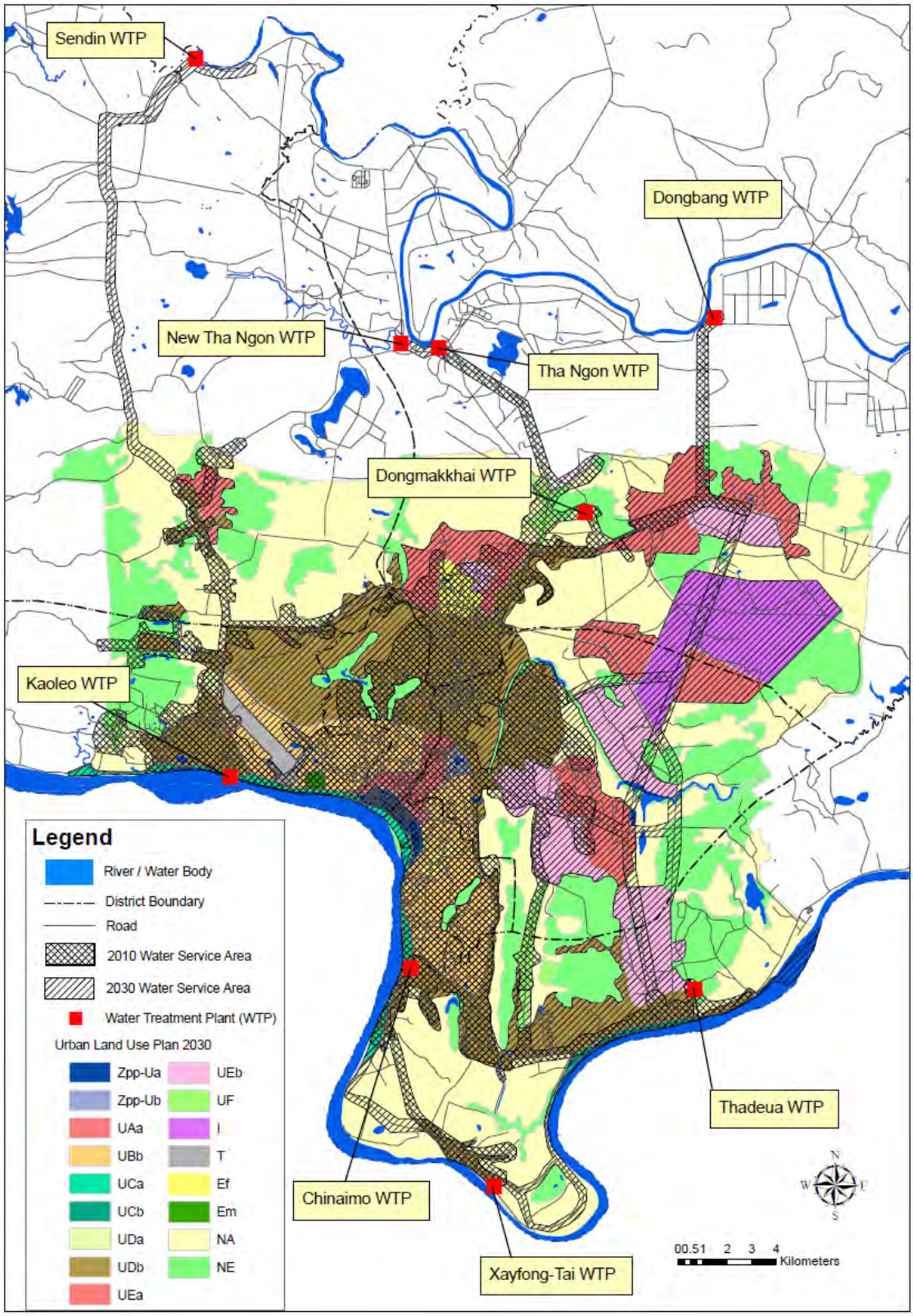
Water service area covers future urban area and industrial area as shown in figures below,

The water service area expands from 172 km^2 in 2009 to 337 km^2 in 2030 based on the figure.



Source: JST

Figure 4.3.11: Water Service Area in Vientiane Capital



Source: JST

Figure 4.3.12: Water Service Area in Core Urban Area of Vientiane Capital

b) Development plan of Transmission and Distribution Facilities

Transmission and distribution facilities of water supply system include transmission pipes, reservoirs, distribution pipes and pumping stations. It is recommended to supply water to customers from distribution pipes, but not from transmission pipes directly for better control water flow. But as mentioned earlier, some customers receive water from transmission pipes directly. It is recommended that water service area is divided by reservoir service areas and WTP supply water to each reservoir by transmission pipes. And distribution pipes must be designed to reach from the reservoirs to customers.

Planning the facilities shall be studied in detail based on the location of WTP, water service area, volume of water demand by areas and land features condition.

c) Development Plan of Reservoir

Capacity of the reservoir is about 5.0hr with WTP reservoir capacity to the water supply in 2010. It is generally recommended to withhold a reservoir capacity of more than 6hrs in order to secure stable water supply to balance the hourly peak water demand to customers within the daily maximum water supply capacity of WTP.

Updated water supply master plan will be required for Vientiane Capital and reasonable water supply facility plan shall be established.

4) Development Plan of Rural Water Supply

Groundwater is generally the best water source for rural water supply as it is less required to treat the raw water for potable water. It is necessary to assure the water quality whether it is not polluted from arsenic or other hazardous materials, and the structure of wells or boreholes shall be free from pollution from wastewater from such as septic tanks.

When groundwater is polluted by hazardous materials, the groundwater shall not be used and other water source shall be studied, such as safe quality groundwater around the site or surface water with treatment.

(4) Operation and Maintenance Plan

1) General

It is identified that following operation and maintenance work are to be improved, i) water pipe management, ii) improvement of NRW and iii) improvement of WTP work as described below,

2) Water Pipe Management

There are two issues for water pipe management such as a) identification of underground pipe location, b) land security for water pipe,

a) Identification of Pipe Location

Locations of water pipes are not clearly understood by NPVC that leads not effective OM work. Water network drawings showing detail location are required for the easy pipe maintenance. The water pipe facilities including valves have been prepared at every road cross section by NPVC, but they are not yet completed.

It is recommended that location of major features such as valve shall be identified from three (3) points such as corner of road or buildings. This work shall be done when pipes are newly installed or newly identified during OM work.

b) Land Security for Water Pipe

Water pipes have been constructed since 1964, and pipes were mainly installed along roads. Houses, temples or buildings have been constructed above some pipes. The situation makes the pipe maintenance difficult. It is observed as follows,

- Houses are built above water pipes which are installed within road limit
- Houses are built above water pipes which are installed out of road limit

Road Law was established in 1999, and it includes a followings regulation,

- The Ministry of Communication, Transport, Post and Construction is the authority to manage and use the land for road activities as stipulate in the Land Law.
- The limit of the road is the total area of the road that includes road surfaces, shoulder footpath, drainage ditch, slope and the reserved zone for the road.
- It is prohibited to construct in any form within the reserved zone for the road. In case of necessity, the construction must be applied to the Road Authority for permission.

JST proposes to control underground structure with following manners for road management,

- An agency in charge of road management shall control occupation space under the road limit for underground structures such as water pipes, sewers, drainages, electricity cables, telecommunication cables and so on. The agency shall make the database of the underground structures
- Utility organization shall obtain permission from the road agency to install their facilities within the road limit / right of way, but not private land.
- When one utility agency installs underground structures such as new construction or repair of their facilities, they shall invite related utility organizations with the road agency, not to damage their underground facilities and proof the safe workmanship.

JST proposes two (2) ideas to manage the water pipes installed under structures as follows,

- Management for water pipes installed within “Right of way” where houses are constructed above the pipes
  The case is a special case and it is allowed to keep the houses at the present location despite they are within right of way. But, it is necessary for the road agency, utility agency and residents / organizations using the land, to recognize the boarder line of the right of way. When road or utility agencies have a plan to expand or renovate the facilities, the land handling shall be discussed with mutually manners.
- Management for water pipes installed out of “Right of way” where houses are constructed above the pipes
  This case is a special and it is allowed to keep the pipes at the present location which is out of right of way. When reinstallation of the pipes is required, they shall be reinstalled inside of the right of way.

3) NRW Rate Improvement

The leakage rate, according to NRW in 2009, is as high as 32% and the target NRW rate is 15% in 2030 in this plan as described before. In this case required WTP capacity is 343,200 m^3/ day and if NRW rate is 20% it is 364,100m^3/ day and if NRW rate is 25% it is 388,300 m^3/ day. So, about 20,000m^3/ day or 40,000m^3/ day WTP would be required more if the NRW rate was 20% or 25% respectively. NPVC has an administrative section of "Technical Leak Detection" but the capacity is not enough.

Proposed measurement to reduce the NRW rate is described below,

a) Improvement of service pipe

Most of leakage is happing along the service pipes especially at connection of distribution pipe and joints. The connection work shall be done by skilled persons and the work shall be checked to confirm there is no leakage before backfill. It is recommended that water work registration shall be established to carry out this work and only the registered staffs or qualified private companies can do the connection or maintenance work. They shall have trainings, pass an examination and register on water piping work to hold technique of selecting pipe materials, connecting pipes and others.

b) Establishment of District Metered Area (DMA)

Distribution network shall be divided into blocks of service areas of reservoirs, and the service area of one reservoir shall further be divided into blocks of District Metered Area (DMA). This management makes it easy to control the water flow by measuring inflow and outflow, and the NRW rate of each DMA can be identified easily.

c) Leakage detecting by routine work

Based on the above measurement, field survey shall be carried out to find out the leakage points with devices.

d) Replacement of the water pipes

Based on the above field survey, leakage parts shall be replaced with new pipes. When leakage is observed above ground, of course it shall be repaired.

When several service pipes are installed along a road they shall be integrated to one distribution pipe. As a preventive measure, old pipes, weak pipes such as asbestos cement pipes shall be replaced in time.

4) WTP Operation Work

WTP of Chinaimo and Dongmakkhai is operated well to produce clean water by NPVC. But, it is observed that at Kaoleo WTP chemical dosing was not properly done, as the turbidity before the filtration was sometimes high. Raw water quality of the Mekong River changes rapidly, so appropriate chemical dosing is required to match raw water quality.

Tha Ngon WTP looks to be not well functioning to treat water.

It is recommended that improving average NPVC staffs technique shall be improved.

(5) Institutional, Management and Financial improvement Plan

1) General

Institutional management, financial improvement plan and human resource improvement are described below,

2) Institution

a) Rural Water Supply

Demarcation of rural water supply management in Vientiane Capital shall be clear whether it is done by NPVC, Naam Sart, or individually.

Rural water supply system is operated and maintained by improper organization like at Phialath village. Adequate organization and institution shall be established for a relatively large rural water supply system. It is recommended that NPVC will be involved for the rural water supply development and operation and maintenance.

b) Revision of registration category

Water users are categorized in Domestic, Government, Commercial & business & industry, large commercial and Foreigner. But they are not categorized correctly, such as the case of some government categories contain government staff residents. The categories shall be revised for controlling water consumption by categories. After the revision of the water user categories, water consumption by user categories could be easily understood and the figures could be used for future plan to estimate water demand by categories.

c) NPVC for wastewater

NPVC is working for water supply management work, although NPVC has been nominated to work for wastewater management in Prime Minister Decision No.37/PM, September 1999. Responsibility of NPVC shall be clearly studied if it has the roll of wastewater management.

3) Financial Aspect

a) Tariff System

The present financial condition of NPVC is not stable, as the income from water charge does not cover the depreciation and capital costs for large scale projects. A revision of water tariff is required to make the financial condition stable.

It is necessary to extend awareness campaign to water users as water supply system is carried out by a self supporting system. Recommended tariff system shall be prepared for user categories of domestic and commercial and industrial and public uses. Water demand could be controlled and reduced by applying following measures,

- Introduction of Gradual/Scheduled Tariff Increases
  A gradual/scheduled tariff would encourage consumers to save water. This tariff system has been already applied.

- Increased Tariffs for Industry
  The present tariff applied to industry is the same as the domestic rate, as they are not

categorized by users. Increasing the industrial water tariff would promote a higher recovery of industrial water consumption.

b) Project Finance

NPVC has been already applying private financing to construct new water treatment plants. It is recommended to promote the same ways to enlarge future water supply system. Also it is necessary to get foreign assistances for the same purpose.

4) Human Resource

NPVC is the public water enterprise in Vientiane Capital. It has high level staffs but abilities of NPVC staff on water supply system are not high enough to properly operate and manage water supply system. It is necessary to improve their technical and institutional and finance capacity as mentioned before. There is a training center, constructed by French aid at Chinaimo WTP for training nationwide water supply enterprise staff, and NPVC are required to assist the training. Although NPVC has been receiving series of foreign assistance, it is difficult for NPVC to improve the capacity especially such as leakage reduction by itself without foreign assistance. So, it is recommended to receive foreign assistance to improve their capacity.

4.3.3 Sewerage/Wastewater

(1) Basic Policy

Planning for proper sewerage/ wastewater management is one of the components in the Vision adopted for this Study: "Comfortably Livable and Beloved Hometown". This includes improving and maintaining sanitary living environment for the residents and reduction in environmental degradation. This approach is also set by the Lao Government towards the urban strategy development in 2020 as well as the direction of the draft 7th National Socio-Economic Development Plan on better sanitation and infrastructure to people with the protection of the environmental water quality to be within the environmental standard. Moreover; the establishing of wastewater treatment facilities is one of the Action Plans mentioned in the National Environment Strategy 2020 and Environment Action Plan 2006-2010.

As for Vientiane Capital which is the most urbanized city in Lao PDR, the strategy for planning and implementation on sewerage / wastewater management system is very important as one of the priority infrastructures development especially when new urban center or sub urban areas are planned. The proper policy to address the strategy shall comprise:

- Priority in high pollution source reduction
- Sustainability in implementation
- Robust financial plan in investment, operation and maintenance
- Phasing in implementation
- Appropriate technology to local authority
- Public participation and involvement

The criteria for water quality target of public water body shall be also set up based on the water quality criteria similar to other Asian countries and aquatic biological survey result from "The Study on Improvement of Water Environment in Vientiane City, Lao PDR." as in the Table 4.3.19 below.

Table 4.3.19: Planning Water Quality Target

River / Canal Stretch	Water Quality Requirement in BOD	Remarks
Down-most Stretch of Mak Hiao River (Near Rivermouth)	≤ 5 mg/l	Best requirement for fishery water
Middle Stretch of Mak Hiao including That Luang Marsh	≤ 8 mg/l	Allowable lowest requirement for sustaining fishery water
Urban Drainage System: Hong Xeng and Hong Ke	8-12 mg/l	Expected requirement for restoration of inhabitable environment for fish

Source: ITR - The Study on Improvement of Water Environment in Vientiane City, Lao PDR., JICA 2010

(2) Wastewater Generation

Sewerage or wastewater generation in 2030 in Vientiane Capital will be from domestic and non-domestic source which is directly related with the growth of population and industrial and commercial development. Wastewater will be generated from the urbanized area and new urban center or sub-centers based on the land use prepared in this study. The projection of wastewater generation in

urban areas of Vientiane Capital up to year 2030 is shown in Table 4.3.20, by assuming that 80% of the water demand for people becomes wastewater.

Table 4.3.20: Estimated Wastewater Generation in Urban Area of Vientiane Capital

Description	Unit	1995	2005	2009	2020	2030
Total Population in Vientiane Capital	Person	514,082	691,731	787,647	1,074,000	1,439,000
Water Served Population in Center of Vientiane Capital	Person	276,776	354,573	404,175	620,000	915,000
Domestic Wastewater Generation	m3/day	26,400	42,400	52,000	84,000	124,800
Non-Domestic Wastewater Generation	m3/day	14,000	26,400	34,800	56,000	87,200
Total Wastewater Generation	m3/day	40,400	68,800	86,800	140,000	212,000

Source: JST, based on the water supply demand estimation in Core Urban Area +Tha Ngon

(3) Facility Plan

The facilities in wastewater management shall be planned at least for a 15 – 20 year period in consideration of future urban development area such as new urban center, suburban area and other new potential development projects in accordance with the master plan land use. The preparation of wastewater collection and treatment facilities in these areas are essential for the future infrastructure planning in light of coordination with other systems.

Components that are needed for future wastewater treatment facilities will depend on the selection of an appropriate treatment system with respect to the following factors:

- Quantity and quality of wastewater generation
- Availability of land or area
- Simple technology, easy in operation and maintenance
- Financial situation
- Number and level of O&M staff
- Awareness and participation of local community
- Implementation time

Selection of centralized or decentralised wastewater treatment systems for each development will depend on an appropriate technical option for areas that faces problems with high population density and financial situations which will have to be taken into consideration for larger centralised treatment systems. For an initial stage of urbanization, simple technologies should be selected for the majority of urban areas with utilization of natural conditions for wastewater treatment. As population density increases the need for higher technology for centralized systems will arise due to a smaller area requirement and higher treatment efficiency.

For a short term plan for Vientiane in consideration of institutional and financial capacities, the concept of on-site and communal (decentralized) systems or Community Based Sanitation (CBS) might be more favorable with a lesser cost compared to the centralized systems. Nevertheless, a larger high density urban area such as the Historic Conservation Zone, a more expensive but less area requiring method may be selected. According to the Study on Improvement of Water Environment in Vientiane City, at least 805 units of small CBS system together with 3 In-stream water treatment at the

ponds prior to discharging to channels or rivers were proposed in urban Vientiane area for a short term and medium term plan as indicated in Figure 4.3.13.

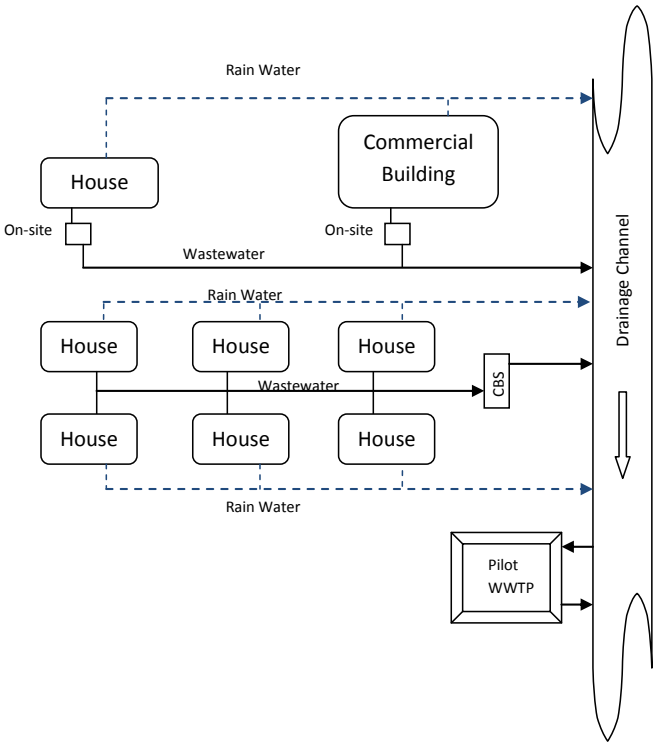
A centralized system may not be appropriate to be implemented over at least 10 years (or medium term plan) as it requires huge budget to construct the sewers to collect wastewater and wastewater treatment plant, and annual budget for the operation and maintenance needs wastewater charges from users. But such a program should be considered in a long term plan with considering construction cost, land availability, OM cost, budget, wastewater charge and affordable payment by users, institution and organization, environmental issues and so on. A pilot centralized sewerage system has been devastated since 2008 after a failure of pumping stations. It is recommended to rehabilitate the facilities with achieving easier maintenance by such as less pumping stations using shallow sewer system in short term plan considering the cost and the budget. Zoning of treatment plant coverage has to be planned so that the wastewater collection system will be minimized or existing drainage channels can be utilized as wastewater collection system in some areas, after that the quality of water in the natural water way will be less polluted and improved.

For a centralized system, including the rehabilitation of the present pilot sewerage system, provision of associated facilities such as sewer pipe network, manhole and pump station shall be taken into consideration during the feasibility study and detailed design period. Schematic diagram of wastewater management system in the short, medium and long term plans can be shown in Figure 4.3.13 and 4.3.14. The proposed location of the treatment system in the short and medium term plans as well as the centralized system for the long term, for which a partial area in the existing marsh should be utilized, is shown in Figure 4.3.17 and 4.3.18. The proposed wastewater treatment facility for each type of land use area can be summarized in the Table 4.3.21 below.

Table 4.3.21: Proposed Wastewater Treatment Facility to Future Land Use

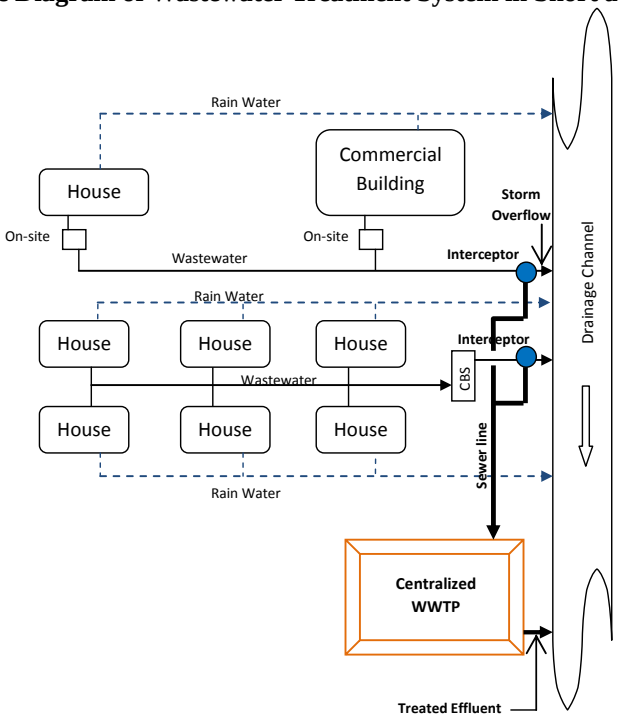
Land Use Area	Land Use Policy	Proposed WWTP
1.Historic conservation zone	Conserved for tourism purpose	Improved septic tank (see Figure 4.3.15) or decentralized treatment system and partial wastewater collection to WWTP at Nongchan and Nongduang
2.Inner urban zone	Higher efficiency commercial use	Same as historic conservation zone
3.Outer urban zone	Expansion of residential area and new town center	Provide overall treatment by on-site or decentralized system to new housing and new development as shown in Figure 4.3.16.
4.Sub-center zone	New urban function development with higher land density	Provide wastewater treatment by on-site or decentralized system to new housing and new development center
5. Urban cluster zone	Village center, agriculture area	Improved septic tank and grease trap

Source: JST



Source: JST

Figure 4.3.13: Schematic Diagram of Wastewater Treatment System in Short and Medium Term Plan



Source: JST

Figure 4.3.14: Schematic Diagram of Wastewater Treatment System in Long Term Plan

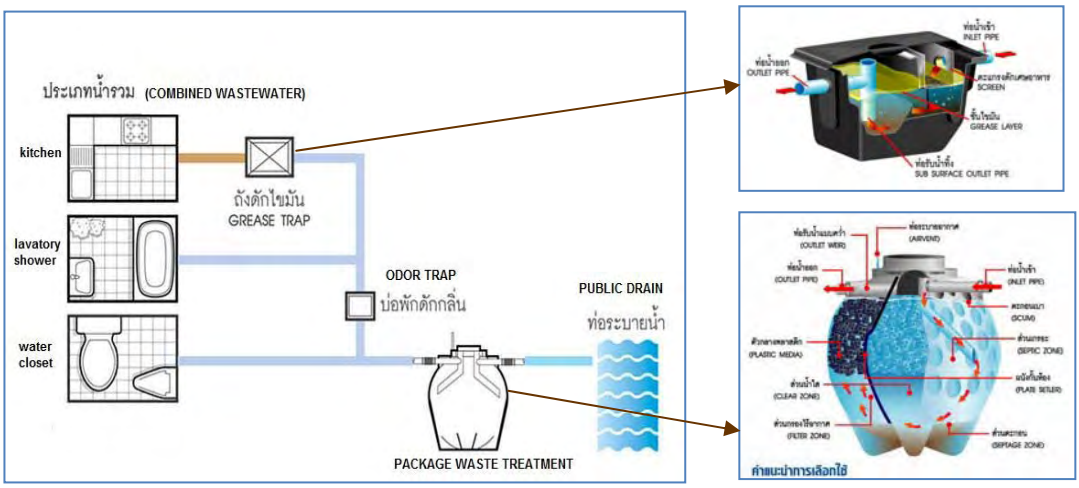


Figure 4.3.15: Sample of Improved On-site Treatment System for Household

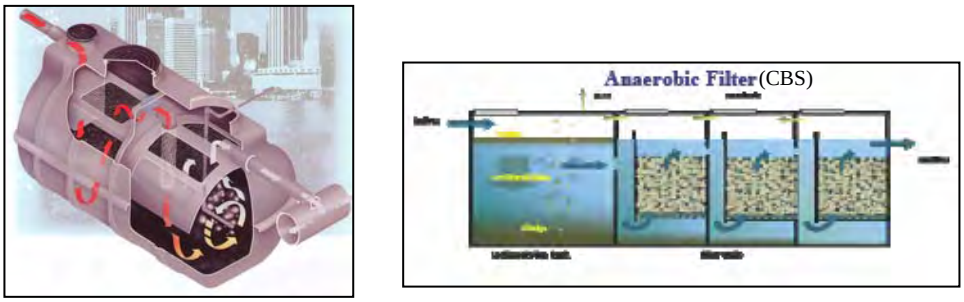
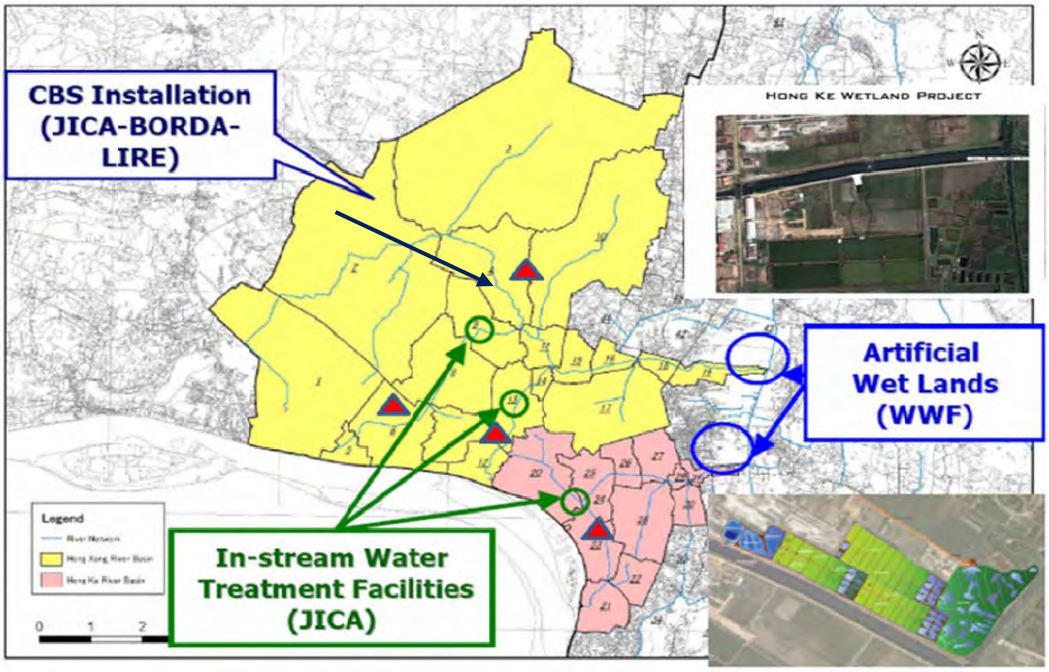


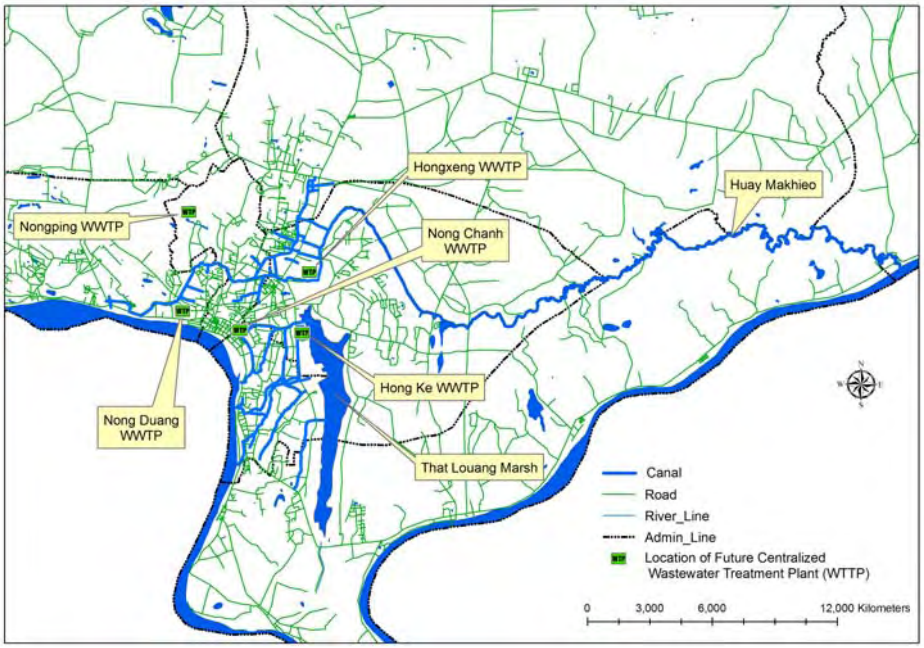
Figure 4.3.16: Decentralized Wastewater Treatment System (Group Treatment)



Source: Modify from ITR – The Study on Improvement of Water Environment in Vientiane City, JICA 2010.

Figure 4.3.17: Proposed location of Wastewater Treatment Plant for Short and Medium Term Plan

Another facility in the wastewater management system that needs to be improved for Vientiane Capital is the Septage Treatment Plant at the solid waste dump site Km32. At present the plant is only a natural pond and the improvement to be a full stabilization pond system with some chemical addition should be considered to provide hygienic treatment of the removal sludge from each septic tank.



Source: JST

Figure 4.3.18: Proposed location of Wastewater Treatment Plant for Long Term Plan

(4) Operation and Maintenance (O&M)

For planning and implementation of a successful wastewater management system, preparation of a proper operation and maintenance plan is a key factor for sustainability of the system. Since construction of wastewater treatment facilities can be conducted with foreign assistance in the initial stage but after completion of construction and installation of all facilities, local authority will be the main body in charge of the operation and maintenance, for which VUDAA will play an important role together with the role of NPVC in combination with water supply service which should be further studied and considered. Therefore; preparation to support the long term plan is essential, and some of the items that need to be set up are as follows:

- Specific organization or unit in O&M in Wastewater Treatment System
- O&M budget
- O&M Equipment
- Monitoring of treatment efficiency

(5) Human Resource, Institution and Legal Development

Preparation and development of human resource and capacity building ranging from training and workshop is needed prior to the completion of Centralized Wastewater Treatment System in order to maintain efficient operation. Different staff levels and positions will have to be responsible in the wastewater management tasks with major requirement that can be illustrated in the Table 4.3.22 below.

Table 4.3.22: Staff levels and Positions of Wastewater Management

Position	Responsibility	Minimum Knowledge Level
Wastewater Management Planner	Overall planning and study in wastewater management	Master degree in environmental engineering/ environmental science
Environmental Engineer	General support in related wastewater activities such as during design and construction of the system	Bachelor degree in environmental engineering/ environmental science
Sewer Facilities Maintenance	Regular maintenance of the sewer network, manhole and pumps	Civil engineer and technician
Treatment Plant Operator and Maintenance	Daily operation, maintenance and monitor of the treatment plant	Environmental engineering/ environmental science/ civil engineer/ mechanical engineer/ electrical engineer and technicians for the above mentioned.
Laboratory Analysis	Water sampling and analysis	Laboratory Science
Tariff Fee Management	Manage in data collection on wastewater service user and fee collection	Bachelor degree with support technician

Source: JST

Most of the human resources required will be provided by the Government sector, such as DPWT, DHUP, WREA, STEA and VUDAA, and some tasks may be transferred to private sector if possible. The tariff fee management can be integrated to the water supply service i.e. NPVC, as it is assumed that all the piped water supply users are wastewater generators.

For the institutional and legal aspect, some improvement and preparation of a legal framework to supplement the existing law and regulations shall be considered, such as:

- Environmental fund

- Water quality monitoring and control
- Wastewater and water quality standard
- Conservation of wetland and natural pond
- Sanitary improvement
- Sludge and septage treatment
- Economic regulation, wastewater fee with polluters pay principle