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Can Combined Priority Bus Lanes, as a Preparatory Step of Bus Rapid Transit (BRT) Implementation, Improve Public Transport Service Performance? Assessing two Bus Route and Layout Options for the City of Chisinau/Moldova

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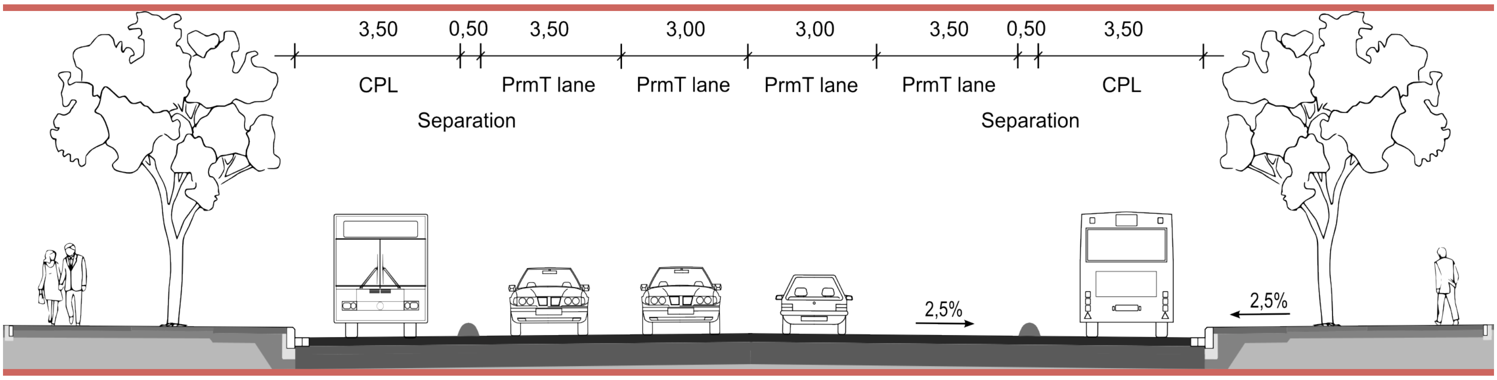

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Cover (Figure 19): Cross section of a carriageway featuring Combined Priority Bus Lanes using an example street in Chisinau's city centre (Design and idea LEDWOCH).

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Abstract

This study assesses the performance impacts of a projected exclusive Combined Priority Lane (CPL) network for the use of all scheduled public transport systems (trolleybuses, conventional diesel buses and minibuses) in the City of Chisinau. For the assessment, two in terms of network extent different route layout options were compared to the current public transport situation. The CPL design enables a subsequent Bus Rapid Transit Systems (BRT) upgrade. In a multi-layered approach a utility analysis was conducted, evaluating 15 performance indicators describing transport and economical efficiency, as well as societal and environmental impacts. Furthermore cost-utility estimations were made for the investment costs of the two layout options. The results were benchmarked with best practice development alternatives. For the procedure a set of empirical methodologies mainly from transport, social, and economic sciences as well as urbanism were used. The results point out that especially transport users and the local economy benefit from extensive travel time savings. In regard to the enhanced travel time competitiveness the measure entails a notable shift of trips from motorized to public transport, which proves to have a positive impact on local environment and energy consumption schemes. Accordingly, the overall rating of the CPL impact on Chisinau public transport performance was positive. However, comparing the CPL model with other development alternatives, it must be clear that it could only be the first step on the pathway to an efficient, equitable, attractive, and sustainable public transport.

Rezumat

Acest studiu evaluează calitatea impactului a unei rețele exclusive de Piste Prioritare Combinate (PPC) proiectate pentru utilizarea tuturor sistemelor de transport public (troleibuze, autobuze convenționale diesel și microbuze) în orașul Chișinău. Pentru evaluarea a doua, în ceea ce privește extensia diferită a rețelei, au fost comparate opțiuni noi ale traseurilor cu situația actuală a transportului public. Designul PPC permite dezvoltarea ulterioară a sistemului Bus Rapid Transit (BRT). Prin prisma unei abordări multilaterale, a fost desfășurată o analiză de utilitate, evaluând 15 indicatori de performanță ce descriu eficiența transportului și cea economică, precum și impactul asupra societății și a mediului. Mai mult decât atât, au fost realizate estimările de cost–eficiență a investițiilor necesare pentru cele două opțiuni de traseuri. Rezultatele au fost evaluate în raport cu bunele practici ale alternativelor de dezvoltare. Pentru acestă procedură, au fost utilizate un set de metodologii empirice, în mare parte din științele de transport, sociale, economice și de urbanism. Rezultatele cercetării indică faptul că, economia de timp pentru călătoriile cu transportul public, poate aduce beneficii, în special, utilizatorilor de transport și economiei locale. Datorită eficientizării timpului de călătorie, această măsura presupune o trecere considerabilă de la călătoriile cu automobilele private la transportul public, fapt ce va asigura efecte pozitive asupra mediului local și a schemelor consumului de energie. Evaluarea generală a impactului PPC asupra performanței transportului public în Chișinău a înregistrat rezultate pozitive, deși raportarea la alte alternative de dezvoltare a evidențiat faptul că PPC ar putea fi doar primul pas pe calea spre un transport public eficient, echitabil, atractiv și durabil.

Аннотация

Это исследование оценивает качество влияния эксклюзивной сети Комбинированных Приоритетных Полос (КПП) предназначены для использования всех систем общественного транспорта (автобусы, обычные дизельные автобусы и микроавтобусы) в Кишиневе. Для второй оценки, в которой отмечается расширение сети, новые параметры маршрутов сопоставлены с нынешней ситуацией общественного транспорта. Дизайн КПП позволяет дальнейшее развитие системы быстрого автобусного транспорта (БР Т) В свете многостороннего подхода был разработан анализ полезности, который оценивает 15 показателей эффективности, описывает транспортную и экономическую эффективность а так же влияние на общество и окружающую среду. Кроме того, были сделаны оценки экономической эффективности инвестиций, необходимых для двух вариантов схем. Результаты были сопоставлены с передовой практикой альтернативного развития. Для этой процедуры были использованы набор эмпирических методов, в основном в транспортной науке, социальной, экономической и городского планирования. Результаты исследований показывают, что экономия времени для поездок на общественном транспорте может принести пользу, в частности, пользователям общественного транспорта и местной экономики. Благодаря сокращении времени поездки, эта мера предпологает значительный переход от частных автомобилей на поездки на общественном транспорте, который обеспечит положительное влияние на местную окружающую среду и схем употребления энергии. Общая оценка воздействия КПП на характеристики общественного транспорта в Кишиневе положительная, хотя отчетность по альтернативному развитию, показало, что КПП может быть только первым шагом на пути к хорошому, справедливому, привлекательному и прочному общественному транспорту.

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Abbreviations and acronyms

Bul.	Boulevard (Romanian: bulevardul)
CBA	Cost-Benefit Analysis
CIS	Commonwealth of Independent States
cp.	Compare
CPL	Combined Priority Lane
CR	Capacity Restraint
CS	Current state
EBRD	European Bank for Reconstruction and Development
EC	European Comission
ECD	Energy Consumption Differences
ed.	Edition
Ed. / Eds.	Editor / editors
EIB	European Investment Bank
et seq.	Following page
EU	European Union
GDP	Gross Domestic Product
GIZ	German Society for International Cooperation
HDI	Human Development Index
inh.	Inhabitants
ITDP	Institute for Transportation and Development Policy
LDC	Least Developed Counties
LPS	Large-panel system building
LS	Late service
n/a	Not applicable
no.	Number
O/D	Origin/destination
OP	Off-peak
p.	Page
PAX	Passenger
PH	Peak hour
PrmT	Private motorized Transport
PS	Planned state
PT	Public Transport
PW	Part worth (utility)

Standi	Standardized Evaluation Framework for Infrastructure Investments in Public Transport
Str.	Street (Romanian: strada)
Tab.	Table
TDM	Transport Demand Management
TRL	Transport Research Laboratory
TTD	Travel Time Differences
UA	Utility Analysis
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
USSR	Union of Soviet Socialist Republics
vol.	Volume
VTTS	Value Travel Time Savings
w/o	Without

Units

sec	Second
min	Minute
h	Hour
d	Day
m	Metre
km	Kilometre
pkm	Passenger kilometre
kWh	Kilowatt hour
MWh	Megawatt hour
EUR	Euro
MDL	Moldovan Lei
B	Billion
M	Million
k	Thousand

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

Gustavo Petro

1. Introduction

1.1 Mobility and development

Mobility and development: An ambivalent liaison

Mobility is a key aspect in the developing world. Following the definition of Peter CERWENKA, mobility implicates flexibility and creativity (intellectual mobility), the opportunity to change one's own personality, life and social status (social mobility) and the possibility to change locations easily, safe and comfortable (spatial mobility) (CERWENKA 1999: 34 et seqq., HILDEBRANDT, DEUBEL & DICK 2001: 6). In science development is perceived in very different ways, from the economy-focused neoclassical concept to a more critical perception of post-development (RAUCH 2009, NOHLEN 2002, SCHOLZ 2004, ZIAI 2010). Likewise, the concept of mobility is a double-edged sword. As a matter of course, an environment of high intellectual, social and spatial mobility can have a high impact on society and the state, as it is strongly connected to collective and individual empowerment, self-determination and participation (LEINBACH 2000: 11). This connection between the three forms of mobility and economic development was indicated by LYKKE E. ANDERSEN for 18 Latin American states (ANDERSEN 2001: 17). On the other hand, it is the way of life and the economic style of the "developed" world, which constantly pushes the boundaries and thus elevates mobility to a dogma. As it is with development, "The Limits to Growth"[1] (MEADOWS, MEADOWS, RANDERS, BEHRENS III: 1972) are likewise not undeniable for mobility (KNOFLACHER 2010: 7). The globalisation-driven competition for production sites as well as the global movement of goods entails growing demands on spatial mobility. Apart from reaching the limits of its capability, considering the world's natural environment and resources (CHAPMAN 2007: 354 et seq.), the issues for spatial mobility also cause operative pressure, quality problems and dubious business practices among suppliers (OBERHOFER & DIEPLINGER 2013).

The availability of spatial mobility seems crucial for economic development. Many authors attest a significant impact to the availability of transport infrastructure on economic indicators, most of all to the gross domestic product (GDP) (inter alia DÉMURGER 2000: 115, SANCHES-ROBLES 1998: 106, CANNING et al. 1994: 306 et seqq.). Whereas other authors' statements are more cautious, including the consideration that upon revision economic development might generate traffic and the need for transport infrastructure (ESFAHANI & RAMÍREZ 2003: 443, WANG 2002: 430). Referring to the example of Eastern German states, it is obvious that the remarkable amount of subsi-

[1] A report by the Club of Rome

dy for infrastructure development did not generate respective economic returns here (BUCHHOLZ 2007: 22) and that infrastructure upgrade and economic development are not necessarily "siamese twins". Irrespective of the causality direction between economic activity and transport supply, it is yet obvious that for the Republic of Moldova economic activity could not advance either without suitable mobility supply. Recent economic growth rates with an average of 5% in GDP increase per year (The World Bank 2014b) state that the yet deteriorated transport infrastructure (MIHAI 2007: 14) will not be able to cope with a further increase in transport. Hence, transport supply deficiencies pose a serious handicap for the location's economic competitiveness. By far the most economic activity is aggregated in the capital, together with commercial sectors, which promise the highest revenues. Therefore it is especially the transport of Chisinau, which plays a key role in the countries future economic prosperity.

The need for sustainable urban transport development

Cities are becoming the living space of the future. While 30% of the global population lived in cities in 1950, it will be 60% by 2030 (UNUP 2013, KRAAS 2007: 80). Especially emerging and developing economies show high rates of urbanisation, creating large, complex and dynamic urban landscapes. Within the contemporary context of growing ecological and resource-efficiency pressure, finding suitable solutions for urban transit development becomes more and more challenging. Whilst transport development has hitherto been focused on quantitative growth, qualitative progress and creative ideas are needed in order to moderate the negative effect of high traffic volumes, on inhabitants, urban ecology and not at least economy.

As many Eastern European cities, Chisinau suffers from an uncontrolled boost of motorized traffic over the past decade, bringing private motorized transport (PrmT) infrastructure to and beyond its limits. The most obvious result is a severely congested traffic flow and a high level of pollution (MIHAI 2007: 14). The less obvious consequences are, amongst many, a constantly growing health impact due to pollution increase, a very high road accident risk and the loss of urban public space effecting people's communication and social life. In Chisinau public transport still has by far the highest share in modal split (see 4.1.2.2), though it is mostly concerned with long travel times running through notoriously delayed mixed traffic stretches. At the same time this situation affects the weaker part of society, which is the predominant user group of the public transport mode. The infrastructure for non-motorized individual transport alternatives is very limited and the low quality bus service presents the only mobility option so far.

1.2 Technical context

1.2.1 Sustainable transport policy instruments

Today a set of advanced transport policy instruments is provided, e.g. from respective development aid and international governmental and non-governmental co-operations, to approach the problems of low system efficiency, high travel times, high emissions, a poor road safety reality, space consumption through transport infrastructure, degradation of urban space and poverty-driven mobility exclusion. The most common approaches used amongst others are promoted by several UN agencies, development banks and international stakeholders as GIZ/SUTP, ITDP, TRL are:

Land use planning and Transport Demand Management (TDM): By influencing the spatial structure as well as location and degree of separation of urban functions in an urban environment, land use planning can contribute to a minimisation of kilometres driven and a high public or non-motorized transport share. A mix of urban functions and dense urban structures, save trips to work, shopping and leisure activities and reduce the general demand for transport (PETERSON 2004: 3[2]).

Implementation of an efficient mass transit: Every transport system has its own range of the best ecologic and economic performance. Passenger cars have their range rather in rural areas where public transport supply is difficult, expensive and comparatively inefficient due to low load factors. Within urban areas however, public transport load factors are potentially high, making motorized individual transport with its small vehicle sizes and capacity inefficient. Therefore, public transport and mass transit options present a crucial development instrument in urban areas, whereas automotive travel should not be understood as inherent. Amongst others, a mass transit system might be Bus Rapid Transit (BRT), Light Rail Transit (LRT), metro or commuter rail transit (WRIGHT[3] & FJELLSTROM 2005: 5).

Diversification and integration of transport systems: Individual transport offers to some extend "door-to-door" connections. Especially mass transit options though implicate a longer distance between the starting point of the trip and the point of mass transit access. Likewise the last part of the trip from mass transit to the destination point might be done by walking, cycling, using other public transport or even a private car. Therefore a suitable public transport option should be available for each link, integrated in an overall system. Amongst others, helpful measures can be co-ordinated scheduling, tariff and ticketing co-operations, integrated passenger information systems, free bicycle carriage in PT and infrastructure for individual transport integration

[2] Ed. GTZ/GIZ

[3] ITDP

(park and ride, bike and ride). Even if a trip consists of many links a well interconnected travel experience helps to reveal the best attractiveness of public transport (ITDP 2007: 463).

Non-motorized transport: For urban transport, bicycling and walking are the most efficient means of transportation. In most developing cities, average trip distances are extremely short. Often over 60% of trips are under 3 kilometres long. These 60% can be done without generating air pollution, greenhouse gases, whilst producing little noise pollution. Furthermore cyclists and pedestrians are more efficient users of scarce road (and urban) space than private motor vehicles, diminishing congestion (HOOK[4] 2003: 1).

Car free development: Today car-free measures are frequent and popular worldwide. "Home zones" (car-free, traffic calmed or shared road spaces in residential areas), car-free inner cities or historical centres and car-free shopping streets are only some of the examples, which can be found (to a lesser extend) in developing, emerging and industrial nations. It is the concept's goal to save or regain urban space for social life, communication, leisure time activities and culture; preserving the main idea of the city: being the living space of its inhabitants. Car-free development can be done with different intensity and as a graduated process, for example with traffic calming, shared space, single car-free streets, car-free neighbourhoods or car-free cities. Permanent or temporary car-free measures can be introduced, such as a car-free day in order to create awareness for liveable cities (WRIGHT 2005: 28).

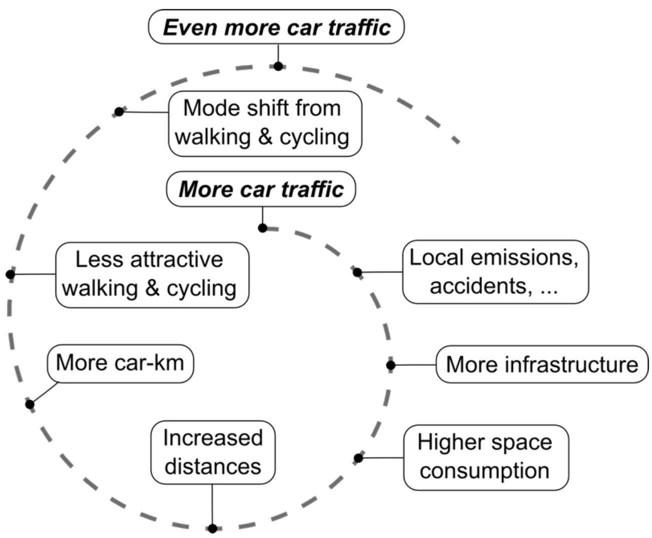

Figure 1: The vicious circle of motorized transport infrastructure promotion (Design: LEDWOCH following PETERSEN 2004: 3).

[4] ITDP

Resource saving development: In urban transport development resources can be saved in a multiplicity of measures. Some have already been presented above: Land use planning has the potential to avoid traffic, mass transit and motorized transport alternatives can lead to a shift of trips towards sustainable transport mode. But also a strategic focus of planners can save resources. Instead of solving transportation problems or balancing capacity shortages, investment in motorized transport infrastructure – for instance – generally has a high risk to enter the vicious circle of spending even more resources (Figure 1). The example shows the importance of decision-making in order to leave the high *path dependency* of high resource consumption (PETERSEN 2004: 3).

Ensuring transport accessibility and equity: Equity refers to fairness with which transport is supplied and accessible to everybody. Transportation planning decisions can have significant impacts on equity and accessibility. Groups of different social status often have a different access to transport supply in terms of availability, costs, travel times and quality. The inhabitants of peripheral low-income neighbourhoods, which are not adequately connected to public transport, are likely to be excluded from any mobility option, if automotive transport cannot be afforded. Further more high public transport fares contribute negatively to transport equity. Accessibility disprofits are also likely to be experienced by persons with physical mobility problems, which includes walking (suitable walkways, ramps and crossings) as well as public transport (station and vehicle access and seating), and is caused through infrastructure deficiencies. Exclusion from transport also means exclusion from society, as well as personal and professional evolvement. In order to ensure better transport equity, analysis and concepts are unavoidable previous to transport projects (LITMAN[5] 2002: 50 et seqq.).

Road Safety Measures: Especially in the developing world rapid urbanisation and (motor) traffic increase drastically impact road safety. With the high development dynamic road safety measures are often of secondary concern. At the same time user awareness of the high risk environment is low. International transport policy advice has come up with the *safe system approach*, which accepts human error as the main accident reason. The approach aims to improve infrastructure safety (e.g. with the appropriate layout and alignment of critical infrastructure elements) and regulation (e.g. speed limits, drinking and driving and general traffic rule enforcement). Raising awareness about these issues is the crucial aspect to reduce accidents. Furthermore the approach has the goal to develop a comprehensive management structure in order to implement road safety in a wider risk, economic an environment context (FLECHER[6] 2010: 4, OECD 2008).

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[5] VTPI

[6] TRL

Generally these instruments offer much prospects of positive change in the overall urban transport structure. Applying the whole set of them or large parts of it sets a course towards a contemporary and adequate urban environment with the high potential to create a fair, healthy and sustainable living space for its inhabitants (JONES 2012: 47).

1.2.2 Paving the way towards an efficient mass transit system

Right now in Chisinau none of the measures described above is effectively in place (Municipiul Chisinau 2004). Planning is insufficient and there is no TDM. A basic first step would be the implementation of an efficient mass transit system, which can be followed by the establishment of other (non-motorized) transport alternatives and their integration into a holistic transport system (JONES 2012: 41).

It is the main idea of this study to analyse a concept with practical interest, feasible for the city, considering the current financial situation. The approach focuses on the enhancement of existing *potentials* with minimal inputs, following the idea of using what already works and improving it to its best advantage. In Chisinau public transport is conducted with buses of different types. An analysis of public transport service (chapter 4.1.2.2) has made it clear, that every system suffers from performance deficiencies, and thus the overall system performance is far from the characteristics of an efficient mass transit system. Due to the limited financial transport development capabilities of the City of Chisinau, this study aims to examine a pre-option of mass transit implementation, which is the simple measure of Combined Priority Lanes (CPL) for all buses in regular service (chapter 4.2).

The CPL measure is not expected to improve the overall performance of Chisinau bus transit to an extent, where it could comply with the performance demands of a mass transit system servicing efficiently a city the size of 660.000 inhabitants (DGS 2013: 11). Conceptually it is close to a BRT system, so if further performance improvement should be necessary, it can easily be extended (chapter 4.2.1).

1.3 Regional context

The Republic of Moldova

Moldova is a small landlocked country in South Eastern Europe located between Rumania and the Ukraine. Historically the lands have been the contact zone between Balkan, Central European, Eurasian and Ottoman cultures. Due to the rich and fertile soils of the Dnepr Basin and the Eastern European Plain field traditionally cropping, horticulture and vineyards has been the main source of sustenance. Being part of the

Soviet Union (USSR) therefore the Soviet Socialist Republic of Moldova had a central role in agricultural production, making the country one of the wealthiest soviet republics. After independence 1991 the country became the Republic of Moldova. Since then it is struggling with a weak and lowly industrialized or technologized economy. Today Moldova is Europe's least developed country also having the least GDP per capita (UNEP 2014, The World Bank 2014a). Though during the last years economy performed strong, supported by improved political economy and fiscal management, however the country's economic development is still volatile. Agricultural products accounted for closely the half of the increase in 2013 (The World Bank 2014b) leaving the small and open economy vulnerable to global economic conditions and dependencies.

The context of transformation

With the collapse of the socialist system 1991, a political and economical transformation process begun with the phases of decline, transition, structuring and consolidation phases (MERKEL 2007: 420 et seqq.). While in Central Europe most countries became functioning market economies, progress in Eastern countries has been uneven, leaving countries stuck in transition with poverty and income inequality much greater than during socialism (TSENKOVA & NEDOVIC-BUDIC: 21). Especially the Republic of Moldova with the historical function being a food supplier within the USSR could not yet disengage from its dependence on exporting lowly processed agricultural goods and food products (LERMAN 2001: 99). Chisinau furthermore is exemplary for a post-socialist city that has not yet accomplished urban transformation, since also urban transition processes are delayed by a sluggish economic development. Urban transformation goes hand in hand with the transformation of transport structure, which is also well behind the development of other (South) Eastern European cities (TSENKOVA & NEDOVIC-BUDIC 2007: 354).

Why Chisinau?

The settlement structure of Chisinau at the moment shows a strong trend towards suburbanisation and reallocation of urban functions, which generates a growing number of undesired effects (not only) in terms of transport structure and demand (chapter 4.1). Urban transformation is the main driver of this process, but it is not completed yet, like in most other post-socialist cities (TSENKOVA & NEDOVIC-BUDIC: 21). Assuming the model of urban transformation (SAILER-FLIEGE 1998: 9) being also significant for Chisinau further development in the city is highly predictable. Thus a good opportunity for a field study on a (initial) sustainable transport development idea. Another process happening right now is the growing amount of motorized private cars, affecting the city's future transport structure and quality. The result of letting both processes continue can be seen for example in Bucharest, which yet experienced its traffic collapse (EMI 2012: 18). Therefore the examination area of Chisinau offers the chance to prevent a problematic development of the "functional city" as experienced in the Western world since the *Athens Charter* (LE CORBUSIER & GRAUDOU 1941). Not at least it is the purpose of this study to present first ideas, how to *leapfrog*[7] the step of an automotive, resource consuming and hostile urban development in Chisinau. The solution lies in the application of methods, which yet have worked for other places – as a matter of course after learning the bitter lesson of automotive cities (KNOFLACHER 2009: 91 et seqq.).

[7] Leapfrogging refers to a societal development processes, leaving out unfavourable development steps. It is connected to the idea, that (economic) resources of non-sustainable fossil technologies can be saved and directly invested in a sustainable development path, instead of tying and/or wasting them in a soon antiquated infrastructure. Leapfrogging is the counterpart of catch-up development, understanding development as the transition to sustainability (DALKMANN et al. 2004: 19).

2. Scope and structure of the study

2.1 Research objective and delimitation

The main research objective is the examination and evaluation of the projected implementation effects of exclusive Combined Priority Lanes (CPL) for the use of all scheduled public transport vehicles (trolleybuses, conventional diesel buses and minibuses) in the City of Chisinau. Therefore a thought model consisting of two different CPL bus route and layout options will be established. The performance of the two CPL options, the planned state 1 (PS1) and planned state 2 (PS2) will be compared to the current state of Chisinau's performance of public transport. In this context, performance of public transport is generally understood as a function of capacity, short travel time, reliability, the overall attractiveness and transport experience. Investments in infrastructure of the CPL measure, as well as a changing transport supply due to performance setbacks/improvements, influence a broad spectrum of aspects. Therefore, 15 indicators for the evaluation were chosen from the fields of transport efficiency, economy, society and environment to analyse in a multilayer assessment.

In addition to the core research objective, the impact results of CPL were benchmarked with performance effects of best practice examples in the discussion part. Furthermore feasibilities for all the options were assessed and compared and put into the actual economical and political context of Chisinau, also bringing up advice for a general development option for Chisinau. Please note that these topics stand outside the research objective. It is not intended to examine these issues to the point of highest accuracy, but to use their input for a multisided discussion and provide inspiration for further ideas.

2.2 Structure

This study follows the basic structure of a scientific expert's report, as amongst others common in Germany to clarify a certain sate of facts. With the aim not to omit important details it is kept as compact as possible. The distinction between a scientific expert's report and one from practice lies in the extensive explanation of the methodology and the discussion part at the end of the document.

As Figure 2 illustrates, in this study the process of gaining knowledge takes course in a set-up part, the procedure, an analysis and assessment part, and the final discussion. In the first part the thought experiment of the projected CPL implementation is set-up. It includes the determination and description of the examination area, the thematic set-up of the research object CPL, as well as the two comparison cases (PS1 and PS2), and includes information on the condition of the current state. In the procedure part all relevant information concerning the three comparison cases is gathered and calculated, so the results can be analysed and assessed in the following part. The results are finally interpreted in the discussion part, with best practice benchmarking also considering factors from outside the thought experiment.

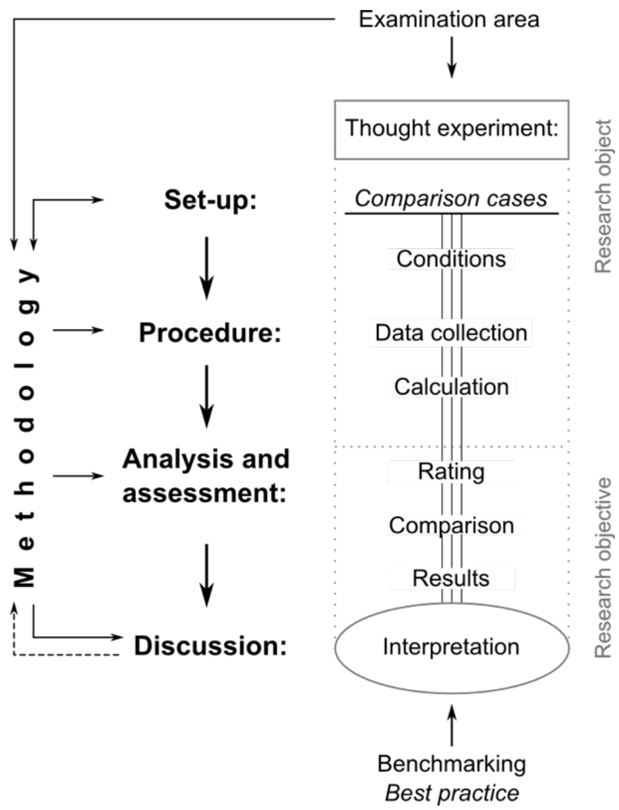

Figure 2: The structure of the study (Design: LEDWOCH).

Being in a feedback relation, methodology influences different steps of knowledge acquisition. First of all, the examination area highly affects the methodology, as circumstances of developing countries are expected to require a different set of methods (especially those of data collection and evaluation) than emerging economies or industrial nations. The setup process is yet determined by a clear methodology, though influences through the development of the comparison cases' characteristics further methodology implications for the consecutive steps. For the procedure as well as the analysis and assessment step methodologies are pre-set by the examination area characteristic depended data types.

Therefore, these steps are influenced by the overall methodology of infrastructure investment assessment; on the other hand feedbacks on concrete data collection and evaluation techniques come out of the process. In the discussion part results are interpreted respecting advantages and disadvantages, as well as quality and significance of data collection and evaluation methods. At this point a methodological feedback is given and the interpretation takes place under the awareness of eventual process deficiencies. A methodology correction loop would postulate different data collection respectively data quality, which was already considered in the beginning of the process and faces no alternative under the given circumstances.

3. Methodology

The main research goal of this study is the assessment of impact differences between three distinct settings – two planned states and the current state – suggesting a standard quantitative approach, as the *Standardized Evaluation Framework for Infrastructure Investments in Public Transport* (Intraplan 2006). However, this choice needs adaptation as it is further determined by two pre-conditions:

1. The difficult research environment (unavailable or deficient quantitative data) of a developing country with a special post-soviet information culture.

2. The study's demand of a multilayer assessment, focusing not only on technical aspects of transport and economical efficiency, but also on society and environmental impacts.

Quantitative data, that is primarily numerically represented abstract data, allows interpretation only if the data user is aware of the data's origin and background (WITT 2001: 3). As it favours exploration, a qualitative approach offers an alternative access possibility to fields with missing or unreliable statistic data (LAMNEK 2005: 90). Furthermore, some topics hardly offer qualitative interpretation possibilities, e.g. the impact of transport infrastructure decisions on urban structure (LOHSE & SCHNABEL 2011: 547). Therefore a combined qualitative and quantitative methodology approach was chosen. It uses a set of empiric methodologies from transport, social, geo, and environmental sciences for data collection and calculation, the selection of the evaluation subject (indicators), analysis, and interpretation. A helpful guide through methodology setup was the EC and CIVITAS supported practitioners' guidebook for urban mobility evaluation "Evaluation matters" (DZIEKAN et al. 2013).

3.1 Qualitative data collection techniques

3.1.1 Primary data

Expert interviews

For the collection of qualitative data one interview was held in December 2013. Additionally interviews from April 2009, conducted for an extensive student research work, the author carried out earlier (LEDWOCH, S. (2009): "Traffic structure analysis of the City of Chisinau/Moldova", at the Institute for Railway and Transport Engineering (IEV), University of Stuttgart). All interviews were a half-structured guideline interviews. It was structured through a list of questions, in order to assure no question has been missed out. The questionnaire featured open answer possibilities (DZIEKAN 2013: 36).

The director of the Chisinau trolleybus operator RETC as well as the main coordinator of public transport of the City of Chisinau were selected as experts due to their role and engagement in Chisinau public transport. The expert from city administration preferred though to answer the questions written. Therefore only one qualitative expert interview was conducted. Furthermore eight minibus drivers were interviewed to gather information on operation and travel times. As experts are assumed so due to their function (LAMNEK 2010: 656), minibus drivers were considered experts of the route's and operation characteristics, which they work on.

The qualitative interview of this study features a guideline questionnaire with thematic questions. For interviews with minibus drivers the same questionnaire was used for all minibus routes. The interviews were held in Romanian in presence of a translator. Due to this multilingualism, audio recordings (as suggested by KUCKRATZ 2010: 38) turned out to be rather confusing. The technique of immediate transcription using a notebook was chosen instead. For this reason transcripts have no continuous timeline. Furthermore they feature a dense content, without the transcription of pauses or filler words. Transcripts and information on the interviews can be found in Annex I.

Map analysis

Map analysis is a useful technique to collect primary information. In contrast to remote sensing this technique is not of quantitative, but of qualitative kind (BORSDORF 2007: 128). Map analysis was used in combination with other method for the exploration of an areas functional structure and living function supply. The map material used was Open Street Map (OSM), a collaborative free editable world map. For the City of Chisinau OSM offered the best data and information density, compared to other print and online map material.

3.1.2 Secondary data

Literature review

A comprehensive literature review was conducted to all relevant topics. German, English, Romanian and to some extend French and Russian language literature was screened. For the concern of primary literature, especially Romanian and Russian language literature was of interest. Most of the titles were professionally translated into English, using a Moldovan translation agency; fragments using the web translation tool Google Translate (Google Inc.). Secondary literature was basically of German or

English language. The literature review was conducted and archived using the open-source Zotero reference management software.

3.2 Quantitative data collection techniques

3.2.1 Primary data

Standardized survey

In order to gain mode shift from PrmT to PT and induced PT traffic data of the projected CPL, the methodology of a standardized survey was chosen. For representative results a sample size of 515 interviewees was chosen. Five local assistants held the interviews face-to-face. To cover different user behaviour groups, neighbourhoods with distinct social structures were chosen.

Each interviewee was asked the same questions in a standardized manner, without alternative filter guidance or questionnaire splits. Answer possibilities were numeric values or predefined using a code scheme, and were directly noted into a (physical) data collection sheet. Since the target group were car users, the questionnaire (Annex I.III) contained one general question verification question of this aim (Q1) and furthermore two questions on mode shift (Q2.1 and Q2.2) and two questions on induced traffic (Q3.1 and Q3.2).

For final data collection the physical sheet was digitalised in MS Excel to permit summarization and further comparison and analysis.

Calculation

For the investigation of travel time differences (TTD) of the three comparison cases the method of calculation was used. TTD are one of the most important information to assess traffic impacts and evaluate efficiency gains of a certain planning action (AHMED & VAIDYA 2004: 1). For an examination area in a developing country data complexity needed for TTD calculation is high, considering different service types (rush hour, off-peak and late services). Therefore a variety of data sources and collection methods were used, which are explained accompanying the calculation procedure. Furthermore the whole TTD calculation process covers several pages within this work. The main TTD calculation method was the *four-step approach*, often used in traffic forecast (LOHSE & SCHNABEL 2011: 211). The four-step approach also is the main algorithm behind macroscopic traffic demand models (cp. for example VISUM of PTV/Germany)and also the most common approach for decision-making in transport planning (PTV 2013).In this sense the results have the best structure for international comparison. The four steps include (McNally 2008: 38et seqq.).

An overview of the four-step approach with 1. Trip generation, 2. Trip distribution, 3. Mode choice and 4. Route choice together with procedure, the necessary input and gained data is given by Figure 3.

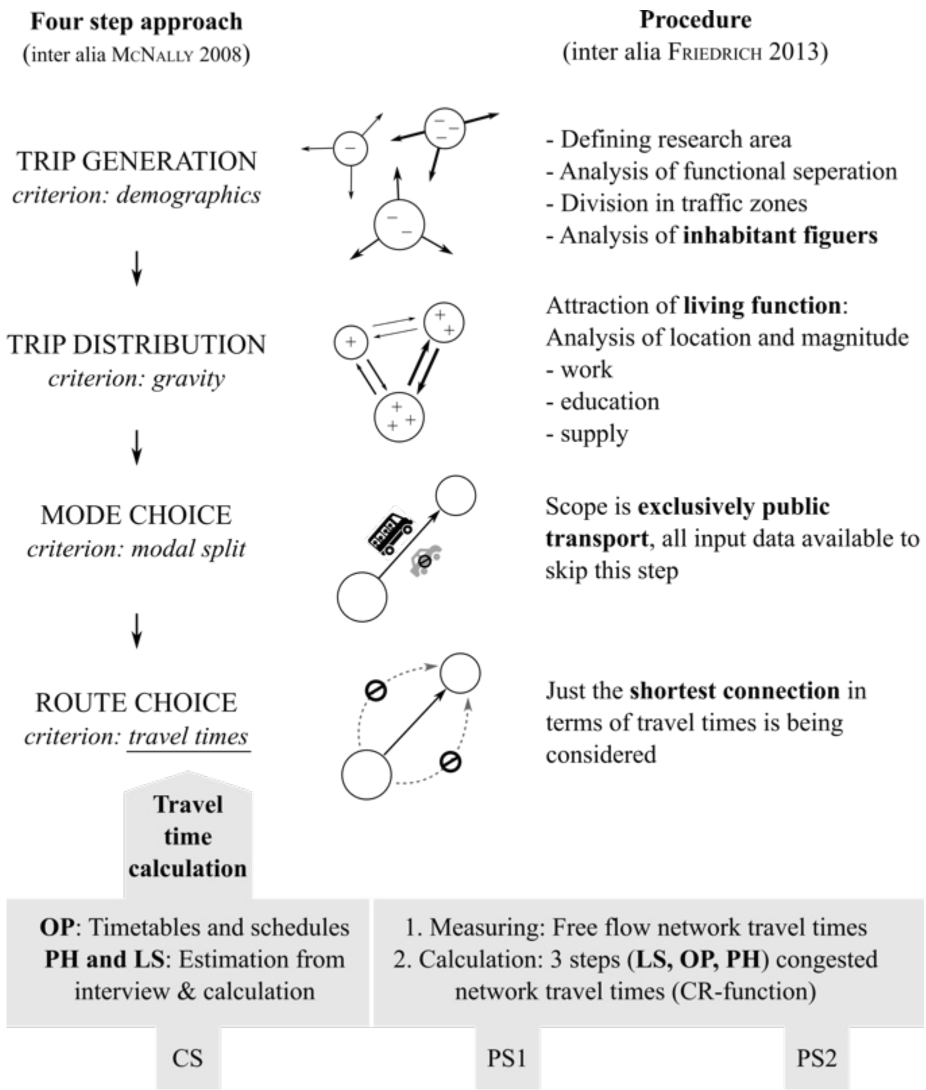

Figure 3: Overview of the four-step approach (Design Ledwoch).

To specify and segregate areas of traffic exchange, the examination area was divided in traffic zones. Commercial transport planning models would feature from 50 up to 1.000 zones for the city of the size of Chisinau, depending on the targeted level of exactness (e.g. the Frankfurt/Main metropolitan area traffic demand model features 800 zones (UFRRM 1999) or Freiburg/Breisgau with 61 zones (VWI 2010: 20). The calculation is being used for estimation with the requirement to be “just” significant enough to set the comparison cases in relation to each other partition in six zones should be enough to represent all the basic traffic flows within city districts. As a matter of course results used for operational planning would require more exact values. As the number of daily journeys and drip distance are pre-set, zone internal trips are notwithstanding respected in the calculation (LOHSE & SCHNABEL 2011: 276).

For journey distribution it is assumed, that life function of each individual (work, supply, education, leisure and communication) is not possible without change of location (MCNALLY 2008: 49). The information on those movements can be deduced from life function variables, which describe the level of attraction (of traffic) of each zone (LOHSE & SCHNABEL 2011: 260). Reflecting the overall problematic data availability situation of a developing country, statistic data describing the living function on traffic zone level is few or of poor quality. For this reason a qualitative approach has been chosen for this part, using the insufficient statistical quality data well considered and carefully for basic orientation, though complementing the information situation with qualitative interview and map analysis inputs.

Mainly structure and separation of urban functions was used as an alternative indicator for the determination of trip generation (FRIEDWANGER et al. 2005: 386 et seqq.). To follow the same logic as above, classical areas of traffic production are residential areas; whereas classical areas for traffic attraction are places of work or education, sales areas and cultural and leisure facilities. For example in a Western European city 0,695 journeys per day of employees are made to work, whereas 0,422 journeys per day of all residents are made for supply and 0,226 journeys per day for the reason of leisure (FRIEDRICH 2013: 84). (Examples figures for a less developed country in South Eastern or Eastern Europe could not be found.) Volume and length of those journeys will be lower for urban areas with a rather mixed use, as work and supply might be closer to the area of living, whereas high separation of urban function will force exchanges towards the location of work and supply (WÜRDEMANN 1999: 203, JESSEN et. al. 1997: 55). In other words, within a functional segregated urban environment the location of attraction points gives evidence on trip distribution, if the areas of production are known.

The results of the combined statistic analysis and qualitative investigation were organized and presented in a table containing an attraction description of each traffic zone. The attraction ratio was rated using the procedure advice of DZIEKAN et al. (2013: 55) with marks from 0 (no attraction), 1 (very little attraction), 2 (some attraction), 3 (quite attractive) to 4 (very attractive). For the rating tables see Annex I.II. The results were then converted to attractiveness coefficients and used in the journey distribution calculation.

The step of the "mode choice" does not apply, since the calculation is framed exclusively within public transport. The differentiation between different PT systems is further unnecessary, since all respected travel times are those of the fastest relation regardless of the PT system. For the research object it is moreover assumed that all vehicle types have the same travel times, which are those of the slowest service vehicle (see chapter 4.2.3).

For the final TTD difference calculation of the CS comparison case actual travel time data was used from December 2013, with few older inputs from 2012. The data was collected from operation schedules of trolleybuses (RTEC 2013), timetables from bus stops and the – by the time of research only and privately operated – information web site terra.md (ТЕРРИТОРИЯ МОЛДНЕТА 2013a, 2013b and 2013c). Also interviews with transport coordinators and operators and minibus drivers (Annex I.II) were held in this respect. For the determination of the planned states (PS1 and PS2) travel times travel times have been measured (see following chapter). Those times would only apply in an empty theoretical network with no other vehicles delaying the cruise of the only vehicle. For values that tend to be close to realistic travel times were recalculated using a capacity restraint (CR) function (FRIEDRICH 2013: 107). The function simulates travel times within a CPL network with a continuously growing number of other circulating CPL vehicles. In the following step the final differences between the travel times of the three comparison cases were calculated in hours per year.

Measuring

Measuring was used as a method of travel time determination for the two hypothetical comparison cases PS1 and PS2.As attempts to gain travel time data through modelling failed due to bad quality of input data, it seemed a promising approach to measure travel times for an empty network under laboratory conditions. The empty network assumes the possibility of a free run for the imagined transport vehicle.

Experiment setup: The measuring was carried out with a testing vehicle, a passenger car (VW Golf Mk6, model 1.4, Figure 30, Annex II.I) under exclusion of as many external influences as possible:

- No influences of other traffic (measuring was carried out at night time, between 2:00 and 4:30 h with no other vehicles circulating) simulating an empty network
- No influence of traffic regulation (no traffic control signals operating), simulating CPL priority in traffic hierarchy

Measuring conditions were furthermore simulating travel characteristics of an average transport vehicle (trolleybus, conventional bus and minibus):

- Choice of exactly the same routes as projected CPL
- Stop at each bus stop along the model route
- A waiting time of 30 sec[8] at each bus stop simulating passenger exchange (ENGELMANN, HAAG & PISCHNER 2001: 10)
- Waiting time of 30 sec[8] at intersections with two primary roads, simulating the average delay effect of passive signal priority. 30 sec at times of low demand[8] is well calculated (LEHNHOF & JANSSEN 2008: 5).
- An additional hold of 1 min[8] on Str. Ciuflea / Bul. Constantin Negruzzi as well as Bul. Stefan cel Mare / Str. Ismail and Bul. Stefan cel Mare / Str. Pushkin intersections in order to recognize critical bottlenecks (MIHAI 2004: 12).
- Slow braking and acceleration of the measuring vehicle in order to simulate the slower average braking and acceleration rates of the average PT vehicle using CPL
- Maximum driving speed of 50 km/h.

The result data as well as the scheme of measuring points can be found in Annex III.I.

3.2.2 Secondary data

Statistics

Since mostly unavailable for the purposes of this study, statistics played no key role for the overall data collection. Statistics contributed mainly with very basic information (e.g. inhabitant figures) with little potential to further exploit the information. However – if available – time tables were considered as an important aspect of statistical investigation, which was used for travel time calculation and comparison.

3.3 Input data collection overview

Table 1 shows the respective data collection technique for each field. The list contains all the basic input data of the study's procedure.

[8] Note that all holding times will be increased through capacity restraint calculation, depending on network congestion.

Table 1: Overview of data types and collection methodologies.

Data	Literature	Quant. interview	Qual. interview	Primary data	Sec. data	Map analysis
Urban structure	✓					✓
Inhabitant figures					✓	
Supply					✓	✓
Workplace	✓				✓	
Educational supply					✓	
Transport structure	✓		✓			
Mode share			✓			
Transport operations			✓		✓	✓
Travel times			✓	✓	✓	
Mode shift		✓				
Induced traffic		✓				
VTTS for Moldova	✓				✓	
CPL Investmt. costs	✓					
CPL Operating costs	✓					

3.4 Evaluation procedure

3.4.1 Evaluation methods

Not only in Germany – where it is a legal requirement and used in the federal traffic route plan (BMVBW 2003: 13, BJMV 2013) – the *cost-benefit analysis* (CBA) plays a main role for infrastructure decisions in transportation planning. Conducting a CBA, the costs of infrastructure projects are put in contrast to the monetarized benefit. A CBA for public transport projects does usually not solely consider direct economic impacts, but also impacts on national economy and society (SCHNABEL & LOHSE 2011: 569; SCHEINER 2009: 2). With the special characteristics of this study investigating in developing country conditions a number of indicators cannot be described quantitatively. In order to conduct a CBA it would be necessary not only have the indicators available but also monetarize them. For assessments in Germany this is done as standard procedure, though being usually contact point for criticism (MARTE 2012: 17 et seq.). For Moldova none of the required monetarized values could be found. It further does not seem to be conductive to the study's accuracy to determine these values within the limited extend of this study. The only exception is the value of travel time savings, since it is a key indicator. It is hardly comparable with the value of "hours per year" and so it had been monetarized in chapter 5.3.

The *utility analysis* (UA) avoids the basic problem of monetarization and uses a point system to rate the indicators and put them into relation. Finally the results can be compared to the costs of the particular measure. This approach is very common among economic cost calculation, within the context referred as "scoring model" (MINTER 2013). It had to be determined the best instrument for the following analysis. Comparing the overall results with other projects/cities, is a serious problem due to the ordinal UA results. Even the approach would be hardly replicable for different examination areas. Therefore the technique unfortunately just permits the comparison between the planned states and the current state within this particular setting (SCHNABEL & LOHSE 2011: 554). A further problem is the impact of subjective judgement. Choice of variables as well as the priorities expressed through weighting conflict an objective comparison. This problem concerns both evaluation methods, the UA and the CBA. But still this point does not necessarily has to be negative, as the disclosure of the subjectivity (chapter 7.1.2) can be the main driver of the discussion (SCHEINER 2003: 6 et seq.).

Furthermore the technique of *benchmarking* was used in the discussion part of this study. It is different from the more evaluative methods above, being focused exclusively on the comparison object and on its change of performance in a timeline. Benchmarking, however, has a focus on possible alternatives of action, encompassing the key elements of performance measurement. The key themes include performance measurement, comparison, considering a best practices level (IBRD & The World Bank 2011: 4). It will be used to compare the UA evaluation results to an overall frame of development options, discussing the advantages of the research object amongst other alternatives of action.

3.4.2 Conservative assumption estimation

For each statement or estimation in the evaluation process the technique of *conservative assumption* is being used. Compared to the *worst-case scenario* it does not consider failure in the sense of Murphy's law ("Anything that can go possibly wrong, does." (SACK 1952: 529) as a basis for all assessment. On the other hand it does neither assume an average distribution, which might just occur over a long perspective – due to probability. Making a conservative assumption presumes, if there is more than one possible outcome, the choice of the less favourable case. With the application of this method all statements and assumption do contain a certitude reserve within the procedure of this study. At the same time this implies that results might have an even higher beneficial impact, but not a worse one.

3.4.3 Indicator selection

To determine evaluation indicators for Chisinau on the one hand standard planning and evaluation regulatory guidance common in Germany was used, as far as it would fit to the special circumstances in Chisinau. On the other hand international and more dynamic evaluation methods were screened. A main source was the Standardized Evaluation Framework for Infrastructure Investments in Public Transport (German: "Standardisierte Bewertung von Verkehrswegeinvestitionen des öffentlichen Personennahverkehrs") (Intraplan 2006). In Germany this standardized benefit-cost-analysis scheme is mandatory to conduct for all state-financed infrastructure investments of over EUR 25M (Deutscher Bundestag 1996). It offers a set of indicators usually being monetarized for comparison (LOHSE & SCHNABEL 2011: 586 et seqq.). Furthermore Todd LITMAN's (2013) work "Well measured – Developing Indicators for Sustainable and Liveable Transport Planning" was found markedly helpful, as well as the "Lyon indicators" (NICOLAS, POCHET & POIMBOEUF 2003), a collection of sustainable transport indicators with special focus on user-perspective, social and environmental aspects, developed and advanced by the City of Lyon/France from 1996 until today on.

Allowing a choice of the below listed 15 indicators, reflecting the fact, that decisions in transport do not exclusively influence traffic performance and systematic indicators, but also impact transit users as well as the whole society, the national economy, resources and their consumption and the environment.

Table 2: Indicators and indicator categories for comparison case evaluation.

Category	Indicator
Transport	Shift to more sustainable modes
	Induced traffic
User	Service frequency increase
	Reliability improvements
	Travel safety and passenger services
	Amenity and travel comfort
Economical	Value of travel time savings
	Costs for accidents
Social	Accessibility improvements
	Costs for community
	Benefit for third parties
Environmental	Reduction of local emissions
	Energy consumption benefits
	Effect on urban space consumption

(Source: Intraplan 2006, LITMAN 2013, NICOLAS, POCHET & POIMBOEUF 2003)

In an ideal case indicators do not cut across the assessment categories, in order to avoid weighting distortions (SCHEINER 2003: 6). Though some of the chosen indicators interfere with other indicators. E.g. “Energy consumption benefits” and “Reduction of local emissions” mainly depend on the indicator “Modal shift”. This dilemma cannot be solved, as mode shift from PrmT to PT is highly interactive with energy consumption and emission quantities. Using mode shift as a “hidden reason” would not be possible since it has high intrinsic value expressing impacts on the transport system beyond environmental impacts. The indicator “value of travel time savings” on the other hand depends directly on the indicator “travel time savings”. As both describe different impacts – the one the monetary impact on economy, the other transport user supply benefits – this is no case of double weighting (ibid.).

3.4.4 Indicator weighting

The weighting was conducted according to the advice of LOHSE & SCHNABEL (2011: 554) and is displayed in Table 3. In order to check coherency of the weighting a sensitivity analysis was conducted within the step of methodology critique (chapter 7.1).

For the weighting at first the categories were divided. Transport systematic and performance indicators should have the strongest influence on the results together with impacts on the transport user. Together these two categories form 50% of the result significance. The other half is divided into the categories economy, society and environment, at which “economy” weights slightly more than “society” and “environment”.

Table 3: Categorized and weighted.

Category	Category weighting	Indicator	Sub-level weighting
Transport	**25%**	Shift to more sustainable modes	40%
		Transport capacity	40%
		Induced traffic	20%
User	**25%**	Service frequency increase	40%
		Reliability improvements	30%
		Travel safety and passenger services	20%
		Amenity and travel comfort	10%
Economical	**20%**	Value of travel time savings	80%
		Costs for accidents	20%
Social	**15%**	Accessibility improvements	50%
		Costs for community	45%
		Benefit for third parties	5%
Environmental	**15%**	Reduction of local emissions	40%
		Energy consumption benefits	30%
		Effect on urban space consumption	30%
Total	**100%**		

For the indicators a sub-level weighting was conducted forming in total 100% of the category weighting. Within the transport systematic and performance category a high impact has mode shift from motorized transport, since it is the main reason for transport improvement out of a sustainability promotion perspective. Transport capacity has further a high impact, describing to large parts the overall system performance. A lower impact have induced trips in the partly electric public transport system, since their negative impact is clearly lower compared to the other two indicators' benefit.

The user category is weighted with a quite comprehensible hierarchy. Service frequency increase as the most important improvement, followed (in descending order of rating influence) by reliability improvements, travel safety and passenger service improvements, as well as amenities and travel comfort.

The economical category usually has a far higher impact on results than 20%. In highly developed countries travel time savings alone account for as much as 80% of the overall benefits (AHMED & VAIDYA 2004: 5), whereas in developing countries they are lower or generally ignored in transport project appraisals, notwithstanding the importance. One of the reasons is the lower value of travel time itself. With even lower development levels, it becomes a marginal factor to the calculation (ibid.). Another reason is the lack of sufficient empirical evidence to support the conventional models for valuing travel time where work patterns, particularly of the poor, are diverse, making it difficult to distinguish between work and non-work activities (ibid.). Travel time savings are respected with a weight of 80% in the assessment, whereby the overall focus is not put on economic impacts of the transport measure. Road safety aspects, also affecting the national economy, are considered to have a comparably lower impact (20%).

The environmental indicators are weighted quite evenly. Reduction of local emissions and energy consumption though form a systematic unity, since both derive from the same influences. Consumption of urban space is a generally important issue with transport infrastructure investments and is weighted 30%.

4. Set-up

As explained in chapter 2 the study follows the basic structure of a scientific expert's report analysing a thought experiment. For the modelling of the experiment simplifications were assumed. First of all the model's extend was limited in reference to two concerns: A spatial limitation, determining a fixed examination area and influencing factors and processes within this area (chapter 4.1). In chapter 4.2 the research object is defined, limiting scope and complexity of the system. This step involves omitting irrelevant object details.

4.1 Examination area

4.1.1 Examination area boundaries

The examination area covers the Chisinau urban area and two of its closest suburbs. Considering the city's administrative division this are the city sectors Botanica, Buiucani, Centru and Ciocana together with its southern suburbs Schinoasa and Codru (see figure 4) The area includes the relevant service and catchment area of the projected CPL network (for details see planned states chapters 4.3.1 and 4.3.2) and all relevant urban areas contributing to the city's domestic traffic. Due to Chisinau urban structure and the research object set-up, terminating and transiting traffic are not considered for the evaluation of CPL, as it impacts inner-urban transit to the highest extend. The examination area in populated by 657.300 inhabitants (Annex III.I).

4.1.2 Characteristics of the examination area

4.1.2.1 Chisinau urban structure

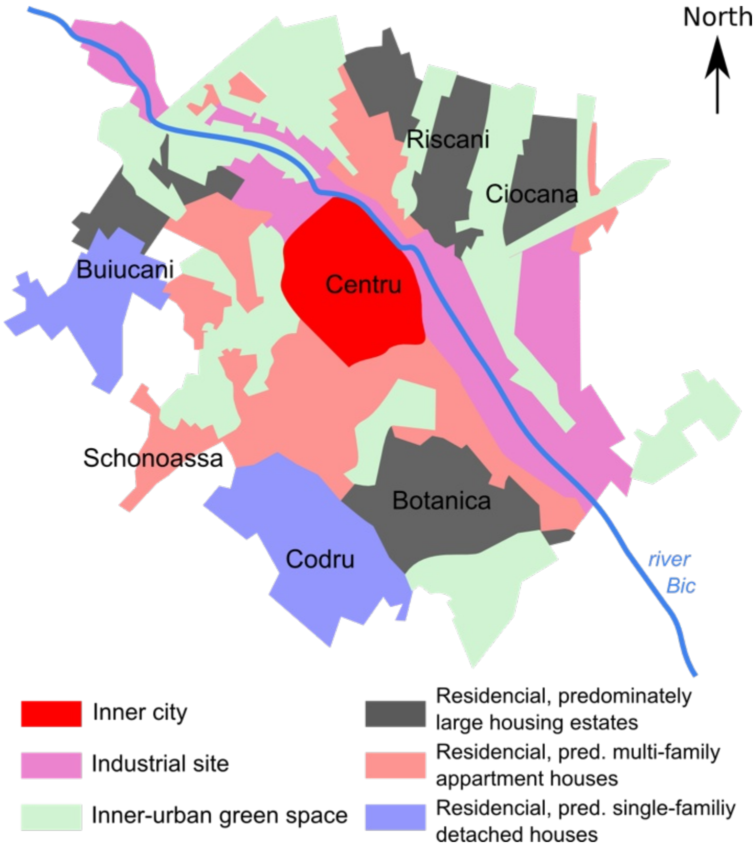

Figure 4: Examination area and separation of urban functions (Design: Ledwoch).

The urban structure of Chisinau is characterized by a high level of separation of urban functions. As seen in Figure 4 it is divided into a central business district (CBD), different types of residential function areas and an area function of predominantly industrial function.

The CBD is located in the inner city and roughly equivalent with the sector Centru. With the availability of goods for all demand types (daily, episodic and luxury) as well as a broad spectrum of western retail chains, it offers supply for the city and the hinterlands (Primaria Municipiului Chisinau 2004: 46). Likewise diverse and specialized services of the tertiary and quarterly business sector are offered here. Most financial and trading enterprises operating in Moldova can be found here (OSM 2014) as well as educational institutions, including the University of Moldova and the Moldovan Academy of Science (UM 2014). Furthermore Centru headquarters many political and administrative institutions oft he Republic of Moldova, including the government house and parliament (OSM 2014). Cultural institutions of national prominence, as the national philharmonics and theatre highlight the district's centrality far beyond the

City of Chisinau (ibid.). Residential function is mostly limited to high-quality and high-price dwellings nowadays (Primaria Municipiului Chisinau 2013e).

Figure 5: Large housing estates in Botanica. (Source: Geoview).

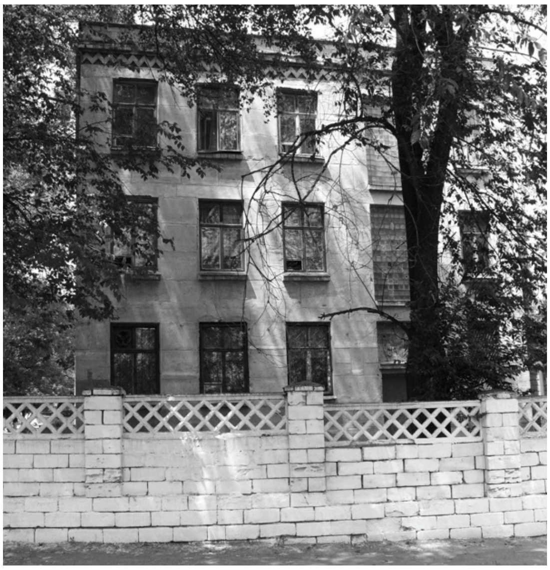

Figure 6 : Urban multi-family dwellings (Source: FÜG)

Figure 7: Beginning residential suburbanisation in the Chisinau surroundings (Source: LEDWOCH).

For urban areas with residential function, there are three types: Large housing estates are located as satellites at the city's edges (Figure 5). The ground plan of the populous neighbourhoods is characterized by block arrangement of large housing estates constructed in concrete and large panel construction typology. Usually they are aligned alongside a magistral connecting to the city's centre, with small access roads intersecting. Historically the satellites have been functionally independent subdivisions, nowadays offering a declining number of living functions. Between the large housing estate the multi-family dwelling neighbourhoods are located (Figure 6). As Centru could be accessed by walking, their supply always depended on the daily markets and shopping possibilities of the centre. Few suburban single-family detached-houses (Figure 7) residential areas can be identified near the city borders. They are of different genetic types. Former independent villages like Codru and Schinoasa nowadays experiencing moderate residential suburbanisation. On the other hand large areas as the southern part of Buiucani experience extensive waves of residential suburbanisation (OSM 2014). The socialist city – even though urban functions were highly segregated in high-density residential areas – had an unintended structure of decentralized concentration. This reduces travel necessity and potentially reduces transport demand (SAILER-FLIEGE 1998: 9 et seq.).

The cities and villages in the outer conurbation area of Chisinau were no suburbs or commuter towns, but separate units offering job, supply and education. This interaction of living and supply could also be seen in the inner city. As the counterpart to the western consumer and business orientated CBD the city centre was a place of culture and living. For its inhabitants, a neighbourhood of short distances. Even the large housing estates offered an independent structure of supply, saving today's trips to either the mall or the city centre. (BOHN 2009: 156, STANILOV 2007: 414). After the Soviet Union's (USSR) collapse land price became the main structuring principle of urban transformation, fostering suburbanisation of the residential function, retail and commerce and services (TSENKOVA, NEDOVIC-BUDIC 2007: 354, PICHLER-MILANOVIC, GURTY-KORYCKA & RINK 2007: 104). As Figure 8 shows in schematic way this process of suburbanisation has not yet terminated in Chisinau. Residential suburbanisation is advancing, though suburbanisation of retailers is yet just punctual (OSM 2014). Beyond suburbanisation, also the functional change of the inner city and declining supply options within the large housing estate neighbourhoods have a negative effect on traffic demand, increasing traffic volumes. Together with a general redirection of traffic flow from the (nowadays inconsequential) industrial areas to the new centres of economic activity, Bologan MIHAI's practical study on PrmT congestion in Chisinau (MIHAI 2007) is proven theoretically.

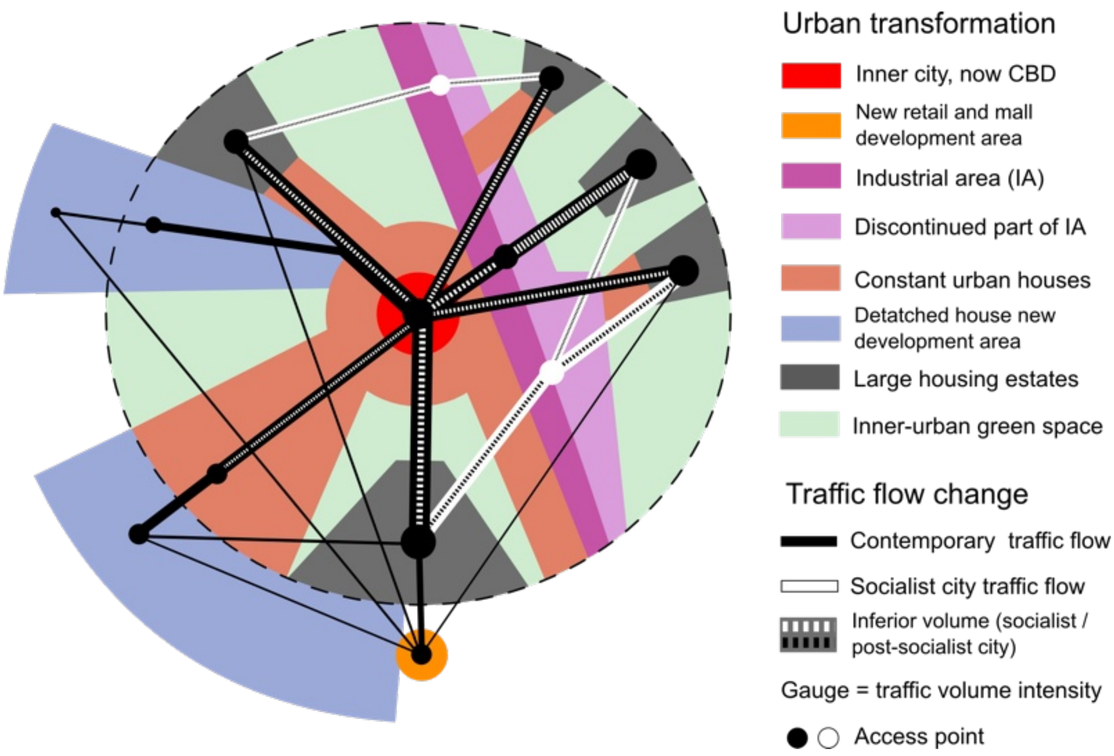

Figure 8: Schematic urban transformation with beginning suburbanisation in Chisinau and the resulting change of selected traffic flow connections (Design: LEDWOCH, following the scheme of posts-socialist urban transformation of SAILER-FLIEGE 1998: 9 and 11).

The understanding of these actual processes of urban transformation and the impacts on traffic flow redirection and volume change will be of high importance for the four-step model travel time calculation (chapter 5.1) and furthermore in the discussion part disputing the impacts of suburbanisation on traffic demand and the consequences for Chisinau urban transport (chapter 7.4).

4.1.2.2 Transport structure

Individual transport

In Chisinau 677 km of urban roads are available for motorized urban transport, of which 255 km (47%) are inner-urban high-capacity corridors. Most (91%) are solid concrete roads, covered with asphalt, being advantageous for handling heavy traffic (Primaria Municipiului Chisinau 2004: 69). The city's main traffic axes run concentrically between the large housing estate areas (Figure 4). In soviet infrastructure planning tradition the connection roads were largely dimensioned and mostly offer two or three traffic lanes per direction (Figure 9). Though the post-socialist urban (see chapter 4.1.2.1) and social transformation process fosters increased transport demand as well as, with the ideology of individual instead collective transport (TSENKOVA 2007: 21, PUCHER 1990: 278 et seqq.), rising car-ownership. Even though the corridors are dimensioned amply, at many waypoints capacity limits are reached and more and more bottleneck situations occur (MIHAI 2007: 4). Furthermore this situation deteriorates, as the connecting axes are not only used by the city's internal traffic, but also for transiting traffic of the Trans European Network (TEN-T) Austria – Romania – Ukraine – Russia magistral E58 with other minor long distance roads (e.g. E581, E584) passing directly through the urban area (OSM 2014), affecting the inner-urban exchange corridors with over 20% in 2007 additional truck and passenger car traffic, with increasing tendency (MIHAI 2007: 14).

Figure 9: One of the largely dimensioned main connecting axes (Source: LEDWOCH).

Figure 10: Cars parked on the walkway of the main shopping district (Source: LEDWOCH).

Infrastructure for non-motorized private transport is very limited. Walkways are badly maintained, deteriorated and blocked by parking cars, making walking difficult; whereas few and unsafe (heavy utilized) roads crossings expose pedestrians to a high road safety risk. Except of the Catedralei square and the Gardina Publica Stefan cel Mare there is no traffic-calmed urban space within the city. The pedestrian space remaining not being used by ample carriageways is to some part heavily disrespected by car users (Figure 10). Cycling infrastructure, such as continuous bicycle lanes or paths does not exist. At the same time roadside cycling can be hardly considered convenient. Generally non-motorized transport is heavily subordinated and exposed to motorized transport (Primaria Municipiululi Chisinau 2004: 69).

Public transport supply

In Chisinau public transport features trolleybus, conventional bus and minibus operations. There is no significant rail transport offering urban or short distance services (CFM 2014).There is no transport association or tariff cooperation. PT fares differ per transport system: MDL 2 (approx. EUR 0,10) for trolley and conventional bus and MDL 3 (approx. EUR 0,15) per minibus one-way ride with no possibility to connect on the same ticket. To handicapped and retirees free rides are offered (Primaria Municipiululi Chisinau 2006: 8). It is worth to note, that Chisinau PT fares are among the most modestly priced worldwide.

The three transport systems operated separately. Trolleybus operations are organized by Regia Transport Electric Chisinau (RTEC), conventional bus Parcul urban de Autobuse (PUA) and the minibuses by 18 small operators from private economy (Primaria Municipiululi Chisinau2004: 70).

Figure 11: A ZIU trolleybus in Chisinau (Source: commons.wikimedia.com).

Figure 12: A modern AKSM trolley on Bul. Stefan cel Mare (Source: LEDWOCH).

The trolleybus basically connects the city sectors with the centre using the main corridors with 26 lines and a route network of 523,6 km (ibid.). Except few areas, overall trolleybus network coverage is very good. Service frequencies differ per line and service type from three to 25 min intervals (Primaria Municipiului Chisinau 2006: 8). The trolley bus fleet consists of 336 articulated units, including an operational reserve, offering around 27.500 seats with 280 units in daily service. In 2007 a large part of the fleet was marked by a high degree of physical degeneration with 22% of the aging ZIU buses (Figure 11) being older than 20 years (Andrus 2013, ТРОЛЛЕЙБУС НЫЙ ЗАВОД 2013, Primaria Municipiului Chisinau 2004: 70). An on-going fleet renewal replaced since 2008 almost 50% of the oldest vehicles with new low-floor AKSM standard trolleys (Figure 12). With final assembly of the Belarusian buses done in Moldova, the investment costs could be reduced to EUR 132.000 – 151.000 per unit (Unimedia 2013).

Conventional buses (Figure 13) serve 31 routes to more peripheral urban areas in a subordinated network. They density the bus network apart the main large housing estate – city centre connections serviced by the trolleybus with a total length 282 km. Service frequency varies widely, also being generally lower than the trolleybuses' frequency. The fleet consists of 110 various diesel standard buses. Over the half being high-floor MAN standard buses introduced since 2000 (Primaria Municipiului Chisinau 2004: 70).

Minibuses (Figure 14) operate the most extensive and dense route network (2.053 km) offering 94 service fixed routes. The network covers the entire urban area and has no special focus area. As routes are fixed, some city centre streets have been excluded from the minibus traffic due to minibuses contributing to general congestion (Mihai 2007: 14).

Figure 13: A MAN high-floor bus (Source: LEDWOCH).

Figure 14: A typical Mercedes Sprinter minibus (Source: LEDWOCH).

All minibus lines are operated by 23 (2006) private enterprise companies (Primaria Municipiululi Chisinau 2006: 7). Therefore operations are characterized by economic considerations. Supply is highly orientated on demand. During peak hour service frequencies can be as little as one minute per service on certain routes. In order to conduct as many turns as possible during this time the driver usually tries to keep passenger exchange times minimal and travel speeds maximal. During off-peak and late hours, service frequencies depend on passenger demand and can contain slower travel speed and waiting times, in order to pick up as many passengers as possible. Though the minibus is the most competitive public transport system within the difficult Chisinau traffic conditions.

Mode share

The share between the PT systems is very different. With an annual transport volume share of 37% of the passengers, the minibus is the second important transport system after the trolleybus (56%). This is explainable with the advantage of competitive travel times, the easy access and the dense network. The conventional bus though carries 7% of the passengers per year. (Primaria Municipiululi Chisinau 2006: 70).

As a result of general supply characteristics as well as the demand induced through demography, economic development status, society and urban structure (CMC 2014) the modal share for Chisinau is formed as shown in table 4:

Table 4: Modal split estimation for Chisinau 2009.

	Public transport	Private motorized transport	Cycling	Walking	Total
Share	60%	25%	0%	15%	
Journeys/d	824.000	340.000	0	200.000	1,4M

(Source: Copaci 2013, cross checked: UNECE 2004:15, EPOMM 2011).

The increasing motorization rate is shifting riders from the traditionally strong public transport share (The Wold Bank 2013). Walking is used to access PT or left to those have no possibility to access PT, though long-distance walking is rather uncommon in post-socialist developing economies (BASETT et al. 2008: 799). The share of this sustainable transport mode is stable, but compared to other (South) Eastern European cities low (22% Bucharest, 32% Budapest, 36% Vilnius). Cycling is virtually inexistent, though not being very common in other post-socialist cities either (Bucharest, Budapest and Vilnius at 1%) (EPOMM 2011).

4.1.3 Public transport development constraints and potentials

Operative and service performance problems

Chisinau public transport performance is limited regarding some important aspects. (Listed in decreasing order of impact gravity):

- Travel times: Sharing the limited mixed traffic infrastructure is problematic and does highly affect PT. It shares not only mixed traffic flow, but has few alternative routing options, but the overloaded connecting corridors. The consequences are long PT travel times and incalculable delays through long congestion hold-ups.
- Trip planning: PT user face problems planning their trips due to lacking time tables causing waiting times of unpredictable duration at PT access points. Furthermore travel times are unreliable due to the traffic hold-ups.
- Accessibility for handicapped: Up to date solely 31% of the PT vehicles (chapter 4.1.2.2) offer low-floor access passengers with reduced mobility. Furthermore bus stops and information infrastructure are not equipped appropriately to serve disabled.
- Road Safety problems of minibuses: Insensitivity to traffic rules, high travel speeds, ticket-vending done by the driver while driving and passengers standing during travel are the most hazardous factors contributing to safety records far beyond regular public transport (MORGOCI 2013).
- Passenger services: Beyond the planning problems for PT trips there is a general lack of passenger services, ranging from the absence of a tickets allowing line transfers to bus stop equipment.
- Travel comfort is limited due to the frequent situation of high passenger loads with few seating places offered. Though this situation is improving with the on-going fleet renewal, up to date high-level entries and the high share of degenerated vehicles cause discomfort.

A performance quality rating of the current Chisinau PT can not be done objectively, as it is not clear what the comparison values should be. Without further responsiveness, compared to other Eastern European cities it might offer a very poor performance. Comparing the PT of the Moldovan capital to other countries with a similar development and economic situation it might perform better than most of its "HDI-neighbours" (e.g. Indonesia, Botswana, Egypt, Mongolia, Paraguay, Bolivia) (UNDP 2014). Though still it is sure the factors listed above influence Chisinau PT perception and image in a negative way and fixing them should be first priority in any case.

Structural development constraints

The public transport performance insufficiencies listed above are the effect of a number of transport development constrains, being interlinked and influencing each other. The most obvious constraint is the difficult financial situation. Following a decade of no investment since the USSR's collapse, the financial situation for transport investments is improving slowly, also through development co-operation with the EU and EC institutions (EC 2013).

Another main constraint is the lack of political concern, resulting out of political underestimation of the topic's importance and impact (potentials). This deficit is highly connected with the absence of adequate transport policy and planning institutions. The whole individual and public transport, as well as it's infrastructure is planned by a dozen persons in three different institutions. The lack of policy institutions leads to know-how problems and irrational conceptual and investment priorities and bad practices, as unilateral promotion of motorized transport (MORGOCI 2013). As no integrated development master plan exists, there is no stringent development strategy, not even a durable transport development plan. In fact, principal PT planning has inverted many times. Within the last years, in randomly changing order the focus was put on improvement strategy of the bus system or planning of a light rail system (PROTV 2011). Furthermore the highly deregulated regulatory and economic environment in Moldova leads to an urban development outside of governmental/municipal control. The resulting urban structures, e.g. of suburbanisation of supply, are visible in Chisinau and often contrarian to resource-saving development interests (PICHLER-MILANOVIC, GURTY-KORYCKA & RINK 2007: 114).

Public transport development potentials

Potentials to develop an efficient, resource-saving and sustainable transport in Chisinau are limited, though some effects could become useful.

- Mixed traffic infrastructure offers good conditions for PT development: Carriageways are dimensioned very amply on all main PT connections (see Figure 9). Though a small number of bottlenecks (see chapter 4.1.2.2) paralyzes both, motorized and public transport. Since solving bottleneck problems for mixed traffic use would quickly cause new bottleneck situations, problems can be easier solved exclusively for public transport. As a matter of course this would need political attention and interest, which is not present at the moment.

- Favourable physical carriageway design for exclusive PT development: 90% of the streets in Chisinau are concrete grounded with a covering layer of asphalt (see chapter 4.1.2.2). For heavy single lane bus operations concrete carriageways minimise road maintenance costs (LOHSE & SCHNABEL 2011: 133).
- High share of cost-neutral PT system: The minibus operates on a self-liquidating cost structure without further subsidies. On the one hand this is favourable, since it broadens the limited financial margin of the City of Chisinau and could allow the reallocation of financial sources for improvement measures. On the other hand the operation of minibuses in urban transport can be seen critically due to worse capacity utilisation and higher emissions than standard buses and furthermore high accident rates (see chapter 6.1.9 and 6.1.14).

Generally frame conditions need to be changed if positive effects should be relieved of from these potentials. Furthermore some are critical since they interfere with other user groups (PrmT) or due to the questionable promotion of the minibus stem.

4.2 The research object: CPL

4.2.1 General characteristics and BRT delamination

The overall aim of Combined Priority Lanes is to meet a certain (pre-set) capacity demand (see next chapter) at lowest investment cost possible, using basic though effective planning features. Transport development potentials (see chapter 4.1.3) are few in Chisinau, but they form a suitable trilogy for CPL implementation: The carriageways being of interest for CPL are mostly spacious, their grounding is of concrete allowing heavy traffic with high frequency on a very limited space (lane). A potential usually not appreciated in this context, for instance for BRT planning, is the minibus. In Chisinau this transport system works without further subsidies. Abandoning it from the CPL concept would mean higher subsidy costs for the overall system in order to fill the transport volume gap arising due to minibus exclusion.

The concept uses a number of BRT features, as it is intended to be a BRT pre-step or at least doesn't harm further BRT development plans. CPL capacity improvements mainly arrive from the regulated and controlled operation of PT vehicles on lanes separated from mixed traffic, CPL trunk lanes. The difference from BRT is the very basic arrangement and the absence of further additional measures of service improvement (Table 5). Using the recently introduced BRT rating scheme by ITDP, the measures for Chisinau would fail the two of five minimum criteria to be rated even basic BRT (ITDP 2013).

The only exception of this "low-cost" concept is the investment in timetables. For cities before CPL implementation lacking timetable information, the back fitting of this passenger service can be helpful, as this is one of the most basic passenger services and general requirement of PT access.

Table 5: Implementation requirements for BRT and CPL.
✓ minimum requirement, **O**optional, ✗ no change projected

	BRT	CPL		BRT	CPL
Trunk			Station security	O	✗
Driveway renewal	✓	✗	Public utilities (WC, shops, ...)	O	✗
Lane separation	✓	✓	Commercial space	O	✗
Partly busway colorization	✓	✓	**Integration**		
Traffic signal priority control	✓	✓	Feeder infrastructure impr.	O	✗
Intersection underpasses	O	✗	Park and Ride facilities	O	✗
Passing lanes at stops	O	✓	Bicycle parking	O	✗
Pedestrian crossings	✓	✓	Taxi	O	✗
Landscaping	O	✗	**Fare collection**		
Stations			Ticket vending machines	✓	✗
Level platform construction	✓	✗	Ticket registering units	✓	✗
Passenger information	✓	✓	Fare collecting IT	✓	✗
Travel comfort upgrading[9]	O	✗	Intelligent fare collecting	O	✗

(Established according to ITDP 2007: 343 et seqq.).

4.2.2 Cost-orientated characteristics

With the aim to gain performance improvements with the expense of as little money expenses as possible, investments exclude everything not affecting transport infrastructure capacity. Therefore all of the assets listed above in table 5 were analysed for their impact on PT efficiency. Only lane separation, busway coloration, signal control and overtaking lanes were detected to have a direct effect. Additionally passenger information (as it is fundamental for transport supply and was non-existent before) and

[9] Can include sliding vehicle access doors at platform, comfortable seating and waiting areas, covered or with sophisticated buildings, station identification signage, climate control, reconstruction of transition and station access area and further aesthetic design features (ITDP 2007: 361et seqq.).

measures of passenger and pedestrian safety (since the safety situation should by no means worsen with the CPL) are included in CPL implementation.

4.2.3 Operational characteristics

Operational aim and technical measures

As uncompetitive travel times have been identified as the main PT supply deficiency the projected measures focus on achieving a stable and continuous traffic flow and the avoidance of long hold-ups. In this context the high travel speeds are not the crucial criterion, as distances between bus stops are short and vehicles tend to accelerate slowly. Furthermore the calculation is capped from the legal traffic speed limit of the Republic of Moldova of 50 km/h for inner-urban roads (UNECE 2009). The measures to achieve these goals are the establishment of busways on all main corridors of the city (different extend for PS1 and PS2), physically separated from mixed traffic and with specially marked entries, traffic signal priority on all relevant intersections and up to 50% of bus stops equipped with overtaking lanes.

Minimum system capacity

CPL benefits are evaluated on the assumption of a concrete minimum capacity the busway provides. This minimum capacity demand are travel times not being delayed more than 80% in the peak-hour congested network, compared to free-flow travel times. Travel time difference calculation and all relevant evaluation is based on this demand of maximum 80% peak-hour travel time delay.

The minimum capacity goal on the one hand does not put a to high/unfeasible pressure on the network infrastructure. On the other hand still allowing comparatively fast travel in the network (of 19 km/h average speed compared to other European cities: 16 – 25 km/h (ITDP 2008: 6 et seqq.) and a high travel time difference potential compared with today's situation.

Generally the full technical design of the busways is not explained in detail, as this information would not be needed for the comparison cases evaluation. Exclusively the determination of investment costs depends on the design characteristics of the busway. In order to determine these costs, ensuring at the same time the minimum delay demand of 80%, *conservative assumption* (chapter 3.4.2) was used, overestimating the necessary infrastructure dimensioning. For the costs the same method was used, delivering at least the true costs of CPL implementation. With an exact technical calculation of the investment actually needed, cost will be lower. The cost estimation was done using the ITDP "Bus Rapid Transit Planning Guide" (ITDP 2007).

Rolling stock

The combined priority lanes are used by the same PT vehicles, which run on the respective routes today. This includes all three bus systems: trolleybus, the conventional bus and minibuses. Although policy-makers and planners would not advice minibus operations on this kind of infrastructure (ITDP 2007: 548 et seqq.), the exclusion of minibuses is not intended. The financial aspect of operating 37% of the fleet without subsidies is at the moment assumed more important than efficiency disadvantages through the smaller vehicle size. Since infrastructure complies with minibus operation, no travel time delays affect CPL the decision. In this context the assessment is conducted with the present-day (December 2013) figures of Chisinau PT fleet. The on going fleet modernization might have further positive effects on the results, but it is not considered in assessment.

Network

The two general network layout possibilities are a network of direct lines (figure 15) or a high-capacity trunk route (BRT, light rail, metro or suburban rapid rail transit) and light rail or bus feeder system with interchange knots (figure 16). Chisinau today features a system of direct lines, which has the advantage of avoiding interchanges. The trunk route/feeder arrangement though is the potentially more efficient system, with high capacity and usually faster transit on the trunk lines and demand adapted feeder routes (ITDP 2007: 21). The Chisinau CPL idea assessed in this study does not include a general change of bus operation characteristics. Beyond this for clear trunk-feeder structure and exclusive feeders services also a vehicle/service hierarchy would be necessary, together with an advantageous ban of minibuses from the CPL and the development of interchange knots. As this is not the matter, no changes in feeding system are planned. Though with CPL reorganisation of the city's main traffic axes, a process of bundling will take place, creating trunk routes and with system of *complementary lines* (cp. Johannesburg BRT, ITDP 2008: 21). In this sense it is projected for Chisinau, that service lines leave the high capacity lanes for their destinations at the same route points as before. With increasing CPL professionalism reaching BRT system standard, more effective feeder structures could be reorganized to more efficient concepts.

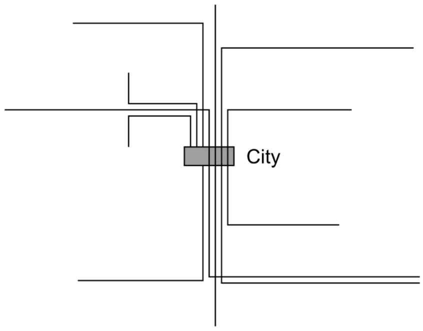

Figure 15: Direct lines throughout the network (Design: LEDWOCH).

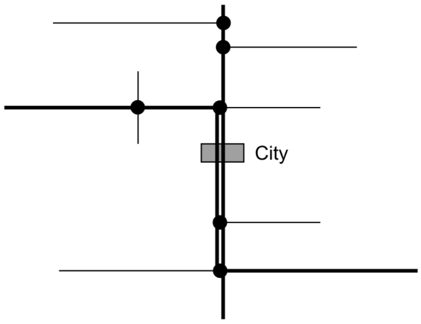

Figure 16: Trunk routes with interchange knots for feeder services (Design: LEDWOCH).

4.2.4 Infrastructure and service features

In the context of evaluation, infrastructure and service feature characteristics are mostly of interest for cost, operational and passenger service quality estimation. Therefore the projection does not feature a detailed technical description or planning. It solely describes briefly the relevant aspects for indicator estimation.

Busway surface material

Suitability of roadway material depends on PT vehicle axle weight and the service frequency envisaged. For high capacity usage concrete driveways deteriorate by far slower than driveways covered with asphalt (ITDP 2007: 346). As a positive fact and heritage of soviet roadway construction habits (WHITE 1979: 234 et seqq.) all projected CPL trunks yet feature concrete pavement or concrete covered with asphalt (Primaria Municipiului Chisinau 2004: 69) offering a high level of deterioration resilience and lower maintenance efforts.

Lane separation

In most cities worldwide driving and enforcement culture are a stressing an unharmed CPL traffic flow (ITDP 2007: 349). Therefore also in Chisinau lane separation would be helpful to physically prevent PrmT vehicles from entering the CPL. The lane separation method takes its example from BRT. Amongst others, adequate barriers can be blocks, bollards, curbing or walls. Chisinau CPL is projected with low rubber blocks (figure 18) as they seem a good compromise between restraint and costs, also making it possible for the bus to leave the CPL in case of heavy obstruction or emergency (ITDP 2007: 349). Busway coloration (figure 18) for the first meters after busway entries, e.g. after intersections will further attract attention can be also helpful to underline the exclusiveness of the bus lane.

Figure 17: Lane separator blocks (Source: FJELLSTROM, ITDP 2007).

Figure 18: Busway coloration (Source: APA 2013).

Traffic signal priority control

Intersections are the critical element for system capacity and travel times along the CPL corridor. Therefore signal control measures can help to minimise CPL traffic delay. In order to control traffic signals in favour of CPL, two strategies can be applied: Passive and active signal priority control. Passive signal priority – extending green phase for the CPL relevant traffic directions – is a basic control method without the need of physical change or investment on the traffic signal equipment. The effects of this measure are delay reductions of four to ten per cent on intersections. The more effective (up to 20 per cent delay reduction), but also costly control method would be active signal priority, using real time information (usually with transponders) of vehicles approaching the intersection in order to change signal setting (ITDP 2007: 312et seqq.).

For the projection of Chisinau CPL the option of passive signal control is chosen and respected in travel time calculation (chapter 5.4). Considering this aim to save costs, for passive signal control, solely costs for modifying traffic light signal equipment occur. For corridors with low service frequency, active priority is used to avoid unnecessary long green phases for one traffic direction, with few PT vehicles benefiting from it. In Chisinau CPL service frequency is high on all trunk routes, so this misallocation of priority would not occur. Furthermore the Chisinau CPL trunk uses exclusively primary roads and is therefore mostly intersecting subordinated roads. At these intersections passive signal control is therefore not affecting main mixed traffic flows.

Pedestrian crossings

Despite the aim to keep investments as low as possible, passenger and pedestrian safety should not be compromised. Furthermore as the effect of CPL operations on the already defective road safety situation for pedestrians in Chisinau (WHO 2013: 173) is uncertain. Therefore an across-the-board provision of up to 60 (PS1) respective 50

(PS2) additional safe pedestrian crossings with signals for the most hazardous crossings is included in cost calculation.

Passenger services and fare collection

As described in chapter 4.1.2.2 passenger services in Chisinau are currently characterized of high insufficiency. It is beyond question that investment in passenger service as listed in the BRT feature comparison catalogue above (Table), e.g. travel comfort, travel safety[10] and not at least accessibility of travellers with reduced mobility, would be important. Though this study analyses a transportation concept for the City of Chisinau feasible the within current financial situation and improvements to these service aspects would make the measure unfeasible. The only exception is made for passenger information, following the idea that improvements in other fields (travel time savings, reliability gains and the possibility of timetable introductions) can only be apprehended by knowing of them through information (ITDP 2007: 321). In order to do so, the currently virtually non-existent passenger information is projected to be improved to an at least very basic level: conspicuous bus stop identification posts, timetables and network maps at each CPL station. Furthermore three information kiosks are projected to be positioned at strategic locations to service passengers with information and tickets.

Fare collection through on-board ticket vending by conductor personnel travelling in each bus or trolleybus (chapter 4.1.2.2) works at a satisfying basis. In fact for the PT customer this system might be more easy and comfortable than most automatized solutions in developed countries. Furthermore the presence of at least one conductor/service person moderates the effect of lacking overall passenger service.

Fare collection on minibuses is usually carried out by the driver, mostly while driving (chapter 4.1.2.2). With this practice being a serious safety risk, either an affordable alternative should be found, or fare collecting only during standstill at bus stops should be enforced. Because of the small vehicle size passenger boarding times should not exceed those of the buses. For the further procedure no budget for minibus fare collection modifications was allocated.

4.2.5 Physical design and alignment

In Chisinau the streetscapes of all projected CPL corridors feature at least a 36 m cross-section (Bul. Stefan cel Mare, Str. Ismail, Bul. Constantin Negruzzi, Str. Mihai Vieteazul) with many parts of the corridor exceeding this value (Str. Ciuflea: 52 m, Sos. Hincesti: 52 m, Bul. Moscova: 56 m, Calea Iesilor 66 m, Bul. Mireca cel Batrin:

[10] It means the safety of travellers and personnel against violence. Not to be confused with transportation/road safety – the absence of transport accidents.

72 m, Bul. Dacia: up to 76 m) (cross-section widths measured with Google Earth 2014). A typical layout for the 36 m minimum cross-section is illustrated in figure 19.

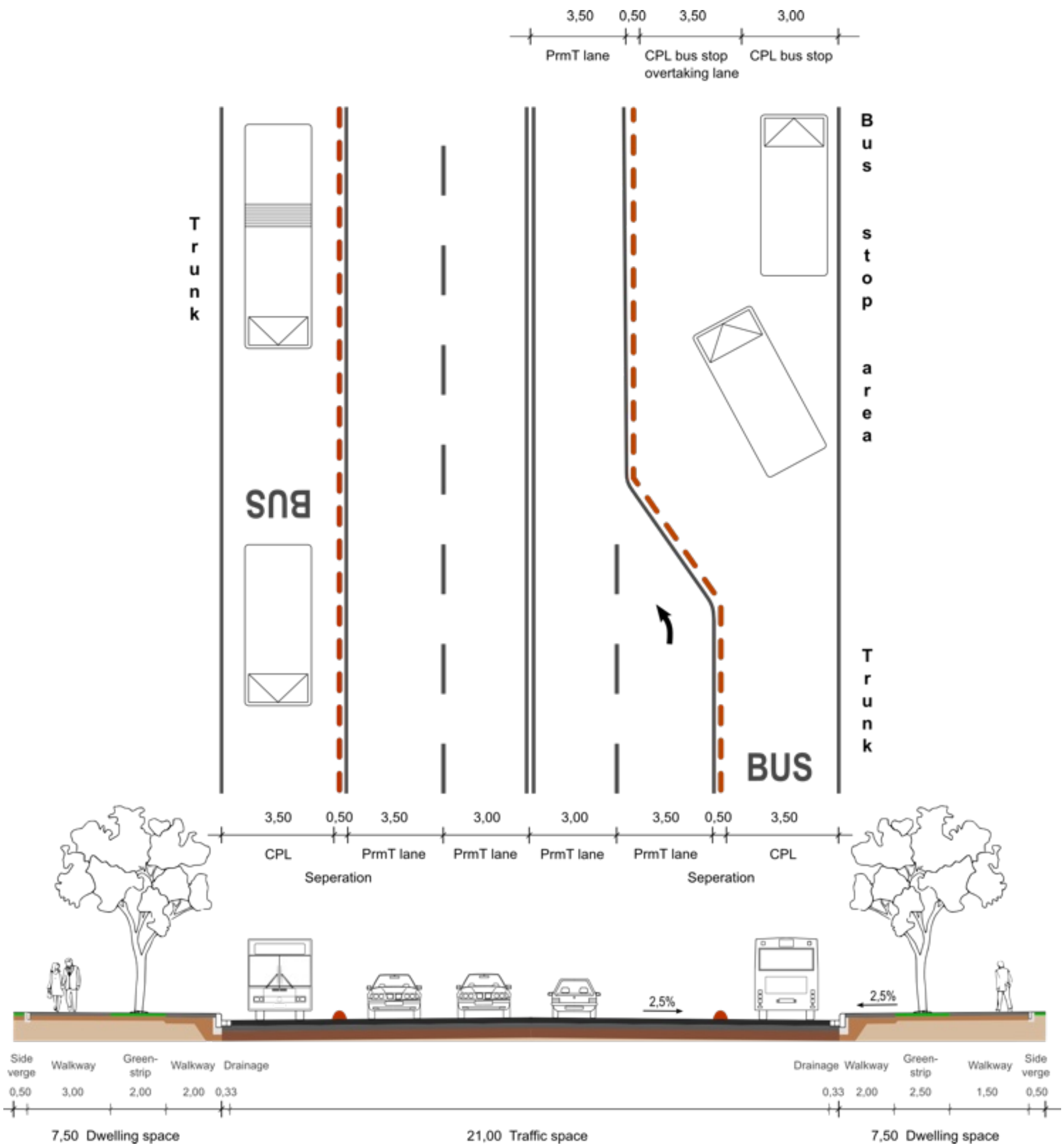

Figure 19: CPL trunk and bus stop lane design and alignment for a 36 m cross-section (all values in m) (Idea and graphical realization LEDWOCH, standard specifications from ITDP 2007: 343 et seq.).

BRT systems are preferably designed using median busways and platforms (ITDP 2007: 183), though edge alignment is not unusual either, as the examples of very efficient BRT in Bogota/Colombia (Transmilenio) or Guadalajara/Mexico (Marcobús) show (MALOUFF 2013). Central bus lanes would require the reconstruction of central bus stations together with either a completely new bus fleet featuring left-side (of travel direction) passenger doors, or operations with a left-hand driving direction. As yet the reconstruction of median bus stations is an criterion for exclusion, the Chisinau CPL busways are projected at the carriageway's edges, without rendering further BRT development impossible (ITDP 2007: 184).

Station layout and passing lanes

Besides waiting times at intersection, station layout is critical issue for system capacity. The trunk itself is not very problematic. Vehicle throughput – even for many vehicles driving in a row at generally low speeds (50 km/h) and without further impact – can be high on the trunk element (SCHMIDT 2003: 9).

A relevant feature of the station layout is the number of stopping bays. Multiple stopping bays permit multiple vehicles to service one station simultaneously. Although most busway systems launch passing lanes primarily for express services, the existence of overtaking lanes can have a very positive impact on traffic flow stability, especially at very busy stations (ITDP 2007: 269). Furthermore the possibility to overtake might balance the disadvantage of slower dispatching, compared to a BRT system. Within the further procedure of this study all travel time calculations and impact assessment is based on the self-imposed capacity demand of a maximum 80% travel time delay for the maximum congested network (i.e. peak hour), compared to (imaginary) free flow network travel times (see chapter 5.1).

Stopping bay dimensioning can be done considering service frequency, vehicle types servicing the stop and experiences from the current state. As the improvised character of bus stops using the simple curb for passenger boarding and alighting will remain, generous dimensioning would not be a problem or bear additional costs. For overtaking lanes dimensioning is relevant for cost calculation. A microscopic traffic flow simulation (e.g. VISSIM), which would allow the dimensioning of the passing lanes (PTV 2013) would be beyond the reasonable workload of a thesis of this type. Therefore the number of necessary passing lanes was assigned trying to overestimate the minimum requirement in any case, with 50% of the CPL stations projected to have passing lanes.

As shown in figure 20 and mentioned above, alignment would be at the carriageway's curb. Bus stops not featuring an overtaking lane stops can be arranged on the direct opposite of each other. For stations with overtaking lanes alternating station alignment should be chosen, in order not to impact mixed traffic unnecessarily. The stations will be positioned at the same locations as today. For the passenger the bus stop will therefor feature the same configuration as today.

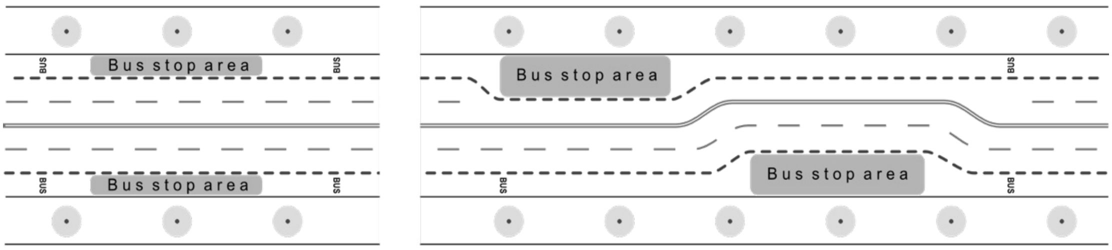

Figure 20: Bus stop alignment possibilities (Idea and graphical realization LEDWOCH).

4.2.6 Impact on mixed traffic

A detailed analysis of CPL implementation impacts on mixed traffic or even the establishment of PrmT concepts accompanying the measure are not within the scope of the study. A short estimation of the effects is listed here to enable a integrated view for the further procedure.

Lane capacity

Using the examples from BRT, many projects do not have adverse effects on mixed traffic (ITDP 2007: 688). Furthermore Chisinau streetscape offers good preconditions to introduce separated lanes for public transport. Even compared to other post-socialist cities as Bucharest, Warsaw, Kiev, Minsk (OSM 2014), each having the standard elements of broad magistrals and well-dimensioned traffic routes, in Chisinau almost no important connection is left with a carriageway featuring less than three lanes for each traffic direction. With CPL implementation mixed traffic will be affected by decreased road space availability:

- At the main corridors the reduction of three to two lanes per direction should not be a problem – situation might even be enhanced due to demixing of traffic having, improving traffic flow stability, as random and often unpredictable stopping of PT vehicles on mixed traffic high-capacity corridors will cease (ITDP 2007: 689).
- At bus situations with overtaking lanes for one of the traffic directions one lane has to be relinquished for the bus stop area (Figure). Especially the lane merging point buries high congestion potential.
- At today's bottleneck intersections (see chapter 4.1.2.2) impacts evolve diversely. As passive signal control is used for the CPL (chapter 4.2.4), PrmT using the same travel direction will benefit from longer green-phases, which could balance the impacts from decreased road space availability for this direction. Turning or using the subordinated (non-CPL) travel directions will most likely face longer waiting times.

Of course the effects generally are subject to unsteadiness in matter of travel times, having a far higher impact during peak-hour then in off-peak hours.

Parking

Since on the main traffic axes no parking is supplied (OSM 2014), CPL will have no impact on the largest sections of the network. Within the city centre few parking sites exist, so most parking is done curb-side or on the pedestrian walkways (ibid.). Both methods of parking need access to the curb, which is not possible with CPL lanes established. Hence the CPL measure would reduce a significant quantity of parking space in the city.

Cycling

Cycling is the best alternative to motorized and public transport. Within the range of 5 km cycling is the fastest and most environmentally friendly mode of transportation in cities. Using an electric bike instead of a car is far more efficient and sustainable and can easily be done up to a range of 15 km (UBA 2012: 63). As of today, the share of cyclists contributes to 0% to the Chisinau mode share (chapter 4.1.2.2). The "low-cost" conception of CPL can hardly contribute to promotion of cycling. Therefore this topic is subject to further BRT development or general bicycle promotion plans. Unfortunately the situation for cyclists might not improve, as cycling on CPL is not foreseen. Cycling on the middle lane now, instead on the curb lane might increase the subjective exposure to motorized traffic.

4.3 The comparison cases

To gain further information, which layout would suite best to the Chisinau transport demand and in order to have a broader basis for interpretation, two different projected concepts (planned state 1 and planned state 2) have been developed featuring different characteristics concerning CPL length. The comparison cases include the whole public transport system and infrastructure of the examination area as it is today. Except the infrastructure of the designated routes being modified to CPL.

4.3.1 Planned state 1 (PS1)

For PS1 the network is displayed in figure 20. It features radial connections of the large housing estate sectors with the city centre; it also offers concentrical connections avoiding the way through the centre for travel between those sectors. With this layout the concept covers all of todays primary and secondary inter-urban traffic flow relations. Therefor it copes with the changes in transport demand resulting out of urban transformation (chapter 4.1.2.1). Additionally an express service route is projected between the most populous sector Botanica and Centru using the Valea Trandafirilor park bridge, avoiding the detour via the railway station and the North Eastern central district.

Following the layout of today's main PT routes, the CPL is split in the South of Centru. From Pantelimon Halipa square the he incoming CPL is continuing towards Str. Ismail, whilst the outgoing CPL uses Str. Vasile Alecsandri. This enables to access this part this part of the centre, without further effort to change one-way traffic routing in this part of the city centre. Furthermore on the high of Telecentru an adoption had been made. Today only the outgoing traffic uses Sos. Hincesti. Due to a general closure for traffic of the underpass between Str. Miorita and Str. Academiei, PT is forced to detour using Str. Gh. Asachi. Though the reasons for this one-way closure of the underpass are not known by the author, the CPL is assumed to run through it.

Network length: 60,9 km; Number of bus stops: 138.

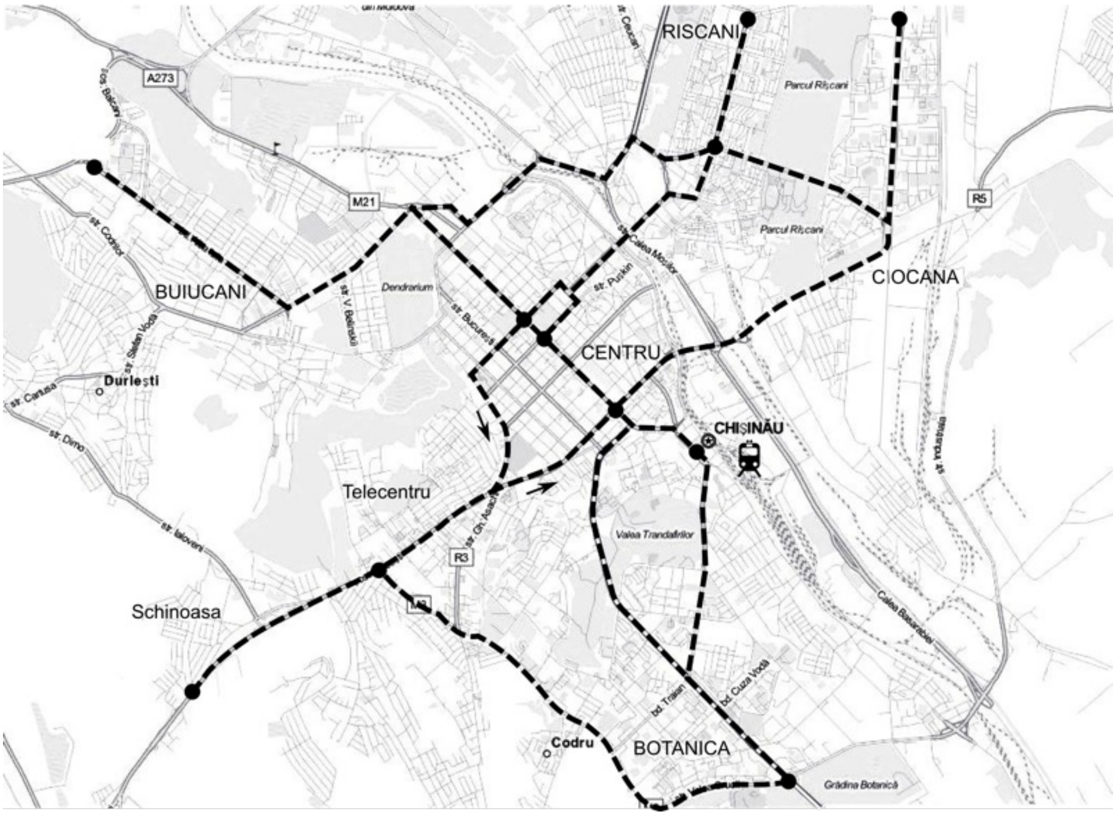

Figure 20: PS1 route network (Design LEDWOCH, map source: OSM 2014).

4.3.2 Planned state 2 (PS2)

As it can be seen in figure 21, the PS2 route layout features a basic variation of the PS1 network: The radial connections are the same, but there are no concentric CPL connections. As a matter of course the concentric relations are still supplied by regular PT at today's service level. Generally the result differences between PS1 and PS2 will describe, weather it is more beneficial to implement just a basic network covering the main axes (PS2) or a more sophisticated and extensive network supplying secondary relations also. Furthermore the express service from Botanica to Centru is not intended for this planned state.

Network length: 49,4 km; Number of bus stops: 94.

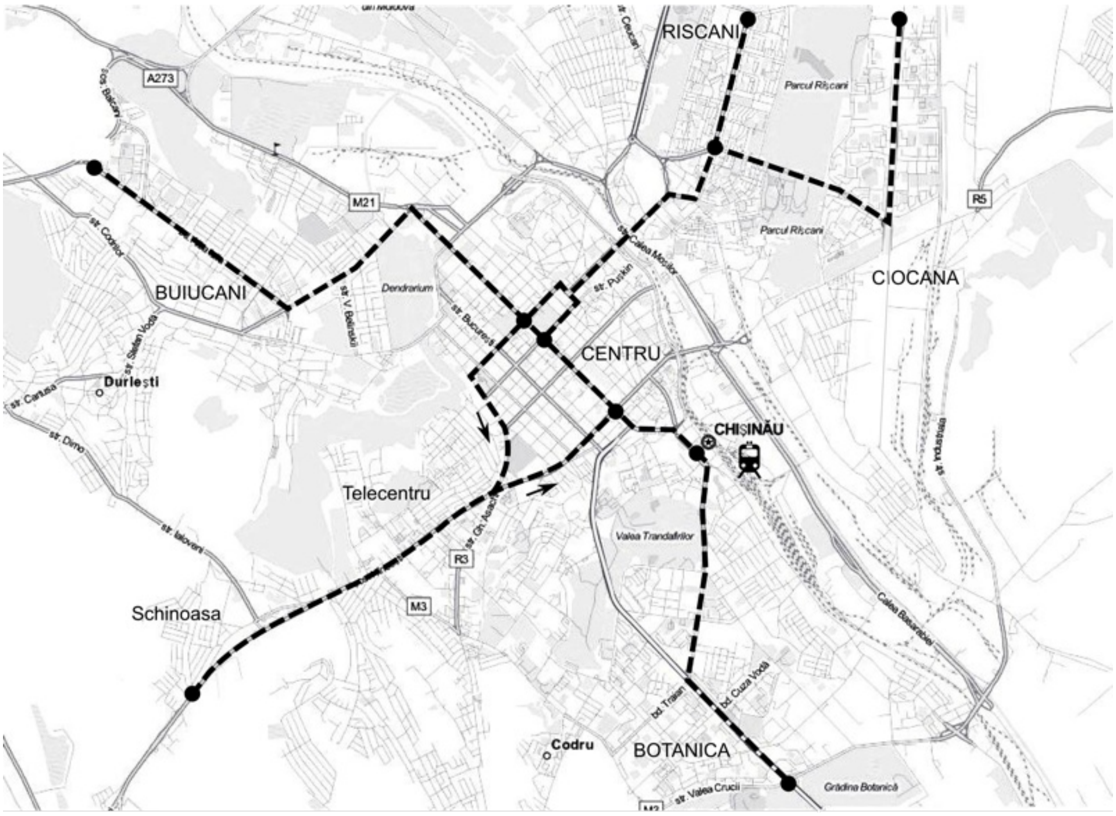

Figure 21: PS2 route network (Design LEDWOCH, map source OSM 2014).

4.3.3 The current state (CS)

The current state respects the overall public transport infrastructure, operations and organisational structures of December 2013. As much travel time data as possible was used of this time, with few older inputs. The earliest inputs are from 2012.

5. Procedure

5.1Travel time differences (TTD)

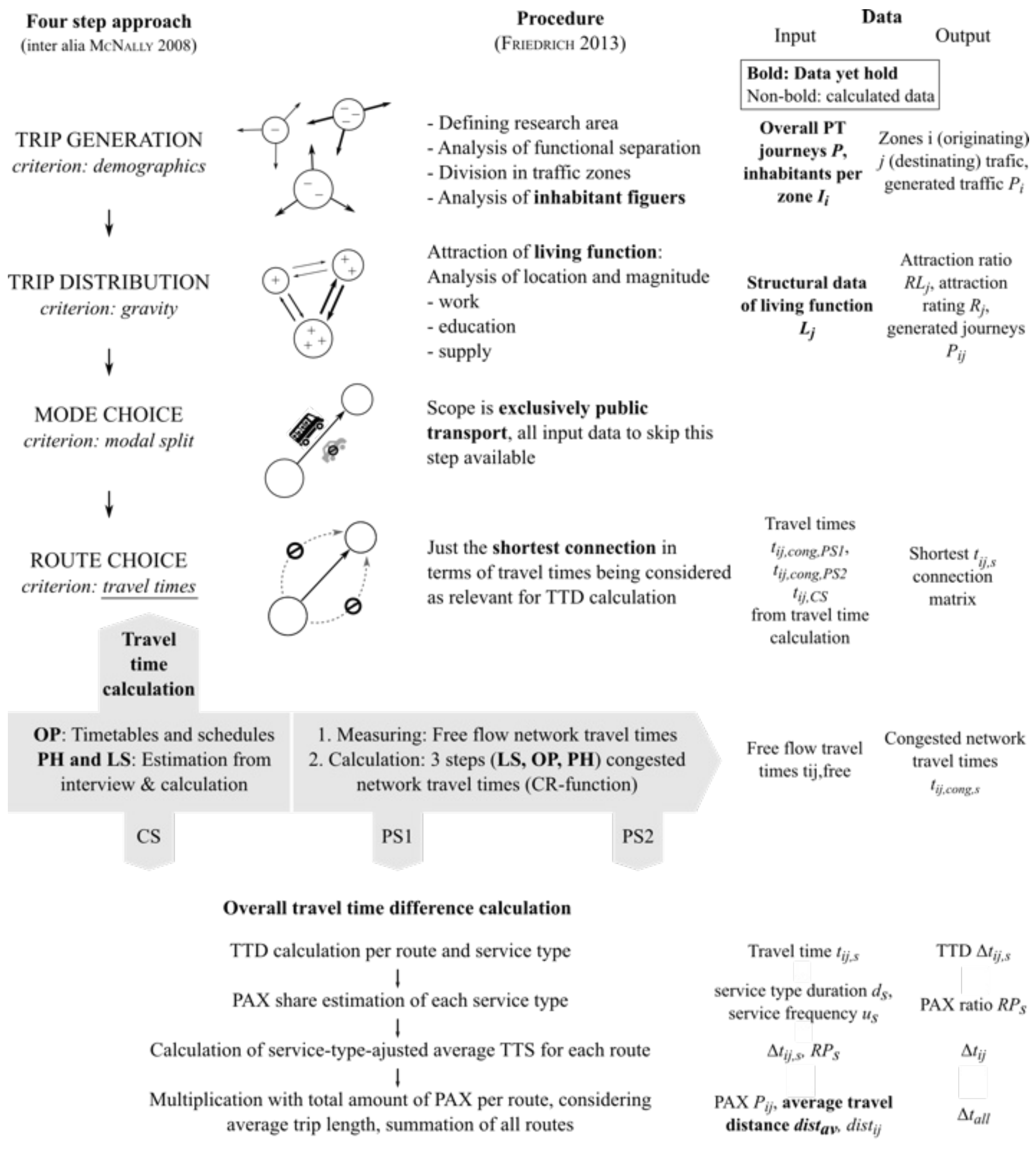

Figure 23: Overview of the four-step approach, procedure, the necessary input and gained data. (Design and idea LEDWOCH, procedure: inter alia MCNALLY 2008, FRIEDRICH 2013).

For the calculation of travel time differences between the comparison cases (PS1 and PS2) and the current case (CS), the *four-step approach* has been chosen (see chapter

3.2.1). Figure 23 reminds the procedure of it and also lists all the relevant data. In order to maintain clarity within the structure of this document, the calculation placed in the Annex III.I, so the elaboration part can concentrate on data sources, procedure and explanation.

(Step 1) Trip generation

The magnitude of total daily travel demand is being quantitatively expressed as the number of daily trips T_i for each fraction i of the examination area (traffic zone i). For Chisinau six traffic zones were assigned (figure 24) representing the urban sectors of Botanica (Bo), Centru (Ce), Ciocana (Ci), Riscani (Ri) and Schinoasa/Codru (Sc).

For the zone elaboration the correlation between the separation of urban functions (see chapters 4.1.2) and administrative division favours the merge of traffic zones with the official urban sectors, so that calculation quality generally benefits from good availability of inhabitant data for the administrative sectors. Sc zone is the only exception, with a CPL catchment area outside the city limits, serving suburban village of Schinoasa and approximately the (north-western) half of Codru. However the South Eastern half of the village of Codru find a closer CPL node in the zone of Botanica. As Figure 23 shows the South Eastern part was assigned part of the Bo zone. The CPL from Schinoasa would be interrupted by a gap of Bo zone of the neighbourhood of Telecentru, which is part of the superordinated administrative sector of Botanica. To solve this zone displacement the neighbourhood of Telecentru was assigned part of the Sc zone, creating a continuous zone until the centre, maintaining a consistent pattern of only centre-fringe zones. In order to balance inhabitant numbers with the swap of zone space, respective numbers of inhabitants were transferred: The half Codru's number of inhabitants (7.500 inhabitants) to Bo zone and from Telecentru 15.800 inhabitants were added to Sc zone (data: DGS 2013: 11, CIORBA 2011).

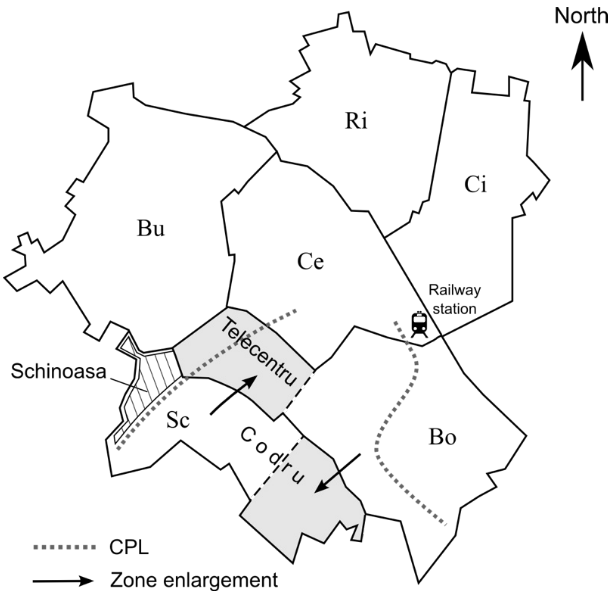

Figure 24: Creation of traffic zones (Design: LEDWOCH).

After adding the information on inhabitant numbers I to all (producing) zones i, and as the quantity of all PT journeys made within the examination area per day P_{ea} is already known (COPACI 2013), the trip generation ratio was determined, comparing the inhabitant number of each zone I_i to the overall number of inhabitants within the examination area I_{ea}. The result is the basis to calculate the number of generated journeys P_i for each zone i per day. (Calculations can also be followed in Annex III.I)

$$P_i = P_{ea} \cdot \frac{I_i}{I_{ea}}$$

As figure 25 illustrate, the busiest zones of trip generation are those containing the populous areas of large housing estates, e.g. Botanica and Riscani. The Ci zone includes, besides some of the cities large housing estates in the North, a large share of – in terms of trip generation unproductive – industrial sites in its South (CISR 2005: 47 et seqq.). The least PT journeys originate out of the Sc zone, as it is, with its high share of single-family detached houses, of very low residential density (OSM 2014). Because of the lack of respective data and the jet extensive TTD calculation, the effect of the long distance bus station "Gara Auto Sud" being located within this zone, is not considered, as little as the city's only significant railway station in the Ce zone and the "Gara Auto Nord" in the Ci zone.

(Step 2) Journey distribution

As the destination of the traffic produced in zone i is not jet known, it is allocated according to the travellers activities and the attractiveness of zone j, where those activities can be met. Data quality on work places (Primaria Municipiului Chisinau 2004: 36) is vague and displayed in a rather odd manner – the percentage of workplace availability of the respective urban sector, in relation to the total availability of work places. Statistical data on education is consisting of the number of higher education and university students. Due to the fact that no respective institutions could be found outside of sector Centru allows the assumption, that every student not living in Centru would need to commute to his place of education (data: BNS 2013). Retailer data (Moldindex 2010) is descriptive, though it is not known, which size of retailers was considered (shopping malls, supermarkets, small local shops), weather the type of supply they offer (daily or periodic needs).

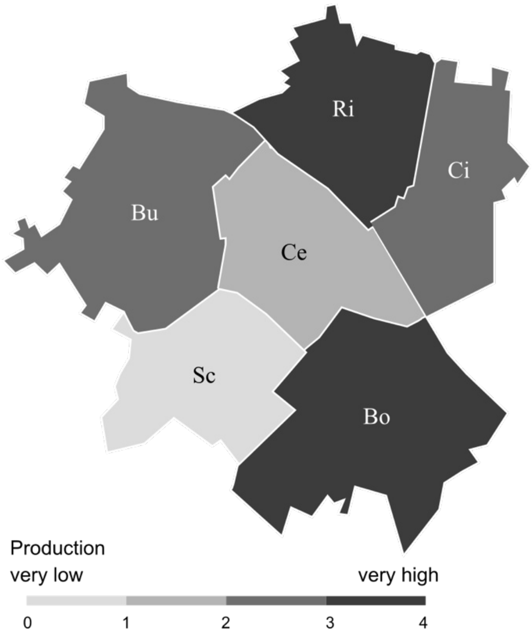

Figure 25: Graphical distribution of the zones' traffic productivity (Design: LEDWOCH).

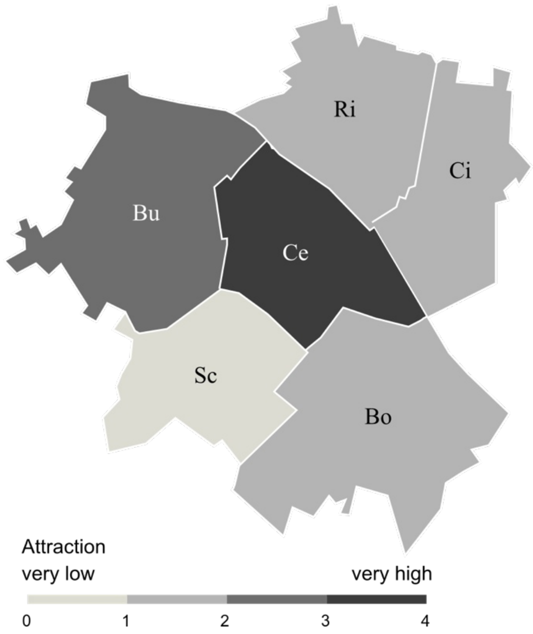

Figure 26: Graphical distribution of the zones' traffic attractiveness (Design: LEDWOCH).

Therefore a qualitative evaluation of the zones' attractiveness was conduced (Annex III.I) using this insufficient quality data well-considered and carefully for basic orientation. The inputs are further complemented with interview and map analysis information. The detailed qualitative analysis can be found in Annex III.I. It consists of an attraction description of each traffic zone together with an attraction rating for the topics work, education, supply and leisure. The result of the qualitative analysis is illustrated in 25, with the grade 0 being the least attractive value and 4 the strongest attraction.

From the results of the attractiveness rating an attraction coefficient a_j with $0 \leq a \leq 1$ was calculated (Annex III.I, table 28) and multiplied with the number of generated journeys of each zone P_i (Annex III.I, table 24). The result is the origin/destination matrix P_{ij}:

Table 6: Origin/destination matrix for Chisinau traffic zones.

to / from	Bo	Bu	Ce	Ci	Ri	Sc
Bo	n/a	46.955	93.910	23.478	35.216	11.739
Bu	23.899	n/a	63.731	15.933	23.899	7.966
Ce	20.191	26.921	n/a	13.461	20.191	6.730
Ci	25.335	33.780	67.561	n/a	25.335	8.445
Ri	29.665	39.553	79.106	19.777	n/a	9.888
Sc	6.580	8.774	17.547	4.387	6.580	n/a

(Step 3) Mode choice

In this step, the origin–destination traffic T_{ij} is distributed on all concerned transport modes. Now the transport demand and traffic load is known on mode-level.

As it is framed just within public transport, this step of mode assignment does not apply for this calculation. The differentiation between different PT systems is not necessary, as the travel times compared relate to the overall PT system. Yet distinguished input data, was merged (in step 4., respective Annex III.I) to receive overall results. For the research object it is assumed, that travel times are equal for all PT modes using CPL (chapter 4.2.3) for all comparison cases.

(Step 4) Route choice and travel time difference (TTD) calculation

The overall trip demand for each mode is now being distributed on different routing possibilities (different transport line choices in PT, respectively route choice in private transport). The result is the information on each PT line's/PrT route's congestion.

First the travel times needed to be calculated for each comparison case displaying real-life conditions, which includes the analysis of different service types: peak-hours (PH), off-peak hours (OP) and late services (LS) as well as the consideration of separate transport vehicle types. Data was collected from the following sources:

Table 7: Overview of travel time composition data used for TTD calculation.

Comparison case	Data type	Source
PS1	PH OP LS	Measuring + CR calculation
PS2	PH LS OP	Measuring + CR calculation
CS	PH	Timetable + expert interview
	OP	Timetable
	LS	Timetable + expert interview

For the calculation of the CS comparison case, actual travel time data was used, with the state of December 2013, with few older inputs from 2012. The data was gained from operation schedules of trolleybuses (RTEC 2013), timetables from bus stops, the – by the time of research only and privately operated – information web site terra.md (ТЕРРИТОРИЯ МОЛДНЕТА 2013a, 2013b and 2013c) and through interviews with transport operators and minibus drivers (Annex I.I and I.II).

As the transport systems of trolleybus and conventional bus share to the highest extent same performance characteristics (HAASE, R. 2007: 229), input data was chosen to come from the trolleybus system, as quality and availability were higher. Its public timetables are generally not divided into different service types and feature only travel time information and service frequency, but no actual time of departure. The given timetable information relates to off-peak travel times, accepting delays for rush hour, as well as being inaccurate for the times of late service. Interviews informed, that for peak-hour delays of at least 30% the off-peak travel times should be expected (MORGOCI 2013). Notorious waypoints are known for often delaying respective lines for another 15 to 20 min in PH (MIHAI 2007: 16 et seq.).

Also operation schedules (COPACI 2013) allowed drawing conclusions for travel time delays in peak hours for trolleybuses, making it possible to double-check the estimations from the interviews, so that finally exemplary bus travel time data was gained for all service types.

For the minibuses no time table or travel time information was available at all. For this reason minibus drivers of each minibus line relevant for CPL comparison were interviewed on travel times for each service type (Annex I.II), with good and reliable results. According their statements there is virtually no travel time difference between off-peak and late services for the minibus system. The reason is an operational speed not higher in times of late service than in off-peak hours. Due to the lower demand the drivers try to catch a many customers as possible, driving slowly and waiting on main access points. The gained minibus timetable data can be found in Annex I.II and III.I.

To determine travel times for the planned state comparison cases free flow travel times $t_{ij,free}$ were measured experimentally (chapter 3.2.1 and Annex II.I). Those times would only apply in an empty theoretical network with no other vehicles delaying the cruise of the only vehicle. For realistic values the travel times were recalculated for a simulated CPL network with a growing number of other circulating CPL vehicles. The growing congestion in the network was assumed in three steps at 20% (late service, LS), 50% (off-peak, OP) and 100% (peak-hour, PH) network capacity, which was the recommendation from an expert interview (MORGOCI 2013). The vague recommendations were crosschecked with an own OP/PH-timetable analysis of service frequency of peak- and off-peak services of 63 bus lines, with the result of a 2,07 times higher service frequency in peak-hour than off-peak (Annex III.I) and found plausible.

Network congestion was simulated using a capacity restraint (CR) function, which generated new travel times $t_{ij,cong,s}$ for each service type:

$$\boldsymbol{t_{ij,cong} = t_{ij,free}(1 + a \cdot (\frac{c}{c_{max}})^{b})}$$

Parameter estimation:

> a = 0,8 in order to respect the pre-set capacity demand (TASNADY 2009: 42) of chapter 4.2.3 (maximally 80% travel time delay in the fully congested network for the peak hour).
>
> b = 2,5 to comply with a medium-high sensitivity towards travel time increase with the system getting more congested (as suggested by FRIEDRICH 2013: 107), reflecting slower acceleration and slower lane changing at overtaking in bus stops. Calibration test results have shown, that neither values for $b \leq 2$, implying a more "agile" vehicle movement, nor values for $b \geq 3$, for "heavier" vehicles have been suitable.
>
> With c being the system's capacity, the fraction c / c_{max} can be also described as capacity utilization u with $0 \leq u \leq 1$. Correspondingly the CR function for different u is:
>
> $$\boldsymbol{f(u) = t_{ij,free}(1 + 0{,}8 \cdot u^{2{,}5})}$$

The respective values for the congestion steps u_{LS}, u_{OP} and u_{PH} deliver for $t_{ij,free}$ = 1 min a travel delay values of:

Table 8: Value table of the CR-function.

u	0,2	0,5	1
$f(u) = t_{ij,free}(1 + 0,8\ \cdot u^{2,5})$	1,014	1,141	1,8

The graph of figure 27 illustrates the growing travel time delay with a higher capacity utilization of the CPL network. The detailed CR calculation together with the resulting travel times for each service type $t_{ij,cong,s}$ can be found in Annex III.I (step 4).

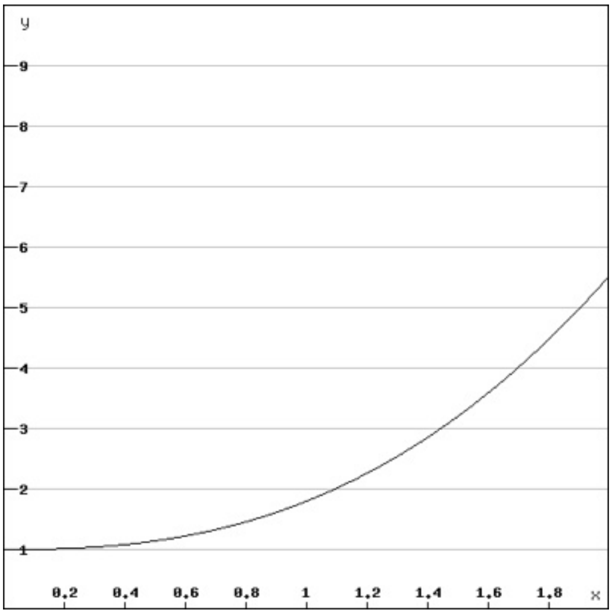

Figure 27: CR graph of $f(u) = t_{ij,free}(1 + 0,8\ \cdot u^{2,5})$ showing assumed travel time delays for CPL with increasing congestion (Graph generated with web tool: www.rechneronline.de).

With this PS travel time calculation, all the relevant travel time sets for TTD calculation are available. Find the travel time matrices in Annex III.I (step 4).

TTD calculation

The share of passengers (PAX) experiencing TTD is not equal for each service type, e.g. more PAX may experience TTD in peak-hour than at late service. As for Chisinau there is neither data available on PAX share per service type, nor did requests at the respective interview partner bring a result. Therefore it has been estimated in relying on available service frequency data. It is assumed, that the relation of service frequency for different service hour types also gives information on the ratio of overall PAX using the transportation offer at a special service time. This means, that if in one hour of peak service PT service frequency is twice as high as in one hour of off-peak service, the double amount of PAX would be transported. Of course this argumentation is not very precise, transport vehicles might for example have a higher occupancy rate in a peak- than in an off-peak hour. Still the remaining values for this calculation are of acceptable quality.

In regard to obtain the percentage of PAX Q per service type Q_s, or the ratio of the same $RP_s = Q_s / 100$, service frequency values u_{LS}, u_{OP} and u_{PH} (hence u_s) were used as used from congestion calculation above in the same chapter (4.3). As they are understood to determine the proportion of service for each service type (hour), they were multiplied with the duration of each service type d_s (in hours) and divided by the sum of all products for all service types, to get an applicable ratio:

$$RP_s = \frac{u_s \cdot d_s}{\sum_{s=1}^{3}(u_s \cdot d_s)}$$

The results (Annex III.I,), that only 8% of the total PAX carried per day travel in late hours, 57% in off-peak and 35% in peak-hours seam plausible, compared to other European cities (TREIBER & KESTING 2010: 25).

The following this step the now expressible TTD magnitudes for all service types on each route were summarized:

$$\Delta t_{ij} = \sum_{s=1}^{3}\left(\Delta t_{s,ij} \cdot RP_s\right)$$

Now the average of the TTD Δt of each journey ij for the **whole** PT lines known. As the origin/destination-distribution of all the 824.000 journeys per day is known, a sum of all connections ij would describe the TTD if every PAX would use the PT line over its full extend, which of course, is not true. From input data it is known though, that each journey has the average dwelling distance of $dist$ = 3,5 km (COPACI 2013). It the TTD for each connection Δt_{ij} is now brought down to an average TTD per km for each route with it's special travel time characteristics. It can be multiplied with the average length $dist$ = 3,5 for each journey for each connection ij. The result is the total TTD per PT line per day in min. In order to receive the result in more handy h, the term is divided by 60. Summarized for all CPL lines within the research area (Annex III.I, step 4.4):

$$\Delta t_{all} = \sum_{ij=1}^{20}\left(\frac{\Delta t_{ij}}{dist_{ij}} \cdot dist_{av} \cdot P_{ij}\right) \div 60$$

Detailed this is:

$$\Delta t_{all} = \sum_{ij=1}^{20} \left(\frac{\sum_{s=1}^{3} \left(\Delta t_{s,ij} \cdot \frac{u_s \cdot d_s}{\sum_{s=1}^{3} (u_s \cdot d_s)} \right)}{dist_{ij}} \cdot 3{,}6 \cdot P_{ij} \right) \div 60$$

with

i	Zone of journey origin	P	Journeys
j	Zone of journey destination	s	Service type (LS, OP, PH)
$dist$	Distance	t	Travel time
u	Network capacity utilization, as calculated from service frequency		

With the result of:

Table 9: Travel time differences between the comparison cases.

Comparison case	TTD [h/day]	TTD [h/year]
PS2 – PS1	34.781	12,7M
CS – PS1	67.040	25,5M
CS – PS2	37.578	13,7M

5.2 Mode shift and induced traffic

How many travellers choose another transport mode for their trip, because there has been improvement in one modes performance? How many additional trips would be made because transport supply has been improved, which otherwise wouldn't be made? As no suitable data was available to calculate or model those impacts of the projected CPL featured PT network, a broad survey was conducted to ascertain travellers' behaviour.

Results

From the 515 surveys held, 404 were suitable for evaluation. The results are:

Table 10: PrmT user behaviour survey results.

	Q1	Q2.1	Q2.2	Q3.1	Q3.2
"YES"	404	194		87	
of total	404	404		404	
No./week					185
%	100,0	48,0	28,3	21,5	

For the survey only PrmT users were taken into account. Therefore Question Q1 "Do you use motorized private transport for any of your regular trips?" has come along with a 100% accordance. Learning about modal shift, 48,0% of the questioned PrmT users would consider using public transport, if improved under CPL conditions (Q2.1: "…would you switch some of your regular trips to public transport?"). The same share of travellers indicated, they would use the improved system for 28,3% of their trips otherwise done by motorized individual transport (Q2.2: "What would be the percentage of the trips switched to public transport?").

The next question Q3.1 ("…would you undertake more trips than you do today, just because you can reach your destinations more quickly?") was about induced traffic, with 21,5% stating that they would consider using public transport for trips they abstain from undertaking them now. Furthermore the question was specified: "How many additional trips would this be per week?" (Q3.2), with the result of 185 additional weekly trips per 404 questioned travellers.

Using the current state modal split data (chapter 4.1.2.2) of 340.000 PrmT journeys per day, a shift of 13,6% between the two systems would mean 46.240 journeys made on public transport instead by car per day and around 18,9M journeys per year.

Furthermore the increased public transport attractiveness accounts for 0,09 extra trips per inhabitant per day. Respecting the Chisinau inhabitant number of 657.300 (CSO 2013) 3,3M trips per year are generated, which were otherwise abstained. These effects have an impact of the overall mode share:

Table 11: New mode share with CPL measures.

	Public transport	Private motorized transport	Cycling	Walking	Total
Share	64%	21%	0%	15%	
Journeys/d	929.390	293.760	0	200.000	1,4M

5.3 Value of travel time savings (VTTS)

The estimation of VTTS is complex and there is no consistent methodology or procedure used for a larger number of countries. Usually in developing country VTTS are raised using surveys, with the problematic outcome of results basically reflecting individual economic perception, not the effect of TTD on overall economy (DFID 2005: 15). In developed countries more complex approaches are chosen, distinguishing travel purpose in commuting trips (negatively accounting to the employee as unproductive "work" time), work trips (negatively accounting to the employer), leisure travel (reflecting the users value of free time) and in some countries commuting for educational reasons (DFID 2005: 10). The outcomes differ widely as table 12 shows. Also – depending on the examination area – different values could apply. In Germany for instance EUR 7 / h of TTD would be used for most CBA (CRILLO &A XHAUSEN 2006: 445 et seqq.), whereas EUR 8,20/h of TTD would be more accurate for a scope within a metropolitan area, reflecting higher hourly earnings compared to the periphery (VTPI 2009: 20 et seq.). Furthermore VTTS could be distinguished by transport system. Especially VTTS of work trips can be significantly lower in transport systems offering the possibility to use time productively for work (e.g. lower VTTS for one saved hour of long-distance high-speed train travelling with featuring desk, electricity and Wi-Fi internet vs. one saved hour of business class air travel with many interruptions of (low-quality) working time) (AHMET & VAIDYA 2004. 1).

Table 12: VTTS for commuting in metropolitan areas in relation to countries' average hourly earnings.

Country (ranking of nominal GDP per capita)	VTTS [EUR]	Part of hourly earnings [%] (country average)	VTTS Source
Germany (21)	8,20	38	SHIRES & JONG, DE 2009: 47
Italy (26)	9,05	60	SHIRES & JONG, DE 2009: 47
Poland (55)	5,02	108	SHIRES & JONG, DE 2009: 47
Moldova (128)	--	--	--
Ghana (136)	0,13	64	DFID 2006: 55
Bangladesh (156)	0,04	51	DFID 2006: 55

Sources: GDP data from: IMF 2013, Earnings from: DESTATIS 2013, I.Stat 2013, CSO 2013.

The example of Poland shows VTTS over the average hourly earning for metropolitan regions, a consequence of steep urban-rural income disparities (VTPI 2009: 4). Considering Chisinau metropolitan area being by far the region with highest earnings within Moldova (EC 2007: 9), the VTTS percentage of hourly earnings appears to has a potential to be comparatively higher than in other countries. However estimation in this study is done conservatively, carefully preventing overestimations and should thus not exceed other countries averages. Therefore the VTTS is determined at EUR 0,70 per h of saved travel time, being well within a frame of 60 to 75% of the average Moldovan hourly wage of EUR 1,03 (BNS 2013).

With this assumption the projected CPL measures benefit to the Moldovan economy with EUR 17,1M for PS1 and EUR 9,6M each year for PS2.

5.4 Investment costs

The investment costs for the CPL network are calculated from ITDP's busway cost calculation handbook of the BRT planning guide (ITDP 399 et seq.) for the two network layouts with:

- PS1: 60,9 km and 138 bus stops
- PS2: 49,4 km and 94 bus stops

required for CPL implementation. The costs are set up according to the system's characteristics in chapter 4.2. Due to the passive signal control, further costs for modification of traffic light signal systems accrue, calculated with EUR 500 for each intersection per traffic direction. The overall investment cost calculation is:

Table 13: Maximum investment cost calculation.

Investment object	Quantity		km/unit costs	Costs [k-EUR]	
	PS1	PS2	[EUR]	PS1	PS2
Driveway					
Lane separators, 10 cm blocks	122 km	84 km	3.650	445	307
Busway entry coloration, 50 m	4,2 km	2,8 km	36.500	147	102
Signal priority at intersections	26	21	500	13	11
Passing lanes at stops[11]	69	47	41.500	2.864	1.951
Stations					
Station identification posts	138	94	580	80	55
Timetables and maps	138	94	2.200	304	207
Information and ticket kiosks	3	3	22.000	66	66
Pedestrian crossings with signals	60	50	14.600	876	730
Subtotal				4.795	3.429
Planning and contingency			20%	959	686
Total			**k-EUR**	**5.754**	**4.115**

(Calculated using investment cost calculation tool from ITDP 2007: 399 et seqq.)

5.5 Operating costs

A higher effectiveness in vehicle operation arrives from shorter travel times, allowing more rotations at the same time, reducing the necessary size of the fleet (IEV 2009: 22). The benefits are of monetary character (analysed in chapter 6.1.11 "Operating costs") and of an overall gain in system sustainability, providing the same amount of transport with fewer resources (benefits for local environment are analysed separately in chapter 6.1.12 "Local emissions").

Vehicle travel durations for one rotation will be shorter with declining travel times (VWI 2009: 20 et seq.). With peak hour travel times (as relevant travel times for fleet dimensioning) 29% lower for PS1 and 15% lower in PS2 (see Annex III.I), a change in fleet size can be expected of[12] (balanced in terms of increased demand due to shifted and induced traffic of 14,5%):

[11] Including electrical equipment for trolleybus

[12] a) At the moment bus services are not organized with exact timetables, but with service intervals. Assuming this TTS would account 1:1 to shorter rotation durations and fleet size demand. If bus services would be organized with exact departure times at the origin, TTS benefits on rotation durations could be diminished by waiting times for timetable departure at starting point. b) For a conservative calculation the expectations are decreased by 5%, as induced traffic is not considered.

Table 14: Impact of the planned states on fleet size [no. of vehicles].

	Trolleybus	Conv. Bus	Minibus
Existing fleet	336	111	1757
Change in fleet size PS1	- 74	- 23	- 361
Change in fleet size PS2	- 29	- 9	- 150

This reduction on fleet demand has the potential to save

- EUR 12,7M for PS1 / 5,0M for PS2 on subsidies. Calculated with the saving of EUR 151.000 (Unimedia 2013) per new trolleybus from XY assembled in Chisinau, as it is the case right now within the on-going fleet renewal (Unimedia 2013). For the conventional bus EUR 65.000 (MORGOCI 2013) were calculated, as this is the price for the usual replacement buses.
- EUR 2,9M for PS1/ EUR 1,2M for PS2 for private sector entrepreneurs, the minibus drivers. The buses are mostly owned privately or in small collectives. Interviews (Annex I.II) state that the investment costs for a minibus are those for a used, ten year old imported and reconfigured Mercedes-Benz Sprinter (around EUR 8.000 per van).

5.6 Energy consumption differences (ECD)

The energy consumption differences derive from changes in transport demand in the three comparison cases: 1. The shift of journeys from motorized private transport to the more energy efficient public transport system. 2. Additional (induced) public transport journeys, which attribute negatively to energy consumption benefits (ENGELMANN, HAAG & PISCHNER 2001: 5). As for modal shift and induced traffic data collection it was not possible to distinguish between PS1 and PS2, for the ECD solely one value can be gained.

Differences of energy consumption in transport can be calculated in relation to effected transport work (SCHNABEL & LOHSE 2011: 581). For motorized private transport an energy consumption of 0,56 kWh per passenger km, a value from 2009 Austrian Federal Environmental Agency (Umweltbundesamt 2009), is assumed, comparing other sources presumably the closest equivalent. The comparison values for Chisinau bus system energy consumption is listed in table 15, with an average of 0,13 kWh per passenger km, weighted depending on the number of bus types in regular service.

Table 15: Chisinau bus fleet and energy consumption characteristics

Bus type and model	Years of construction/ delivery	Quantity in service (+ operational reserve)	Energy Consumption[13] [kWh/pkm]
Electric trolley ZIU-9/-10, Skoda-14Tr, YUMZ-T1/-T2	1968 – 1996	171 (+50)	0,13
Electric trolley AKSM-321/-32101/-213	2008 – today	115	0,09
Diesel conventional MANSL223/263	2000 – today	50	0,16
Diesel conventional, various types	1980 – 1998	41 (+20)	0,25
		Weighted average:	0,13

(Sources: Municipiul Chisinau 2004: 70 et seq., COPACI 2013, ANDRUS 2013, ТРОЛЛЕЙБУСНЫЙ ЗАВОД 2013, MAN 2014)

A journey done by public transport instead of using the car therefore saves the energy with the amount of $\Delta E_{shifted}$ = 0,43 kWh/pkm. An induced journey accounts to the calculation negatively with $\Delta E_{induced}$ = –0,13. For trip length, the average PT trip length *dist* = 3,5 km is assumed, generating overall savings of $\sum\Delta E_{shifted}$= 28,4M kWh and $\sum\Delta E_{shifted}$= –1,5M kWh each year, with the overall ECD of ΔE = 26,9M kWh each year for both comparison cases compared to the current state.

5.7 Local emission differences

Generally is the potential of saving local emissions high for the projected cases. The main emission benefit arrives from the shift of trips from private motorized transport to public transport. The emission characteristics of the systems are very different and feature a strong gap in emission volumes.

For the calculation of carbon dioxide (CO_2), oxides of nitrogen (NO_x) and particulate matter (PM_{10} and $PM_{2,5}$) the TEEMP (Transport Emissions Evaluation Models for Projects) is a basic calculation tool using MS Excel offered by the Clean Air Initiative and ITDP. TEEMP enables the estimation of emissions in both “project” and “no-project” scenarios and can be used for evaluating short to long term impacts of projects. The TEEMP tools have been developed in such a way that required input data are based on what data is available and easily accessible (Clean Air Initiative 2014). Still calculation requirements for this study were not compatible with the tool. Since it

[13] Recuperation is included for electric vehicles

is the only “simple” calculation tool of this kind appropriate within the extend of this study, the rating needed to be estimated (see chapter 6.1.14). The estimation does also include the rating of noise emission differences.

6. Analysis and assessment

6.1 Indicators appraisal

For the appraisal each indicator was rated with marks from 0 (no impact), 1 (very little impact), 2 (some impact), 3 (quite strong impact) to 4 (very high impact) (DZIEKAN et al. 2013: 55).

6.1.1 Shift to more sustainable modes

Survey results predict a shift of 340.000 journeys per day, respectively 18,9M journeys per year from motorized to public transport (see chapter 5.2), enabling an enormous growth of the city's share of sustainable transport. Considering furthermore, that 56% of public transport is powered electrically, the potential to contribute to an efficient and clean urban transport and a liveable city is even higher. The mode shift potential is broken down for PS2 using the network length as criterion.

Rating PS1: 4 PS2: 3,2 Broken down: Network length

6.1.2 Transport capacity

Due to the general layout idea, no capacity increase is intended. The calculation is based on the same demographical and structural data for all comparison cases, meaning transport demand is supposed to be same for all cases. But still the increased attractiveness of public transport fosters travel demand, which necessarily leads to a higher transport capacity. As both contributing factors, mode shift and induced traffic, together account for 14,5%, it is the value of the increase of capacity, which is necessary to balance the additional demand. It is rated "some impact", respectively it might be lower for PS2, with a less attractive route network (break-down criterion km).

Rating PS1: 2 PS2: 1,2 Broken down: Network length

6.1.3 Induced traffic

On the other hand, survey results predict 0,09 extra trips per inhabitant per day (3,3M trips per year) due to increased public transport supply accounts for inducing. Without enhanced PT service these trips were otherwise abstained. Being a negative impact, induced traffic accounts negatively to the rating. The level is deducted from the mode shift rating, comparing the impact intensity (3,3M vs. 18,9M). The fact, that an induced trip-km on PT accounts less negatively ($\Delta E_{induced}$ = 0,13 kWh/pkm) to the overall calculation, than the impact of an shifted trip-km ($\Delta E_{shifted}$ = - 0,43 kWh/pkm) is already respected with the indicator sub-level weighting.

Rating PS1: - 0,7 PS2: - 0,6 Broken down: Calculation result

6.1.4 Service frequency increase

The two CPL concepts basically consist of the same route layout and service characteristics as the current state, merely speeding up the cities main public transport corridors at the same service frequency as today, also keeping all other services unharmed. Therefore, service frequencies do not differ in the particular comparison cases (not considering supply increases through increased demand from shifted and induced trips).

Rating PS1: 0 PS2: 0 Broken down: Network length

6.1.5 Reliability improvements

Delays (congestion resilience)

Delays due to traffic flow breakdowns and severe congestion are the main harm of reliability on today's main connecting corridors making planning for transport users in peak hour hardly possible (MIHAI 2004: 7). The CPL's technical design and capacity minima guarantee a constant traffic flow. In this sense hold-ups are avoided, though traffic flow is (max. 80%) slower in peak hours, but delays are controlled and communicated with a timetable. This impact is profound and an important advancement.

Cancellations (rolling stock failure)

Together with projected CPL implementation no improvement beyond the on-going fleet renewal is planned. The level of rolling stock failure remains at the contemporary level, which is not very harmful to the system's reliability (MORGOCI 2013). Today over 50% of the fleet is younger than 10 years with an ameliorating tendency (see chapter 4.1.2.2). Furthermore the impact of cancellation of one bus service, e.g. due to technical fault, is quickly compensated through the high service frequency on the CPL.

Conclusion

Précised, rolling stock failure and cancellation is not a core problem of Chisinau PT reliability, though the improvements in congestion resilience and the possibility to plan PT trips can add a high benefit to the overall PT system.

Rating PS1: 2,5 PS2: 2 Broken down: Network length

6.1.6 Travel safety and services

Travel/passenger safety[14]

The concept does not envisage increasing the number of security personnel in buses or at stations. As every trolley and conventional bus carries at least one ticket vendor and/or service person (MORGOCI 2013), travel safety problems are not a core issue in Chisinau PT.

Passenger services

The most important improvement of passenger services will offer the possibility to plan PT trips. Predictable travel times in peak hour will enable the establishment of timetables. Earlier PT users could not know their exact time of departure, just the frequency of service. Also the durations of journey needed to be estimated, with the high risk to be several times longer than expected. Concretely, CPL implementation would go along with the installation of analogue timetables at each bus stop, together with timetables available online (as an enhancement of the yet planned online-information of service frequencies) (MORGOCI 2013). Since the improvements are implemented at CPL corridors only, the rating is broken down for PS2 to a lower level.

Conclusion

Generally, travel safety remains on the same level, which is at the moment not problematic. Passenger services do not experience an improvement except from passenger information. Considering though the (first-time) introduction of timetables travelling will be much easier for transport users.

Rating PS1: 1,5 PS2: 1,2 Broken down: Network length

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[14] As also mentioned above travel safety means the safety of travellers and personnel against violence. Not to be confused with transportation/road safety – the absence of transport accidents.

6.1.7 Amenity and travel comfort

The most important amenity with CPL implemented will be shorter travel times. An average travel time saving of 4,8 min per PS1-trip and 2,7 min per PS-2 trip has an impact on the competitiveness of this transportation mean. Improvements of rolling stock are not planned within the context of the projected CPL implementation. Travel comfort therefore remains on the same (low, but with the on-going fleet renewal improving) level as in CS (Unimedia 2013). Yet, shorter travel times and the absence of long congestion hold-ups might improve the passengers' travel experience. The PS2 rating was influenced by the difference of the average travel time.

Rating PS1: 2 PS2: 1,2 Broken down: Network length

6.1.8 Value of travel time savings

Travel time savings benefit to the Moldovan economy with EUR 17,1M for PS1 and EUR 9,6M each year for PS2. Compared to a GDP of EUR 5.2B in 2013 (The World Bank 2014b) the CPL measures offer an outstanding impact. PS2 rating is broken down using the VTTS ratio of both comparison cases.

Rating PS1: 4 PS2: 2,5 Broken down: Calculation result

6.1.9 Accident costs

The standard bus road safety situation in Chisinau is not critical (MORGOCI 2013). Minibuses, however, are concerned for their safety (chapter 4.1.2.2), so the implementation of CPL promises enhancement for the minibuses (ITDP 2007: 554, UNECE 2009, WHO 2013: 173). Pedestrian safety is respected with the investment in 60 (PS1) / 50 (PS2) signal crossings, which should improve the overall pedestrian safety situation or at least digress a possible worsening. As the beneficial effect on accident costs of both aspects of road safety is not quantitatively describable, nor plausibly assumable, it is rated conservatively as “not very high”, with the respective brake down for PS2.

Rating PS1: 1 PS2: 0,8 Broken down: Network length

6.1.10 Accessibility

Ticket prices

Ticket prices are set politically, changes would not happen in context with CPL.

Supply

Being excluded due to supply deficiencies of some areas or neighbourhoods is another great social accessibility hazard (PETERSON & RAJÉ 2007: 152; CASS, SHOVE & URI 2005: 540 et seqq.). PT route layout would not change with CPL implementation, so no changes to bus stop availability and distribution occur. This leaves the accessibility unchanged for conventional buses. Accessibility to minibuses would decrease on a minimal level, as minibuses operating within CPL are not accepted to stop outside official bus stops. Strictly speaking this change in operational procedure does not represent a supply decrease, just a deflexibilization of the dynamic service concept of the minibus. Furthermore, it does not change supply with regard to social aspects of access, as the same routes would still be available.

Handicapped

At the moment the Chisinau bus fleet is in the process of modernization and a growing number of low-floor vehicles are introduced into service (chapter 4.1.2.2). This improvement of quality is in no connection with the CPL concept, so it does not contribute positively in this rating.

Conclusion

The conclusion is that neither ticket prices will rise due to CPL implementation, nor supply deficiencies for some neighbourhoods might occur more than today. The only deficiency is a slightly reduced supply of the minibuses' accessibility. As this impact is sensitive to CPL-length it is higher for PS1 than PS2, respectively their km-ratio.

Rating PS1: - 1 PS2: - 0,8 Broken down: Network length

6.1.11 Costs for community

A higher effectiveness in vehicle operation may arrive from shorter travel times, allowing more rotations at the same time, reducing the fleet size necessary to conduct operations (chapter 4.2.3). This fleet reduction allows a long-term saving of EUR 14,9M for PS1 / 5,8M for PS2 for new vehicles as the amount of vehicles needed to be modernized will be lower.

Rating PS1: 4 PS2: 2,2 Broken down: Network length

6.1.12 Use for third parties

A public group affected by CPL implementation are minibus drivers. Obviously those depending on semi-informal transport are vulnerable to the changes towards more regulation. Though CPL does not mean the extensive repression of minibuses, it leads to some cuts in their business model:

- Reduced minibus fleet of PS1 176 / PS2 422 vehicles, due to shorter travel times and optimized rotation (chapter 5.5) accompanied with the loss of at least one to two times the number of jobs. EUR 3,4M / EUR 1,4M of investments can be saved due to the smaller fleet.
- Nowadays the minibus offers comparably fast travel times, due to higher flexibility than the larger buses and often unlawful and aggressive driving (MORGOCI 2013). In CPL cruising velocities are constant and similar for all PT vehicles, as overtaking is not possible. Therefore, average speed might decrease on some route parts not vulnerable to congestion.
- The advantage of flexible hop-on/hop-off stops outside official bus stops would be restricted. Another main attractiveness bonus for minibus users (and the reason to spend 50% more of the regular bus fare).
- Lowering capacity utilization in some service hours, lacking the possibility of going slower in order to collect more passengers in hours of less demand, which is a common procedure (Annex I.II).

Conclusion

The minibus business model suffers alongside with its employees of diminished attraction of minibuses and growing competition from the buses, leading to shrinking minibus PT share. This is rated as a generally negative (social) effect, which is sensitive to CPL-length.

Rating PS1: - 2 PS2: - 1,6 Broken down: Network length

6.1.13 Energy consumption benefits

The general ECD due to mode shift is ΔE = 26.900 MWh (induced traffic included) each year. It can be expected to be lower in regard to the network length. Considering electric energy consumption, it is the same amount 180.000 people consume during one year in Germany (JOCHUM 2010: 15) or the quantity 2,3 average efficiency German wind turbines produce over one year (BMU 2009: 22).

Compare to other cities/BRT impacts.

Rating PS1: 4 PS2: 3,2 Broken down: Network length

6.1.14 Local emissions

Since the amount of trips shifted from private motorized transport to public transport is huge, the potential of saving local emissions for the projected cases is also high.

Combustion engine emissions

Comparing the for instance carbon dioxide, oxides of nitrogen and particulate matter emissions of a passenger car, which has a average occupancy rate of approximately 1,8 passengers (COPACI 2013) to the occupancy rate of an average public transport vehicle the difference in emission quantity can be exemplified. Therefore it is assumed that the mode shift of 18,9M trips per year has a highly positive impact on emission efficiency per travelled passenger km.

With a public transport system composition of 56% trolleybus system, 37% minibus system and 7% diesel bus further impacts are to consider. The electric powered trolleybus is neutral of local emissions, since the electric power is produced outside the city. As a matter of course this mode of transport is not free of emissions at all respecting the Moldovan mix of electric energy generation, which is most of all done with hard coal (approx. 80%), gas (approx. 19%) and a negligible proportion of hydropower (> 1%) (calculated from IEEJ 2011, data from 2009). Therefore the path to conduct emission-free trolleybus transport is still long, still the indicator determines "local emissions" and the trolleybus does not stress the urban environment with combustion engine emissions.

The minibus contrasts the in terms of local emissions exemplary trolleybus. Compared to the conventional diesel bus it features unfavourable emission characteristics, at the same time conducting a major share of the city's public transportation volume. Despite being less efficient[14] than the conventional bus, is still has advantages compared to a private car carrying 1,8 passengers on average.

[14] Assuming that both systems do not have a heavily diverging similar occupancy rate

Noise

A severe transport pollutant is furthermore noise. Even more than with air pollution this field is affected by number and kind of circulating vehicles. Noise is being emitted more through acceleration (and engine braking) of combustion engines. Electric engines (apart from heavy rail transport engines) are usually by far les troublesome in urban transport. Cruising sound also causes pollution, especially with a multitude of vehicles. Furthermore this effect is highly dependant on travel speed (TANG & WANG 2007: 1760). The effect of 40 passengers travelling in five minibuses instead of 23 cars might not have an outstanding effect. More though if the same amount travels in one diesel bus or even more for a electric trolley instead of 23 cars. Therefor in the sum the shift from motorized to public transport is very likely to have a medium up to high effect on reduction of noise pollution.

Conclusion

Overall the effect of CPL on local emission should be very favourable. Though the minibus system makes the impression to be less productive in reducing emissions, than the other transport systems. Unfortunately the exact impact in this matter could not be analysed qualitatively, therefore emission reduction is conservatively rated with below the best result. As this impact is sensitive to CPL-length it is lower for PS2.

Rating PS1: 3 PS2: 2,4 Broken down: Network length

6.1.15 Space consumption

For the estimation of increasing or decreasing urban space consumption through the implementation no exploitable arguments could be found. Of course mode shift from PrmT to PT urban space would release a certain amount of urban space of, for instance since less space for parking would be needed. On the other hand this argument can be easily disproved with the fact that CPL construction will eliminate a high number of parking places in the city centre due to the curb side alignment of the bus lane. This discussion demonstrates, how vague the pro and contra the arguments are and that the result might close to zero.

Rating PS1: 0 PS2: 0 Broken down: Network length

6.2 Appraisal summary

Table 16: Utility analysis and results.

Category	Category weighting	Indicator	Sub-level weighting	Overall weighting	Part-worth utilities PS1	Part-worth utilities PS2	Weighted PW utilities PS1	Weighted PW utilities PS2
Transport	**25%**	Shift to more sustainable modes	40%	0,100	4,0	3,2	0,400	0,320
		Transport capacity	40%	0,100	2,0	1,2	0,200	0,120
		Induced traffic	20%	0,050	-0,7	-0,6	-0,035	-0,030
User	**25%**	Service frequency increase	40%	0,100	2,0	1,2	0,200	0,120
		Reliability improvements	30%	0,075	2,5	2,0	0,188	0,150
		Travel safety and passenger services	20%	0,050	1,5	1,2	0,075	0,060
		Amenity and travel comfort	10%	0,025	2,0	1,2	0,050	0,030
Economical	**20%**	Value of travel time savings	80%	0,160	4,0	2,5	0,640	0,400
		Costs for accidents	20%	0,040	3,0	2,4	0,120	0,096
Social	**15%**	Accessibility improvements	50%	0,075	-1,0	-0,8	-0,075	-0,060
		Costs for community	45%	0,068	4,0	2,3	0,270	0,155
		Benefit for third parties	5%	0,008	-3,0	-2,4	-0,023	-0,018
Environmental	**15%**	Reduction of local emissions	40%	0,060	3,0	2,4	0,180	0,144
		Energy consumption benefits	30%	0,045	4,0	3,2	0,180	0,144
		Effect on urban space consumption	30%	0,045	0,0	0,0	0,000	0,000
Total	**100%**			**1,000**			2,370 PS1 utility	1,631 PS2 utility

The overall results of the two measures are 2,370 for PS1 and 1,631 for PS2 show a difference of 0,739 rating points in favour of PS1.Including the investment costs – as they are not respected in the utility analysis – the difference of benefits is as low as 0,01 in favour of PS1. The difference *D* was calculated with

$$\Delta \sum_{c=1}^{2} D = \frac{u_c}{i_c}$$

using respective utility *u* for each comparison case *c* and the investment costs *i*.

7. Discussion

7.1 Methodological critique and result significance

In this chapter the disadvantages and advantages of the methodology used for the procedure are discussed. Meaning, quality and significance of the results is influenced by choice and type of methods. Knowing about strengths and weaknesses of the results is crucial for a defensible conclusions and a correct interpretation.

7.1.1 Data collection procedure

The difficult research environment of a developing country with unavailable or deficient quantitative data as well as a deliberate information and data exchange culture indeed had a strong impact on data collection. Instead of conducting a quantitative approach, as it is usually done with this question, even with the many different aspects of the multi-layered approach, collection methodology had to be complemented with a mix of qualitative and quantitative techniques. Despite a lucky selection of experts, general data quality remained at low level, especially concerning the structural data of Chisinau and the value of travel time indicator, leaving some need for estimation. On the other hand estimation is a normal and in many cases an essential practice to limit a (thought) model's complexity. With special reference to the assessment of infrastructure investments, it is very common that variables are estimated. It is practitioner's standard to estimate VTTS, monetary values of emissions and demographic data components if no reliable data is available or the data collection effort is exceedingly high (Intraplan 2006). In Germany this procedure is often subject to public discussion, especially in the context with large infrastructural projects (BRETTENSCHNEIDER 2013: 186 et seqq.). Nevertheless it demonstrates that obtaining an entity of very accurate data is mostly illusory and a certain level of imprecision is inevitable (SCHNABEL & LOHSE 2011: 547). Therefore, if indicators were estimated it was carried out conservatively, avoiding overestimation of the results. The overall quality of the data collected as well as the quality of the "weakest link" is found significant enough to obtain defensible results. However it should not be used for (further) detailed technical calculations.

A further quality aspect concerns problematic data actuality. Literature on post-socialist urban transformation and development structures originates mostly from the period between 1996 and 2000, which does not constitute a severe problem, as it was the main phase of research in this regard. With the development phases being delayed in Chisinau, it is further negligible. Qualitative input data though used for calculation to some parts is aged up to ten years. This, for instance, concerns some structural data (urban structure and employment) and parts of the emission data (vehicle emissions). Of course it is to assume that these fields made more or less distinct advancements over the last years, so the results will be inaccurate.

However, accordant to the research goal, scope and the envisaged extend of this study, the results provide an adequate basis to give – at least a qualitative – statement on the research question in reference to the result data. As further explained in the next chapter, with the assessment methodology of utility analysis, the quantitative data would have been assessed in a subjectivity-influenced manner. This leaves a qualitative result, with the possibility to respect a variance of the result value in the assessment procedure.

7.1.2 Assessment procedure

With the general approach to rather expect unprofitable results in estimations (conservative assumption), all statements and assumption within the procedure of this study contain a certitude reserve. Overestimation – intended or not – favouring a special outcome as sometimes observed in valuation practice is therefore prevented.

The evaluation itself was conducted on the methodological basis of utility analysis with 15 weighted indicators. A considerable aspect hereby is the subjectivity of the weighting process. Until the 1970s researchers insisted on being separate from the active research process, virtually like a *deus ex machina* removing themselves from the research results (PFAFFENBACH 2007). Though the researcher does not live in the indefeasibly ivory tower of science, he is part of the research itself, being the link between the research object and the scientific result (REUBER 2007: 156 et seqq.). So the subjective intervention in the evaluation process through weighting, just means to create an *interpretative paradigm* (REUBER 2007: 156, PFAFFENBACH & REUBER 2005: 107). In order to interpret the results correctly, it is important to understand the weighting to its full extend. In this assessment the focus is clearly on transport systematic characteristics, but the weighting also sets high value on the transport user. Economical aspects are further considered in a stronger relation than social and environmental impacts (chapter 3.4.4).

Another considerable aspect in the evaluation process is the usage of an ordinal scale which is without alternative when conducting an utility analysis. The problem which arises is furthermore one of subjectivity. The score system does not offer a shared zero-point for all variables nor can it be calibrated (SCHNABEL & LOHSE 2011: 554). Therefore the generated ordinal rating point results are only valid within the system of Chisinau and their background of generation and offer no further possibility of comparison to other cities. Comparison can only take place using qualitative description.

7.1.3. Sensitivity analysis and result applicability

In order to test the weighting and result quality a *sensitivity analysis* was conducted (Annex III.II) at which weighting relations were changed. Afterwards the deflexion of the result sequence was analysed (SCHNABEL & LOHSE 2011: 555). The analysis was conducted for three most plausible weighting alternatives. There was no impact on the order of ranking, except for results with less than 0,1 of score points difference. Since this is not only reasonable but furthermore inevitable, the weighting was found adequate and the results suitable in terms of the weighting method. Considering the critique of chapter 7.1.2 generally fine value differences should not be used for the expression of far-ranging statements though.

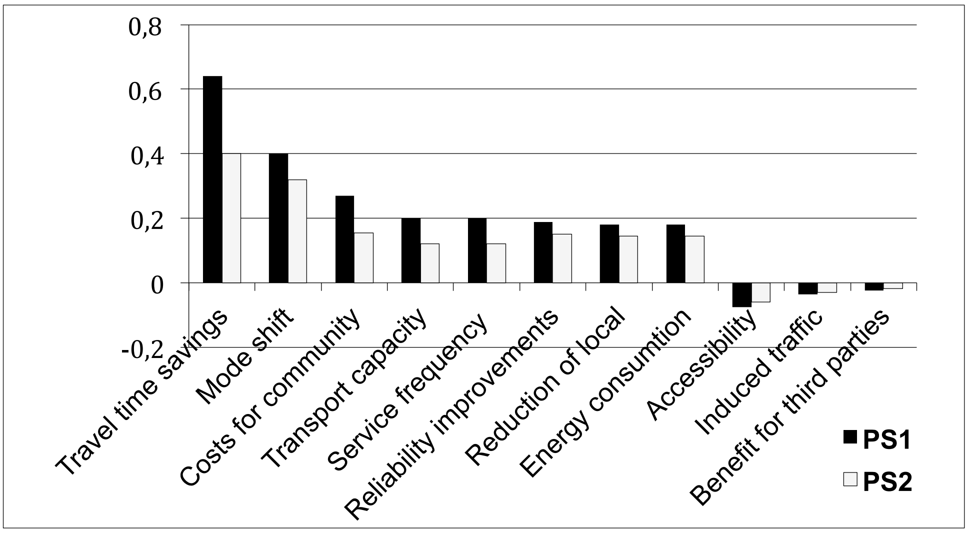
7.2 Result interpretation

7.2.1 Main outcomes

For evaluation of the Combined Priority Lane (CPL) impact 15 indicators were selected to describe the impacts of the two planned states (PS1 and PS2) compared to the current state of public transport in Chisinau. The overall results of the two measures are 2,4 for PS1 and 1,6 for PS2 on the scale of 0 (no impact), 1 (very little impact), 2 (some impact), 3 (quite strong impact) to 4 (very high impact). In matters of utility PS1 is the preferable, with a utility benefit of 0,739 rating points higher than PS2.

Main contributors and detriments

Table 17: Main contributors and detriments.



As table 17 shows, the main utilities form CPL implementation are:

- The current situation with traffic flow disturbances, congestion delays and long hold-ups is obviously improving with CPL introduction. So the by far highest utility is generated by travel time savings and the economic value resulting from them.
- A further strong impact arrives from the enhanced attractiveness of public transport, shifting many trips from motorized transport to the more sustainable bus transport.
- A circumstance, which still accounts positively to a high extent are decreased costs for the community (tax payers).
- A lower impact on the utility calculation has both, an increased transport capacity and an increased service frequency.
- At the same level impact an enhanced reliability and the ability to plan trips and travel duration in preparation of the journey to the benefits.
- A similar effect on utility of CPL also has both, the reduction of local emissions and energy consumption benefits.

Furthermore negative effects of a CPL implementation would be:

- Accessibility, due to changed minibus operation on CPL trunk routes. In the CS minibuses also stop outside fixed bus stations on-demand. A practice fairly famous among the passengers, since the minibus can be accessed from virtually anywhere. Due to higher organisational requirements in the CPL, this practice is no longer possible in PS1 and PS2.
- Induced trips, due to the improved attractiveness of public transport in PS1 and PS2.
- The minibus business sector. For services on CPL minibuses lose their basic operational and service advantages, challenging their business environment.

A number of indicators did not contribute to the result in a noticeable way, implying there has been no or just a very slight change from the actual state. These indicators are in decreasing order of their effect: Cost benefits from improved road safety, travel safety and passenger services, amenity and travel comfort and the effect on urban space consumption.

Comparison of the planned state alternatives

Table 18: Main contributors to the difference between PS1 and PS2.

Indicator	PW utility difference (PS1 – PS2)
Investment costs	-0,639
Value of travel time savings	0,240
Costs for community	0,115
All indicators	**0,01**

The general utility benefit for PS1 is 0,739 rating points higher than for PS2. As main contributors accounting travel time savings for 0,240 to the difference. Due to the larger CPL network layout, conducted travel time savings are higher in PS1. At the same time cost savings for the community are higher. With CPL improving vehicle rotation efficiency, investment costs savings for the community occur in a higher rate for PS1 with its more extensive network, than for PS2. Further utility indicators play a minor role in the distinction of the comparison cases. For a general consideration of a benefit-cost relation, both planned states are closely to be equal with PS1 being 0,01 rating point preferable over PS2. Considering a valuation error, respectively a variety in the result validity, no significant difference between the two planned states can be declared.

7.2.2 Outcome interpretation

Performance increase

With the evaluation results it is possible to answer the research question positively. Considering performance as a function out of capacity, service speed, respectively travel times, reliability and image the implementation of CPL educes for both bus line and layout options good performance improvements for most of these aspects. If aspects of financing are considered, the ratio of performance increase and costs is even more attractive. From its organisational design the CPL have an open concept, making it very flexible to further adaptions and additional performance improvements.

The key effect of travel time savings

Especially transport users and the local economy benefit from extensive travel time savings. Seen from the perspective, that the monetary consideration of the VTTS

[EUR] instead of the direct indicator TTS [h] potentially even devalues the enormous time savings of the new bus system. Indeed the value of travel time savings accounts for less than 10% to the overall result of 15 indicators. In a structural sense and comparison to industrial or post-industrial nations, the results are quite exemplary though. In highly developed nations time is the most critical aspect in travel, contributing with as much as 80% to transport measure benefits (AHMED & VAIDYA 2004: 1). So the valuation should consider lower productivity and monetary losses for each hour of missed working time (ibid.). Nevertheless through enhanced travel time competitiveness the CPL entails further a notable shift of trips from motorized to public transport, releasing positive effects on local environment and energy consumption schemes.

… not without conflicts

Generally, many and strong positive impacts overlay few proportionally smooth negative impacts. The less grave but maybe the most sensitive negative impact is the one on the minibus business. With just slight influences, it is not very likely to cost jobs or jeopardize existences on this semi-informal business sector, as it happened with many comparable projects, where the minibus system was abandoned completely, e.g. Johannesburg/South Africa BRT “Rea Vaya” (VENTER 2013: 8). From its main idea though, the long-term planning goal is enhanced efficiency, which is only to achieve with appropriate operating equipment in terms of vehicle sizes. Sooner or later a solution will need to be found on this critical issue. Up to date most trials have failed elsewhere (VENTER 2013: 13).

Are CPL enabling mass transit?

For the service of Chisinau’s main traffic flow corridors and – as the close results of 0,01 rating points between PS1 and PS2 demonstrate – secondary links within the city, a (gradual) mass transit options would be desirable. Despite the positive results, CPL do not provide a sufficient level of overall performance improvement to speak of a mass transit system. Capacity improvement potential is remarkable, but most probably not high enough to adopt a high-quality lead role in overall urban transit. CPL still leaves potential for travel time savings, compared to a “real” mass transit system. Under Chisinau conditions a mass transit option could feature an average travel speed of 30 km/h or above (ITDP 2008), instead of the 19 km/h with CPL. Also the concept offers no measures in improving the deficient travel and service experience and attracts no perception as a modern and competitive transport system. In this context the good performance gains are somehow relativized. Furthermore in the next chapter CPL performance impacts will be put into relation with other development alternatives.

7.3 Benchmarking and comparison with development alternatives

CPL has proven to be a good possibility to increase public transport performance in Chisinau. Up to this point, the concept (with two layout options) has been evaluated in comparison to the Chisinau actual state, which is of course the most relevant decision-making factor. In order to broader the horizon and make a definite assessment, it should be briefly benchmarked to other development alternatives.

7.3.1 Development alternatives

Considering today's state of Chisinau (public) transport of course more suitable courses of action for transport system improvement exist. The most self-evident ones are BRT, a light rail transit (LRT), the introduction of a metro system and the option to continue with the same concept as today (no measure). Except BRT and of course CPL, all the measures were subject of more or less serious planning ideas in the last decade (PRO TV 2011). These alternatives feature different cost and utility characteristics compared to CPL.

Light Rail Transit (LRT)

Yet, in soviet transport tradition of favouring electric energy (PRYDE 1991: 36) the electric powered transport system in medium and large cities as famous was as the trolleybus (TARKHOV 2000: 17). Indeed LRT offers a great performance, with low travel times and an advantageous passenger capacity per vehicle. From an efficient, environmental, liveable city point of view, it might be the best alternative for Chisinau. Considering the city's size it has appropriate operational characteristics: Being capable to operate primary traffic axes, but still not being over-dimensioned for services on the secondary concentric connections (see chapter 4.2). Furthermore it would not just offer enhanced accessibility for handicapped; LRT is also might be the most famous transport system among passengers (JAHN 2010: 36 et seqq.). Modern railway vehicles offer a higher level of comfort than buses, with a low level of noise and smooth cruising (ibid.).

From the financial point of view, track-guided vehicles usually make a higher financial effort necessary. Also LRT implementation would not only need fixed rail infrastructure with stations and pedestrian access infrastructure, but also require a great redevelopment of carriageways and intersections. To build a line network equivalent at least to the extent of CPL PS2, investment expenditure would be high, up to critical concerning the financial situation of the City of Chisinau. Not only the "Tranvía del Este" in Buenos Aires (Enelsubte 2013) or the Mumbai "Maximum City" (HAYDEN 2014) demonstrate once more that stand-alone solutions featuring solely one mass transit system line or the plan to implement "initially" one segment until further financing is available, should be strictly omitted (ITDP 2007: 53).

Bus Rapid Transit

BRT comes along with low investment costs compared to LRT, but similar performance features. Especially the renovation of the existing trolleybus system and conversion to BRT would place the system's characteristics even closer to the favourable LRT solution.

Metro

An underground rapid rail transit would offer the highest capacity of all the options and by far the highest travel time savings, as it is unlike the other options and an exclusive right-of-way system (HINKEL, TREIBER, VALENTA & LIEBSCH 2010). With around 660.000 inhabitants living in the urban area of Chisinau (DGS 2013: 11), the development of a metro system is marginal in terms of proportionality (LOHSE & SCHNABEL 2011: 121). Except for the Botanica – Centru routing, the capacity offered by the system might be beyond demand. With the generally enormous infrastructure investments necessary, also consequential costs of the infrastructure maintenance would be proportionally high. General supply, network density and accessibility are likely to suffer under the effort of high investment costs of an expensive stand-alone project. Due to larger impacts during construction a metro also features worse environmental characteristics than the LRT. In general, the implementation of a metro under the actual circumstances results in adverse impacts.

(Sub-) urban Rapid Rail Transit

Chisinau does neither provide the appropriate size, nor urban structure to implement urban rapid transit. For a combination of urban and suburban services, the suburban settlement structure with small and unevenly scattered villages is complicated. The existent railway line buries, considering its track routing, few potential for an urban services upgrade. Therefore the possibility of a suburban rapid rail transit is no further considered. For an over ground track-guided system, in any case LRT would be the preferable solution.

Table 19: Overview of selected cost and utility characteristics.

	No measure	CPL	BRT	LRT	Metro
Costs					
Infrastructure investments	4	4	3	2	0
Investment in rolling stock	4	4	2	1	0
Operating costs	3	3	2	2	0
Infrastructure maintenance costs	4	4	3	2	0
Utility and performance					
Transport capacity	2	2	3	3	4
Travel time savings	0	2	3	3	4
User and service	0	1	3	4	3
Social	0	2	1	1	0
Environment	0	3	3	4	3

7.3.2 Serving a niche in the development process

As benchmarking shows, other transport systems offer very beneficial solutions for public transport in the city, each system with its own performance cost characteristics, as illustrated in figure 28. With the metro system exceeding the dimensioning for Chisinau, the light rail system appears to be a quite appropriate measure. It is situated well inside appropriate performance range and still with an image bonus compared to the road vehicle systems. BRT offers perfectly the needed performance and requires less investment expenditure than LRT.

Generally all the “sophisticated” transport systems are in some cost- and performance-wise distance to the actual transport systems, the Chisinau bus systems and the minibus. As detected and described earlier these systems perform well below the necessary performance, outside the range of appropriate performance, leaving a certain performance and financing gap between the actually operating Chisinau transport and all possible system alternatives. Bus systems using CPL though have a higher performance than the current Chisinau transport. Furthermore and as proven earlier in the evaluation, the CPL operations even save money compared to today’s state. Therefore the ability to fill the performance gap to some extend – without the need to fill the cost gap – seems as the CPL concept’s main advantage.

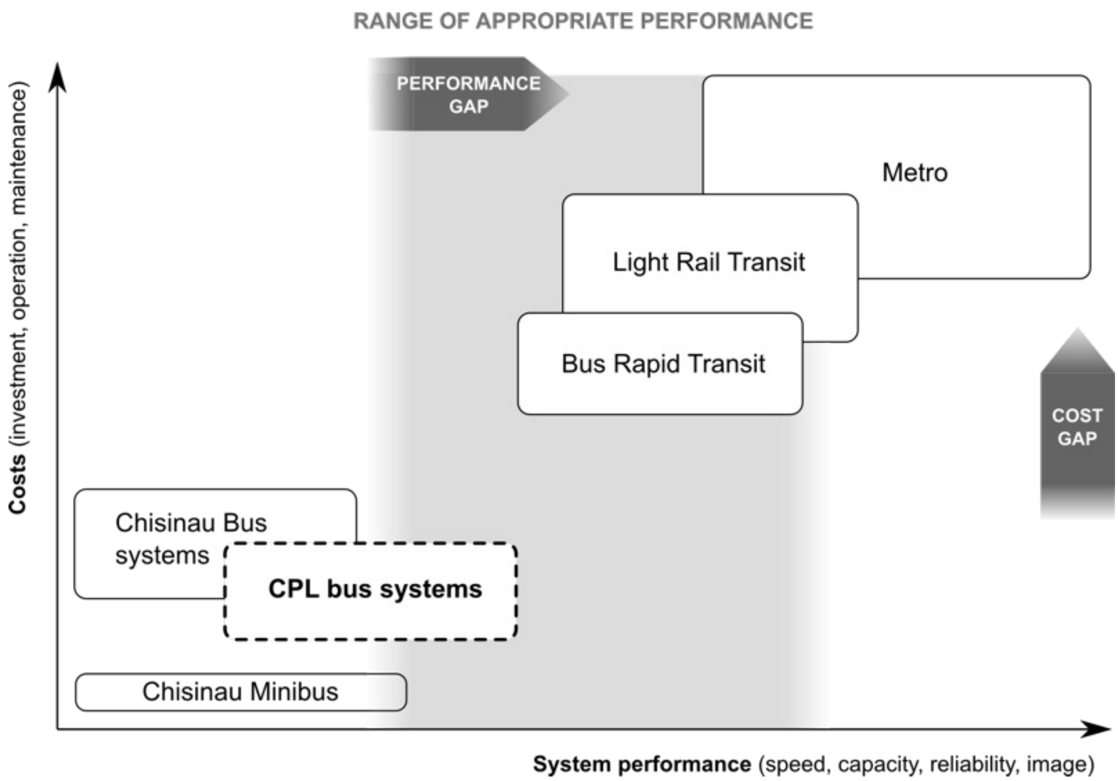


Figure 28: The cost/performance relation of transport development alternatives (Design and idea: LEDWOCH).

Compared to the other transport systems, the "low-cost" concept of using CPL still performs on the lower part of the scale, reaching middle system performance as a maximum. Dividing the transport systems performance in mass-transit systems and underperforming systems, still a notable leap between these two types occur. It reflects the relatively low improvement impacts, compared to common best practice solutions.

7.4 Feasibilities under the constraining situation in Chisinau

Despite its moderate improvement potential, how does the CPL cope in the challenging Chisinau transport development environment? Main development obstacles are financial, political and know-how deficiencies (chapter 4.1.3). Is the simple concept of CPL better suitable to these conditions?

Financial challenge

The collapse of the collective transport orientated USSR caused a deep crisis for public transport financing, lasting up to date. After a general standstill of urban transport infrastructure investments of approximately 15 years until the first half of 2000 (Unimedia 2013, MORGOCI 2013). Slowly developing, nowadays investments are mostly via development aid or other forms of foreign co-operation. For instance, for the up to date EUR 15M worth trolley bus fleet renewal (see chapter 4.1.2.2) EUR 10M were credited from European Bank for Reconstruction and Development (EBRD) and European Investment Bank (EIB) and EUR 3,7M were an EU grant within the Neighbourhood Policy Programme (EPC 2011, EIB 2010).

Therefore, not solely good utility implications are essential for transport decision-making, but also financial feasibility for investment options. Both BRT and LRT require large-scale investments. Both systems need a complete new fleet (depending on implementation scenario 50% fleet renewal for BRT) of transport vehicles. Not just the LRT furthermore necessitates extensive investments in track infrastructure. A mass-transit capable BRT should come along with a considerably station improvement, feeder and non-motorized transport integration and streetscape reconstruction. Without finding large-scale investment possibilities, an operationally and economically expedient implementation is not foreseeable.

The problem could be indeed overcome with CPL implementation, as a first step towards a BRT system. Compared to the scale of serious transport infrastructure investments, costs for CPL are a fraction, with investment costs limited to lane separation, basic pedestrian crossings and passive signal control (chapter 4.2) and no fleet investments at all. Operational costs persist at today's low level with a 37% share of the transport volume provided by the semi-informal and subsidy-free minibus system (chapter 4.1.2.1 and 4.2.3). Maximum investment costs for the projected CPL are conservatively estimated with EUR 5,8M for PS1 and EUR 4,1M for PS2 (chapter 5.4), having each year EUR 17,1M (PS1) respectively EUR 9,6M (PS2) of economical savings on the income side. The savings do not include monetary benefits of external costs[15], and EUR 18,3M (PS1) / EUR 7,2M (PS2) of one-time savings due to enhanced system efficiency (chapter 5.5). From a national economic point of view investments in CPL are paid off after the first year. Under these condition financing could be much more realistic, than for the development alternatives. Considering other transport (co-) investment projects as the EUR 3,5M "traffic control programme" the City of Chisinau implemented end 2013 (TRM 2013) for PrmT surveillance, chances could be good for projects with a potentially higher beneficial impact[16].

[15] Decreased public health costs and economic productivity savings, due to decreased accident rates and pollution, also beneficial impacts on environment and emissions.

[16] For instance the 2013/2014 implemented "traffic control programme" equipping 41 of Chisinau's intersections with high-performance traffic surveillance cameras. The HUAWEI built equipment is a EUR 3,5M Chinese development aid project, partly financed by the Chisinau municipality (TRM 2013, HUAWEI 2013). Considering that Chisinau road infrastructure lacking basic elements as decent road signs does make the quality of this practice questionable (Allmoldova 2009).

Political challenge

A main transport development constraint is the absence of political concern towards urban or transport policy. The result is a lack of political support of sustainable public transport or public transport at all. Furthermore the absence of governmental planning in the highly deregulated economic environment of Moldova leads to a "self controlled" urban development. It follows the general interest of lobby groups and investors, which usually contradicts any form of reasonable development and featuring a high degree of car-orientation. This circumstance leads to the paradox situation that in order to handle the effects of the unregulated development an automotive development is supported by public politics.

If public transport is being supported it is done irrationally, as no integrated development master plan, nor a durable transport development plan exist. In fact a randomly inverting public transport policy makes coherent long-term development difficult (chapter 4.1.3). Under the given conditions the implementation of new public transport systems is expected to be rather difficult, but not impossible. Not at least the on-going bus fleet renewal (chapter 4.1.2.2) demonstrates that political will and financial capabilities do meet sometimes.

Know-how

The lack of know-how very likeable derives from lacking political concern and of course the absence of relevant policy and planning institutions (chapter 4.1.3). For LRT this fact might have a lesser impact than for BRT. Tram systems have a long tradition in CIS states, whereas BRT has its main distribution area in the Americas and in the recent years in South/South East Asia and China. Moldova would be the first post-socialist state with a Bus Rapid Transit (ITDP 2008). Especially in an environment of weak professional skills, this lack of planning tradition (and experience) can yet be a reason to exclude the system as an option for implementation.

In this context the role of a bus concept using CPL is ambivalent. On the one hand traditional bus services are common practice and the improvement of those using CPL would not cause major know-how problems. Yet, the director of the trolleybus operator RTEC indicated in an interview the desirability of CPL for the Chisinau bus services (excluding the minibuses though, which is no option for the concept analysed in this study, see chapter 4.2.3) (Morgoci 2013). On the other hand the CPL concept analysed in this study is the "BRT's little brother", sharing the idea and many conceptual aspects. Not at least the findings within this chapter state, that the CPL implementation can just be the first step of a process. For technical reasons however (chapter 4.2), the succeeding system has to be a BRT system. Considering this, it would either not to a great extend be advisable to implement CPL, and/or a fixation on further BRT development would harm its implementation chances. Though it seems this challenge should not be very severe, and to be solved with the respective sensitiveness to the respective conditions.

7.5 Quo vadis Chisinau?

In this chapter the results of the discussion part are put together and debated freely. The inputs include the actual Chisinau situation (chapter 5.1), findings on the impacts of a projected CPL implementation (chapter 7.2), general best practice development options (chapter 7.3) and actually feasible development possibilities (chapter 7.4). With these inputs an image is drawn of the public transport and urban development future of the City of Chisinau. This chapter aims to give a concluding overview of development trends and the useful impact of possible CPL implementation. Furthermore, the initial problem of the growing economic, social and ecologic pressure on transport solutions is picked up. It is explained why this problem in Chisinau is basically related to automotive development and urban structures. Further contemporary perspectives of public transport and urban development action are presented in reflection of CPL's potential.

Urban sprawl: Following a negative trend

The post-socialist urban transformation always comes along with decentralisation. It happens with the transition of centralized planning on land prices as the crucial element of spatial structuring. With the absence of political planning and relevant institutions the transformation process usually educes decentralized structures with a very low degree of spatial concentration. This effect is called urban sprawl. Due to the deregulated business environment decentralisation of retailers and commerce process is predominately investor-driven, constraining a sustainable development through growing (car) trip demand. As this suburbanisation is mainly impacting traffic structures, the suburbanisation of the residential function also contributes to urban sprawl, causing decentralised low-density settlement structures. From the nature of its extensive and scattered spatial structuring the settlement form is highly car-depended, evoking on the long term a development into an *automotive city*, quite the contrary of an energy-saving and sustainable settlement structure.

Up to date this process of suburbanisation has not terminated though. Restricting the process to a high extend of course will neither be possible or favourable as a measure of urban development. It is part of a general catch-up development, which is difficult to contain. The western lifestyle ideal of "living in the countryside" is popular among a small Moldovan middle-class. Considering *leapfrogging* the step of catch-up suburbanisation appears worthwhile, but cannot happen with restrictions, which also would not be appropriate. But leapfrogging could also mean not the omitting of suburbanisation, but the direction into reasonable urban structures, moderating negative impacts.

With this idea the concept of decentralised but concentrated development is of interest. It does not necessarily assume a higher degree of density, though features a development concentrated on a (sub-) central place. The effect on travel demand is somewhat lower, as a number of living functions can be served in the nearby central place, reducing trip length. Furthermore, the concentration on a central point of transport supply offers the possibility to bundle transport wishes to a combined traffic flow. This can be supplied by a decent public transport system, offering a higher efficiency than individual transport.

Automotive development: Loss of public space

Despite the tendency of increasing PrmT traffic volumes between the city and its surroundings due to suburbanisation other factors contribute to a growing PrmT share in Chisinau. For one the motorization rate increases with increasing economic well-being. Furthermore the actual public transport situation does not offer an attractive alternative to this development. As a consequence PrmT traffic situation deteriorates despite the ample dimensioning of PrmT infrastructure. With politics intervening with further automobile promotion finally a virtuous circle is created, as increasing supply (literally "adding another lane") is usually not a constructive approach to cope with demand problems, capacity will be quickly consumed and a new excess develops[17].

This virtuous circle proceeds within urban life and living quality of the City of Chisinau. Yet, public space is heavily affected by motorized transport. The streetscape is dominated by car traffic, the little space for pedestrians and meeting is occupied by parked cars, decreasing the city's liveability. With the contribution of the recent "new consumerism" as a sociological appearance, emerging shopping malls serve as the attractive social hotspots and thus further weaken the public urban space in its function for social life and communication. Huge supermarkets on the open field and the opening of the "Mall-dova" outside the city centre are just the first observable steps towards the privatisation of public space in Chisinau. Urban life is transferred from the lively street space open and accessible to everybody into the private shopping heavens with their sterile monotony of global retailer franchise shops.

Access to mobility: Enhancing social inequality and exclusion

As stated at the beginning of this study, mobility is a key aspect in the developing world and should be accessible anybody equally. With influence of automotive mobil-

[17] „Who plants roads will harvest traffic" (METTERNICH 2013) referring to SAY's law of the impossibility of overproduction in a national economy, as all supply creates new demand (WOLTHERMANN 2013).

ity growing in a weak public or non-motorized individual transport environment an equal accessibility to mobility can decrease. Considering the *capability approach*[18] of Amartya SEN, in low-income and high income disparity conditions further pro-automobile development would be very questionable, as it could lead to a fatal *double-exposure* of the most vulnerable: Those who have restricted capabilities due to their exposure to poverty (e.g. enjoying a decent education) would also be revoked of their possibility to participate in society at all, because of not having the possibility to own an automobile. Living at the margins of mobility, conflicts with job opportunities and self-fulfilment and has the high potential to lead to social marginalisation of individuals, neighbourhoods or urban areas.

Accident rates and environmental impact

Road safety statistics show a continuing negative trend for Eastern Europe, with the City of Chisinau performing at the rear. As all other transport modes are considerably safer or represent less of a hazard to other ("weaker") modes of transport, a further increase of PrmT transport share inevitably means an increase of fatalities. Instead of a frequent use of public transport, as well as cycling and walking – of course the respective infrastructure would need to be developed in Chisinau – would decrease the number of traffic accident victims.

Among this description of Chisinau development trends for different topics, environment of course is one of the most important. It has its impacts not just within the city boarders affecting peoples' health but also beyond the city borders, amongst others being relevant for global changing processes of global climate. Generally an automotive development contributes more to local and overall emissions negatively impacting environment, than completely emission free walking and cycling or public transport with moderate emissions.

How can CPL advance the situation?

All the development prospects given above, cause to high extends economic, social and environmental costs and negative effects. The concept of buses using CPL has the potential to balance some of these effects. As also explained schematically in figure 29, CPL shows good performance results under the given Chisinau situation. Compared to high-cost best-practice solutions such as BRT, CPL is less competitive, as it generates less capacity improvements, still leaves a large part of travel time saving potential unfulfilled and offers an inferior travel experience and passenger services.

[18] It is the idea and goal ofthe capability approach to understand the capabilities (material and immaterial contributions), someone requires to fulfil self-achievement, as more important (for measuring welfare economics) than economic riches itself (measurable with GDP) (The capability approach was the first multi-dimensional approach to measure welfare economics and is the basis of the HDI.) (SEN 2005: 151).

At the point though were the demand towards a transport system meets reality, it has proven clear that none of the best-practice options is a feasible option for Chisinau right now. Therefore to advance the current *status quo* other strategies are necessary.

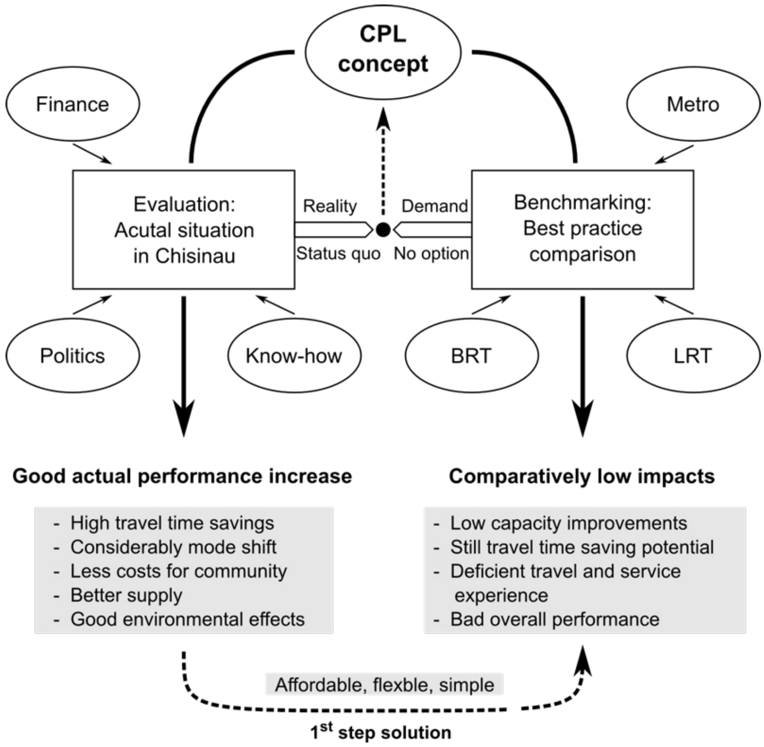


Figure 19: CPL in the system of transport demand and development reality (Design and idea: LEDWOCH).

From its idea of simplicity and low-cost structure the concept of CPL has advantages or resilience against difficult financing, contra productive political support and decision-making and the lack of institutions and know-how. It seems therefore a good first step solution to attack the number of negative development tendencies Chisinau is about to face in the upcoming time.

The problem of urban sprawl, suburbanisation and the resulting transport demand increase cannot be approached by a transport system itself. However, if suburbanisation is politically brought into the form of decentralized concentration, CPL can serve as a transport system serving bundled traffic flows beyond the city's borders. Offering a fast transport link – compared to mixed traffic – within the city, this measure has the potential to contribute to a better mode shift.

Accessibility and transport equity does not improve from an enhanced bus system itself[19]. The CPL bus concept is planned to improve existing bus services in terms of travel speed and compatibility to PrmT. Spatial accessibility not increase, in fact minibus accessibility will decrease. The access to affordable transport though is the essential reason, why CPL is beneficial; through improving service and attracting (more) users durability of the transport system in the deregulated competition is assured.

The CPL effect on the negative trend of increasing energy impacts was yet analysed above. Here the concept allows field benefits, due to the shift towards resource saving transport modes. As also stated above, road safety benefits equally arise from mode shift to saver transport (car to public transport), but additionally benefits from public transport operational safety improvements.

Further implications on sustainable urban development

A large aspect of a measure's quality is also the further development it implies. Despite having impacts on economy, society and environment, the CPL implementation remains a punctual measure and should be included in an advanced overall conception for sustainable urban development. An option, which is at the same time recognized in the scientific debate as well as promoted by most international co-operations in the field of transport, is the *avoid – shift – improve*[20] approach.

Avoiding trips should be the first step towards resource savings and sustainability. This is basically possible through a mix of urban functions and dense urban structures, saving trips to work, shopping and leisure activities. Supply options servicing all the living functions in a decentralized way should therefore be improved. Short distances within the neighbourhood lead to shorter trip lengths, which might influence mode choice. Chisinau potentially holds good possibilities for that. Many sectors are dense *neighbourhoods of short distances* due to the buildings' typology. As discussed above, emphasizing urban space is an important point to raise these sub centres attractiveness. Possible measures are reducing PrmT space and traffic calming to regain urban space for rearrangement. Adding nature (and urban gardens) improve urban climate and shape attractive places to stay and reside.

Shifting trips from motorized transport is the next very important step to save resources and emissions. Transport alternatives are important. Of course an attractive public transport supply, as discussed above, is a must. This is the step where CPL has its punctual influence. Furthermore non-motorized individual transport should gain a

[19] Thinking of mass-transit systems crossing low-income neighbourhoods with no access points for local inhabitants, public transport can be enhanced fostering social inequality.

[20] Since 1990 in scientific focus (STEIERWALD, G. 1994: 377, KAGERMAIER 1998: 548, KOCH 2001: 54) this approach is promoted by UNDP, UNEP, VTPI, GIZ, The World Bank, IEA, etc.

higher share. Infrastructure for pedestrians might include car-free zones, living streets, maintained and lighted sidewalks, walkways and safe street crossings. Establishing cycling as a transport mode is not impossible[21], but only procurable with promotion and the appropriate safe infrastructure: Hierarchic and dense route network with uninterrupted cycle paths, or safe shared space, bike parking facilities and transfer to other transport modes. As motorization rate is still low, it is possible to keep up with good shares, if actions are taken in time.

Improving the last unavoidable bit of transport. This field might contain several ways of improvement. For instance increase car occupancy rates (car-pooling) for the remaining car traffic or car utility rates (car-sharing) in order to reduce urban space consumption for parking. Furthermore technological improvements, which guarantee decent emission standards help keeping up with energy consumption efficiency and pollution. Altogether improving unavoidable motorized transport performance keeps impacts for urban life and environment as low as possible.

General development goals

Combined all development strategies should be orientated towards a general development goal. As impact and significance of peak-oil and coming up against capability borders of the environment are well known and of course likewise relevant for the City of Chisinau, it is a contemporary demand to an overall development goal to create a green, liveable and sustainable city.

Table 20: Possible urban development principles.

Goal	Green	Liveable	Sustainable
Strategy	Saving today's resources and potentials:	Regaining lost values:	Leapfrogging undesirable trends:
Objective	Nature and clean air	Urban space for social life and communication	Automotive infrastructure and urban structure

As further explained in table 20, preserving the city's natural resources and potentials includes control of emissions and urban space consumption, and furthermore interconnects with liveability. Green urban spaces offer enhanced living quality. But liveability also means lively; and, as explained above, a city should be a place a of communication, exchange and culture. Sustainability should exist in the city's subsistence

[21] Cycling in Lviv/Ukraine: The implementation of Ukraine's first cycling plan airs to construct 270 km of cycling infrastructure in Lviv until 2019. The measure yet shows visible sucsess (ELTIS 2013).

strategy. Amongst others this means the promotion of local economy and supply. An important sustainability aspect, which is however quite fare beyond the scope of this study. But it is evident that in order to create a green, liveable and sustainable city a sophisticated, efficient, equal and attractive urban transport is indispensable.

8. Conclusions

The examination of the projected implementation effects of exclusive Combined Priority Lanes (CPL) for the use of all scheduled public transport vehicles (trolleybuses, conventional diesel buses and minibuses) in the City of Chisinau showed good results on public transport performance. For the evaluation 15 indicators were analysed conducting a multilayered assessment, putting importance not only on technical aspects of transport and economical efficiency, but also on societal and environmental impacts. For the procedure a set of empirical methodologies mainly from transport, social, and economic sciences as well as urbanism was used. For the assessment an utility analysis was conducted using a scale of 0 (no beneficial impact) to 4 (very high beneficial impact)[22]. Two network layout alternatives were rated with the grades 2,4 for the concept alternative featuring a route network servicing all primary and secondary inner-urban traffic flow connections and 1,6 for the basic CPL network covering just the city's main traffic axes. Respecting the different investment costs of EUR 5,8M, respectively EUR 4,1M for the basic alternative the ratio between benefits is close to the same for both measures.

In the study performance is conceived as a function of capacity, service speed, reliability and passenger services. Therefore the CPL measure impacted different aspects of performance. Especially transport users and the local economy benefit from extensive travel time savings. Through the enhanced travel time competitiveness, this measure entails a notable shift of trips from motorized to public transport, releasing positive effects on local environment and energy consumption schemes. (With the trolleybus as main system of public transport posing further potential to reduce fossil fuel consumption.) Changes in bus operations cut network accessibility to some extend and affect, to an even lower extend business opportunities of the semi-informal minibus sector. As another disadvantage of the CPL measure account a number of induced public transport trips due to the enhanced attractiveness of the transport system. Compared to the distinct and extensive positive effects, negative impacts are fractionally.

As the study has pointed out, Chisinau public transport performs on a very low level. Under the contemporary conditions, it is possible to attest a high utility benefit to the CPL measure. The comparison to best practice solutions made though clear, that the implementation of CPL is no substitution of an efficient mass transit system, which the city needs urgently. Benchmarking showed that Bus Rapid Transit and Light Rail Transit systems would suite better to the city's size and structure and generate even

[22] With the intermediate steps of: 1 (very little beneficial impact), 2 (some beneficial impact), and 3 (quite strong beneficial impact).

higher performance benefits than CPL. It appears reasonable to assume that whatever change is made on a very low level, leads to strong impacts. Nevertheless, respecting the financial situation of Chisinau, which hardly permits any investment in this field, CPL has proven to be a good first step towards a competitive public transport. Most system alternatives are of questionable feasibility, leaving the risk of a fragmentary and unintegrated implementation with poor operating efficiency, ending up as lightly used or disintegrated stand-alone system. Particularly since CPL is designed as a cheap, simple, flexible and open system, it is easily extendable or upgradeable to the higher performance Bus Rapid Transit. As a first step it therefore causes few dependencies and leaves the option to be adopted according to future development needs.

Development prospects for the city of Chisinau are considerable. Most of the problematic consequences of post-socialist transformation are unambiguous and will undoubtedly occur in Chisinau as they occurred in many other Eastern European cities. The main conflicts are catch-up suburbanisation and the advancing demixing of urban functions in combination with a growing number of private car ownership. This process leads to a spatial expansion of the settlement area, which is not only in terms of energy consumption and protection of environmental resources doubtful. Furthermore urbanity, urban life and quality of life are at risk with the proceeding loss and degradation of public space through automotive development. Keeping in mind that these processes are well delayed compared to other Eastern European cities, an early response could prevent the serious consequences of misguided urban development and high follow-up costs for further generations. In order to leapfrog these undesirable development trends, an important aspect is the promotion of a capable transport system. It needs to be integrated in a contemporary vision for urban structure and provide an attractive alternative to motorized private transportation. Not least public transport has a key role within the approach of avoiding transport demand through an intelligent urban structure, shifting trips on sustainable modes of transport and improving the remaining amount of motorized transport in terms of efficiency, pollution and safety. Therefore Combined Priority Lanes for urban bus transport are even with limited resources a feasible and effective first step for the City of Chisinau towards a sustainable, green and liveable urban future.

Sources

AHMED, F. & VAIDYA, K. G. (2004): The Valuation of Travel Time Savings in Least Developed Countries: Theoretical and Empirical Challenges and Results from a Field Study. In: World Conference on Transport Research Society (Ed.): Conference paper of the 10th World Conference on Transport Research, Istanbul, 4.7. – 8.7.2004.

Allmoldova (2009): Investor will not give money to purchase road signs for Chisinau streets. Publication of 2009-11-28, http://www.allmoldova.com/en/moldova-news/1249045701.html (as of 2014-02-20).

ANDERSEN, L. E. (2001): Low Social Mobility in Bolivia. Causes and Consequences for Development. In: IfW – Kiel Institute for World Economics (Ed.): Kiel Working Paper. Ed. 1046, pp. 1-47.

BASETT, D. T. et al. (2008): Walking, Cycling, and Obesity Rates in Europe, North America, and Australia. In: *Journal of Physical Activity and Health*, vol 5/2008, pp. 795-814.

BMJV – Bundesministerium für Justiz und Verbraucherschutz (2013): Bundeshaushaltsordnung vom 19. August 1969 (BGBl. I S. 1284), die zuletzt durch Artikel 2 des Gesetzes vom 15. Juli 2013 (BGBl. I S. 2395) geändert worden ist.

BMU – Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (2009): Strom aus Erneuerbaren Energien – Zukunftsinvestition mit Perspektiven.

BMVBW – Bundesministerium für Verkehr, Bau- und Wohnungswesen (2003): Bundesverkehrswegeplan 2003: Beschluss der Bundesregierung vom 2. Juli 2003.

BNS – Biroul Nacional de Statistica al Republicii Moldova (2013a): Castigul salarial mediu in anul 2012 si luna decembrie 2012.

BNS – Biroul Nacional de Statistica al Republicii Moldova (2013b): Institutii de Invatamint Superior si Studenti, pe Municipii si Orase, la inceputui de studii 2012/2013. Chapter Chisinau, number of higher education and university students, no page no.

BOHN, M. (2009): Von der europäischen Stadt zur sozialisti- schen Stadt und zurück? Urbane Transformation im östlichen Euro- pa des 20. Jahrhunderts. In: Collegium Carolinum (Ed.): Bad Wiesseer Tagungen des Collegium Carolinum, Band 29.

BORSDORF, A. (2007): Geographisch denken, wissenschaftlich arbeiten. 2. Auflage. Spektrum, Heidelberg/Germany.

BRETTENSCHNEIDER, F. (2013): Die „Schlichtung“ zu „Stuttgart 21“ – Wahrnehmungen und Bewertungen durch die Bevölkerung. In: BRETTENSCHNEIDER, F. & SCHUSTER, W. (Eds.): Stuttgart 21 – Ein Großprojekt zwischen Kritik und Akzeptanz, pp. 185-208.

CANNING, D.; FAY, M. & PEROTTI, R. (1994): Infrastructure and growth. In: BSALDASSARRI, M., et al. (Eds.): International Differences in Growth Rates. New York City/USA, pp. 285 – 310.

CASS, N.; SHOVE, E. & URRY, J. (2005): Social exclusion, mobility and access. In: *The Sociological Review*, vol. 53, issue 3, pp. 539-555.

CERWENKA, P. (1999): Mobilität und Verkehr. Duett und Duell von Begriffen? In: *Der Nahverkehr*, ed. 5/1999, pp. 34-37.

CFM – Calea Ferata din Moldova (2014): Centrul Informativ de Calcul la indicatia administratiei “Calea Ferata din Moldova”. http://www.railway.md/ (as of 2014-04-30).

CHAPMAN, L. (2007). Transport and climate change: a review. In: *Journal of transport geography*, vol. 15, issue 5, pp. 354-367.

CHRISTALLER, W. (1950): Das Grundgerüst der räumlichen Ordnung in Europa: Das System der zentralen Orte. Frankfurt am Main/Germany.

CIORBA, N. (2011): Suburbiile municipiului Chisinau. Date generale. Unpublished slideshow presentation of the Tudor Arghezi library, Chisinau.

CIRILLO, C. & AXHAUSEN, K. W. (2006): Evidence On The Distribution Of Values Of Travel Time Savings From A Six-Week Diary. In: Ortuzar, J. D. (Ed.): Transportation Research Part A: Policy and Practice, vol. 40, issue 5, pp. 444-457.

CISR - Institutul Naţional de Cercetari si Proiectari Urbanproiect Centrul de Investigatii Strategice si Reforme (2005): Planul strategic de dezvoltare social-economica al Chisinaului pana in anul 2020.

Clean Air Initiative 2014: Transport Emissions Evaluation Model (TEEMP) Tool**.** http://cleanairinitiative.org/portal/TEEMPTool (as of 2014-23-04)

CMC – Chisinau Municipal Council (2014): E-urbanism tool Chisinau. http://map.chisinau.md/ (as of 2014-01-05).

COPACI, L. (2013): Interview with the Director of transport management of the Municipality of Chisinau, Mr. Lilian COPACI. Conducted by LEDWOCH, S. 2013-16-12.

CORBUSIER, Le & GRAUDOU, J. (1941): Le Charte d'Athèns de le Congrès internationaux d'architecture moderne – CIAM.

CSO – Central Statistic Office (2013): Average paid employment and average gross wages and salaries. http://www.stat.gov.pl/gus/5840_1786_ENG_HTML.htm (as 2014/21/02).

DALKMANN, H. et al. (2004): Wege von der nachholenden zur nachhaltigen Entwicklung – Infrastrukturen und deren Transfer im Zeitalter der Globalisierung. In: Wuppertal Institut zur Globalisierung (Ed.): Wuppertal Papers, no. 140, Jan. 2004.

DECKERS, B. (2004): Die raumstrukturelle Wirkung von Transformation und EU-Osterweiterung. Zur Rolle der ortsansässigen Bevölkerung bei der Regionalentwicklung im nördlichen deutsch-polnischen Grenzraum. In: STEINGRUBE, W. (Ed.): Greifswalder Geographische Arbeiten. Ernst-Moritz-Arndt-Universität Greifswald.

DÉMURGER, S. (2001): Infrastructure Development and Economic Growth: An Explanation for Regional Disparities in China? In: *Journal of Comparative Economics*, ed. 29, pp. 95-117.

DESTATIS – Statistisches Bundesamt (2013): Earnings and Labour Costs: Development of gross earnings. https://www.destatis.de/EN/FactsFigures (as 2014/21/02).

Deutscher Bundestag (1996): Erfahrungen mit dem "standardisierten Bewertungsverfahren". Drucksache 13/4228 vom 26.03.1996.

DFID – Department for International Development & I.T. Transport Ltd. (2005): The Value of Time in Least Developed Countries: The African Studies. Project Report.

DGS – Directia Generala pentru Statistica a municipiului Chisinau (2013): Chisinau in Chifre – Anuar Statistic 2012. In: Biroul Nacional de Statistica al Republicii Moldova (Ed.): Statistica Moldovei.

DZIEKAN, K. et al. (2013). Evaluation matters. A practitioners' guide to sound evaluation for urban mobility measures. Waxmann, Münster/Germany.

EC – European Commission (2007): European Neighbourhood and Partnership Instrument: Republic of Moldova Country Strategy Paper 2007-2013.

EC – European Commission (2013): Development and Cooperation – EuropeAid. Country Co-operation Moldova. http://ec.europa.eu/europeaid/where/neighbourhood/country-cooperation/moldova/moldova_en.htm (as of 2014-01-03).

EIB – European Investment Bank (2010): Chisinau Trolleybuses Project. www.eib.org/projects/pipeline/2009/20090161.htm?lang=-en (as of 2014-01-03).

ELTIS – The European Mobility Portal (2013): Case study Lviv. Zero Carbon Mobility – Cycling in Lviv.

EMI – European Metropolitan network Institute (2012): Case study on the economic vitality of Bucharest Part of EMI's Knowledge- & Research Agenda Economic Vitality of European Metropolitan Areas January 2012.

Enelsubte (2013): ¿Por qué Metrobus y no Premetro? Published 2013-15-10 http://www.enelsubte.com/noticias/metrobus-y-no-premetro-2892 (as of 2014-04-05).

ENGELMANN, F. C.; HAAG, G. & PISCHNER, TH. (2001): Berechnung und Bewertung des induzierten Verkehrs im Rahmen des Bundesverkehrswegeplans.

EPC – European Projects of the Municipality of Chisinau (2011): Primăria Chişinău face precizări vizavi de proiectul de achiziţionare a 102. http://chisinauprojects.eu /index.php?option=com_content&view=article&id=92%3Atransport-public-chisinau &catid=46%3Acompleted-projects&Itemid=113&lang=en (as of 2014-01-03).

EPOMM – European Platform on Mobility Management (2011): Modal Split Database. http://epomm.eu/tems/index.phtml?Main_ID=2928 (as of 24-03-2014).

ESFAHANI, H. S. & RAMÍREZ, M. T. (2003): Institutions, infrastructure, and economic growth. In: *Journal of Development Economics*, ed. 70, pp. 443-477.

FLETCHER, J. (2010): Urban Road Safety. In: GTZ – Gesellschaft für Technische Zusammenarbeit & SUTP – Sustainable Urban Transport Partnership (Ed.): A sourcebook for policy-makers in developing countries, Module 5b.

FRANCK, N. & STARY, J. (2008): Die Technik wissenschaftlichen Arbeitens. 18. Auflage, UTB Schöningh, Paderborn, München/Germany.

FRIEDRICH, M. (2011): Wie viele? Wohin? Womit? Was können uns Verkehrsnachfragemodelle wirklich sagen? In: FGSV – Forschungsgesellschaft für Straßen- und Verkehrswesen (Ed.): HEUREKA '11 – Optimierungen in Transport und Verkehr, conference paper of summit on 16. And 17. March 2011.

FRIEDRICH, M. (2013): Multimodal Transport Planning. Unpublished lecture script of the Institut für Straßen- und Verkehrswesen, Lehrstuhl Verkehrsplanung und Verkehrsleittechnik, University of Stuttgart/Germany.

FRIEDWANGER, A. et al. (2005): Verkehrsreduktion durch kompakte Raumstrukturen. In: *Zeitschrift der Sozialwissenschaftliche Studiengesellschaft*, vol. 45, issue 3/2005, pp. 386-403.

Google Earth (2014): Virtual globe, map and geographical information tool. Google Inc., Mountain View/USA.

GWILIAM, M. G.(1997): The Value of Time In Economic Evaluation of Transport Projects Lessons from Recent Research. In: The World Bank (Ed.): Infrastructure Notes Transport Sector, no. OT-5, Jan. 1997, pp. 1-7.

HAASE, R. (2007): Für eine Rennaissance des O-Buses. In: DVG – Deutsche Verkehrswissenschaftliche Gesellschaft e.V. (Ed.): Internationales Verkehrswesen, vol. 59, issue 5, pp. 229-231.

HAMALI, A. (2013): Despre troleibuz si tramvai in Chisinau. Thematic blog on Chisinau transport history. http://andrusic.wordpress.com/2013/02/03/despre-troleibuz-si-tramvai-in-chisinau (as of 2014-03-03).

HAYDEN, M. E. (2014): The Global observer: Mumbai's monorail cost $ 450 million, so why is it loosing a quarter million a month? In: *Smart Planet*, vol. 3, issue 18, May 2014.

HELFERICH, C. (2009): Die Qualität qualitativer Daten. Manual für die Durchführung qualitativer Interviews. 3rd edition, VS, Wiesbaden.

HILDEBRANDT, N.; DEUBEL, K. & DICK, M. (2001): Mobilität Ein multidisziplinärer Begriff im Alltagsverständnis.

HINKEL, W. J.; TREIBER, K.; VALENTA, G. & LIEBSCH, H. (2010): Gestern-heute-morgen – U-Bahnen von 1863 bis 2010. Schmid-Verlag, Wien/Austria.

HOOK, W. (2003): Preserving and Expanding the Role of Non-motorised Transport. In: GTZ – Gesellschaft für Technische Zusammenarbeit & SUTP – Sustainable Urban Transport Partnership (Ed.): A sourcebook for policy-makers in developing countries, Module 3d.

HUAWEI Technologies Co., Ltd. (2013): Public Safety Successful Case. Slideshow presentation on HUAWEI large-scale high-capacity surveillance projects worldwide. www.huawei.com (as of 2014-03-03).

I.Stat – Italian Statistics (2013): Gross earnings per full time equivalent unit index. http://dati.istat.it/ (as 2014/21/02).

IEEJ – Implementation of energy strategy of the Republic of Moldova (2011): Energy policy of Republic of Moldova. Presentation.

IEV – Institut für Eisenbahn und Verkehrswesen (2009): Vorlesung "Planung und Betrieb von öffentlichen Verkehrssystemen", Kaptel 4: Betrieb im ÖPNV. Unpublished lecture script.

IMF – International Monetary Fund (2013): World Economic Outlook Database October 2013: Report for Selected Countries and Subjects. http://www.imf.org/external/pubs/ft/weo/2013/02/weodata (as 2014/21/02).

International Bank for Reconstruction and Development & The World Bank (2011): A framework for urban transport benchmarking. No. 70091.

Intraplan (2006): Formblätter Standardisierte Bewertung von Verkehrswegeinvestitionen im öffentlichen Verkehr, Version 2006. Intraplan Consult GmbH, München.

ITDP – Institute for Transportation and Development Policy (2007): Bus Rapid Transit Planning Guide. 3rd edition, New York City/USA.

ITDP – Institute for Transportation and Development Policy (2008): Bus Rapid Transit – An International View. New York City/USA.

ITDP – Institute for Transportation and Development Policy (2013): The BRT Standard. New York City/USA.

JAHN, H. (2010): Die Zukunft der Städte. Die französische Straßenbahn und die Wiedergeburt des urbanen Raumes. Phoibos, Wien/Austria.

JESSEN, J., ROOS, H. J. & VOGT, W. (1997): Stadt – Mobilität – Logistik: Perspektiven, Konzepte und Modelle. In: Stadtforschung Aktuell, Band 63.

JOCHUM, J. (2010): Wie viel Energie verbrauchen wir wirklich? Zahlen zum Bedarf. Präsentation zum Vortrag. In: Universität Tübingen (Ed.): Studium Generale, Sommersemester 2010.

JONES, P. (2012): Developing sustainable transport for the next generation: The need for a multi-sector approach. In: *IATSS Research Journal*, vol. 35, issue 2, pp. 41-47.

KAGERMAIER, A. (1998): Nachhaltigkeitsdiskussion: Herausforderung für die Verkehrsgeographie. In: *Geographische Rundschau*, vol. 50, issue 1, pp. 548-550.

KNOFLACHER, H. (2009): Virus Auto – Die Geschichte einer Zerstörung. Ueberreuter, Wien/Austria.

KNOFLACHER, H. (2010): Schneller – öfter – weiter –immer dümmer. In: HEGE, H.-P. et al. (Eds.).: Schneller, öfter, weiter? Perspektiven der Raumentwicklung in der Mobilitätsgesellschaft. Arbeitsberichte des 13. Jungen Forums der ARL , 13. bis 15. Oktober 2010 in Mannheim.

KOLLMORGEN, R. (1994): Auf der Suche nach Theorien der Transformation. Überlegungen zu Begriff und Theoretisierung der postsozialistischen Transformation. In: *Berliner Journal für Soziologie*, vol. 3/1994, pp. 381-399.

KRAAS, F. (2007): Megacities and global change: key priorities. In: *The Geographical Journal*, vol. 173, nr. 1, pp. 79-82.

KUCKARTZ, U. (2010): Einführung in die computergestützte Analyse qualitativer Daten. 3rd edition, Schöningh, Paderborn/Germany.

LAMNEK, S. (2005): Qualitative Sozialforschung. 4th ed., Beltz, Weinheim/Germany.

LAMNEK, S. (2010): Qualitative Sozialforschung. 5th ed., Beltz, Weinheim/Germany.

Le monde diplomatique (2001): La Moldavie en 2001. Published 2001-19-01.

LEHNHOFF, N. & JANNSEN, S. (2008): Untersuchung und Optimierung der Fahrgastwechselzeit. Working paper, Institut für Verkehrswirtschaft, Straßenwesen und Städtebau, Universität Hannover/Germany.

LEINBACH, T. R. (2000): Mobility in development context: changing perspectives, new interpretations, and the real issues. In: *Journal of Transport Geography*. Ed. 8/2000, pp. 1-9.

LERMAN, Z. (2001): Agriculture in transition economies: from common heritage to divergence. In: *Agricultural Economics*, vol. 26 issue 2001, pp. 95-114.

LITMAN, T. (2002), Evaluating Transportation Equity. In: *World Transport Policy & Practice*, vol. 8, no. 2, pp. 50-65.

LITMAN, T. (2013): Well measured – Developing Indicators for Sustainable and Livable Transport Planning. Working Paper of the Victoria Transport Policy Institute. Ed. Nov. 5, 2013, pp. 1-98.

LITMAN, T. & DOHERTY, E. (2013): Travel Times. In: VTPI – Victoria Transport Policy Institute (Ed.): Transportation Cost and Benefit Analysis. Techniques, Estimates and Implications. Partly updated version of the 2nd ed.

LOHSE, D. & SCHNABEL, W. (2011, Eds.). Grundlagen der Straßenverkehrstechnik und der Verkehrsplanung: Band 2 – Verkehrsplanung. Beuth Verlag.

MALOUFF, D. (2013): The US has only 5 true BRT systems, and none are "gold". In: Greater Washington, published 2013-17-1. http://greatergreaterwashington.org/post/17389/the-us-has-only-5-true-brt-systems-and-none-are-gold/ (as od 2014-16-03).

MAN Bus Deutschland (2014): Stadtbusse. MAN Lion City Busse. http://www.bus.man.eu/ (as 2014-03-03).

MARTE, G. (2003): Kritik der Nutzen-Kosten-Analyse für Verkehrswegeinvestitionen. In: Gruppe unabhängiger Verkehrswissenschaftler (Ed.): Berichte.

MCNALLY, M.G. (2008): The Four-Step Modell. In: HENSHER, D. A. & BUTTON, K. J. (Eds): Handbook of Transport Modeling. 2nd ed., chapter 3, Elsevier Science, Amsterdam.

MEADOWS, D. H.; MEADOWS, D.; RANDERS, J. & BEHRENS III, W. W. (1972): “Limits to Growth” by the Club of Rome.

MERKEL, W. (2007): Gegen alle Theorie? – Die Konsolidierung der Demokratie in Ostmitteleuropa. In: *Politische Vierteljahresschrift des Wissenschaftszentrums für Sozialforschung*, vol. 48, issue 3, pp. 413–433.

MIHAI, B. (2007): Congestiunea traficului urban din municipiul chişinău: cauze şi solutii. In: IDIS Viirtorul (Ed.) Politice Publice.

MINTER, S. (2013): Nutzwertanalyse. In: In: Gabler (Ed.): Wirtschaftslexikon, Springer Verlag, Heidelberg/Germany.

Moldindex (2010): Comertul si dezvoluzarea umana din Republica Moldova: Comertul in Chisinau. www.moldindex.mirfa.md/profilulchis.php?l=ro&idc=336 (as of 2014-01-08).

MORGOCI, G. (2013): Interview with the Director of Regia Transport Electric Chisinau (RTEC) Trolleybus parc no. 1, Mr. Gheorghe MORGOCI. Conducted by LEDWOCH, S. 2013-16-12.

Municipiul Chisinau (2004): Planul Urbanistic General (PUG), elaborated by INCP Urbanproject, HIS Romaia SRL, Business Consulting Institute, I.U. BelNII-Gradostroitelistva.

NICOLAS, J.-P.; POCHET, P.; & POIMBOEUF, H. (2003): Towards Sustainable Mobility Indicators – Application to the Lyons conurbation. In: *Transport Policy*, ed. 3, vol. 10, pp. 197-208.

NOHLEN, D. (2002): Lexikon Dritte Welt: Länder, Organisationen, Theorien, Begriffe, Personen. 12th Edition, Rowohlt, Hamburg/Germany.

OBERHOFER, W. & DIEPLINGER, M. (2013): Sustainability in the Transport and Logistics Sector: Lacking Environmental Measures. In: WELFORD, R. (2013): Business strategy and the environment. Wiley, ERP Environment.

OECD - Organisation for Economic Co-operation and Development (2008): Towards zero: Ambitious road safety targets and the safe system approach.

ONS – Office for National Statistics (2014): Average weekly earnings. Reference table, MS Excel Document.

OSM – Open Street Map (2013): The free wiki world map. Collaborative and freely editable map. Humanitarian map layer of Chisinau. www.osm.org (as 2014/10/02).

PETERSON, J. & RAJÉ, F. (2007): Accessibility, mobility and transport-related social exclusion. In: *Journal of Transport Geography*, vol. 15, issue 3, pp. 151-160.

PETERSON, R. (2004): Land Use Planning and Urban Transport. In: GTZ – Gesellschaft für Technische Zusammenarbeit & SUTP – Sustainable Urban Transport Partnership (Eds.): A sourcebook for policy-makers in developing countries, Module 2a.

PFAFFENBACH, C. (2007): Methode qualitativer Feldforschung in der Geographie. In: GEBHARDT, H. et. al. (Ed.): Geographie. Physische Geographie und Humangeographie. Elsevier, München/Germany.

PFAFFENBACH, C. & REUBER, P. (2005): Methoden der empirischen Humangeographie. Beobachtungen und Befragungen. Westermann, Braunschweig/Germany.

PICHLER-MILANOVIC, N.; GUTRY-KORYCKA, M. & RINK, D. (2007): Sprawl in the Post-Socialist City: The Changing Economic and Institutional Context of Central and Eastern European Cities In: COUCH, C.; LEONTIDOU, L. & PETSCHEL-HELD, G. (Eds.): Urban Sprawl in Europe Landscapes, Land-Use Change & Policy, pp. 102-133. Blackwell Publishing.

Primaria Municipiului Chisinau (2008): Sectorul Botanica al municipiului Chişinău şi raionului Kurzemes al oraşului Riga au semnat un Acord de colaborare. Factsheet of the sector Botanica.

Primaria Municipiului Chisinau (2013a): Internet presence of the City of Chisinau, Sector Botanica. www.botanica.chisinau.md/ (as of 2014-10-02).

Primaria Municipiului Chisinau (2013b): Internet presence of the City of Chisinau, Sector Buiucani. http://www.preturabuiucani.md/ (as of 2014-10-02).

Primaria Municipiului Chisinau (2013c): Internet presence of the City of Chisinau, Sector Ciocana. http://pretura.ciocana.md/ (as of 2014-10-02).

Primaria Municipiului Chisinau (2013d): Internet presence of the City of Chisinau, Sector Riscani. www.riscani.md (as of 2014-10-02).

Primaria Municipiului Chisinau (2013e): Preturi de sector. www.chisinau.md/category.php?l=ro&idc=443 (as of 2014-10-02).

PROTV (2011): Primarul Capitalei vera sa aduca la Chisinau tramvaie. Article from 2011-21 (as of 2014-10-04)

PRYDE, P. (1991): Environmental Management in the Soviet Union. In: Cambridge University (Ed.): Soviet paperbacks. Cambridge University Press, Cambridge/UK

PTV – Planung Transport Verkehr (2013): The company's internet presence. www.ptvgroup.com/en (as of 2014-05-02).

PUCHER, J. (1990): Capitalism, Socialism, and Urban Transportation Policies and Travel Behavior in the East and West. In: *Journal of the American Planning Association*, vol. 56/3, pp. 278-296.

RAUCH, T (2009): Entwicklungspolitik. Theorien, Strategien, Instrumente. 1st Edition, Westermann, Braunschweig/Germany.

REP – Europe Real Estate (2008): First Chisinau shopping mall was opened – 50m USD investment. http://europe-re.com/the-first-mall-of-chisinau-shopping-malldova-was-opened-md/30981 (as of 2014-02-10).

REUBER, P (2007): Interpretativ-verstehende Wissenschaft und die Kraft von Erzählung. In: GEBHARDT, H. et. al. (Hrsg.): Geographie. Physische Geographie und Humangeographie. Elsevier Verlag, München.

RODRIGUE, J.-P; COMTOIS, C. & SLACK, B. (2009): The Geography of Transport Systems. 2nd Ed, Routledge, New York City/USA.

RTEC – Regia Transport Electric Chisinau (2013): Operation schedule of trolleybuses. Unpublished internal document.

SACK, J. (1952): The Butcher: The Ascent of Yerupaja epigraph. Reprinted in: *The Yale Book of Quotations*. P. 529.

SAILER-FLIEGE, U. (1998): Characteristics of post-socialist urban transformation in East Central Europe. In: *GeoJournal,* 09-1999, vol. 49, issue 1, pp. 7-16.

SANCHES – ROBLES, B. (1998): Infrastructure Investment and Groth: Some empirical evidence. In: *Contemporary Economic Policy*, ed. 01/1998, vol. 16, pp. 89-108.

SCHEINER, G. (2003): Bewertungsverfahren in der Verkehrsplanung. In: Fakultät Raumplanung TU Dortmund (Ed.): Raum und Mobilität. Arbeitspapiere des Fachgebiets Verkehrswesen und Verkehrsplanung, vol. 9, May 2003, pp. 1-16.

SCHMIDT, G. (2003): Fahrzeugdurchsatz im Kolonnenverkehr. In: Regierungspräsidium Rheinland-Pfalz (Ed.): Bildung – Mathematik.

SCHOLZ, F. (2004): Geographische Entwicklungsländerforschung. Studienbücher der Geographie. Gebrüder Borntraeger Verlagsbuchhandlung, Berlin/Germany.

SEN, A. (2005): Human Rights and Capabilities. In: *Journal of Human Development*, vol. 6, No. 2, pp. 151-166.

Soccerway (2013): Online search and information engine on football stadiums: RS Lilcora Chisinau. http://en.soccerway.com/teams/moldova/rs-lilcora (as 2014/10/02).

STANILOV, K. (2007): The Post-Socialist City. Urban Form and Space Transformations in Central and Eastern Europe after Socialism. Dordrecht.

Statistisches Bundesamt (2013): Verkehr auf einen Blick. Selbstverlag des Statistischen Bundesamtes, Wiesbaden/Germany.

STEIERWALD, G. (1994): Verkehr und Mobilität. In: Bultinger, R. (Ed.): Technikfolgenabschätzung, pp. 377-391. Tauber Stuttgart/Germany.

TAG – Transport Analysis and Guidance (2006): Value of time and operating costs. Online publication unit 5.3.6, http://www.webtag.org.uk/webdocuments/3_Expert/5_Economy_Objective/3.5.6.htm (as of 2014-01-09).

TANG, U. W. & WANG, Z. S. (2007): Influences of urban forms on traffic-induced noise and air pollution: Results from a modelling system. In: *Environmental Modelling & Software*, vol. 22, issue 12, pp. 1750-1765.

TARKHOV, Sergei (2000). Empire of the Trolleybus: Vol. 1 - Russia. Rapid Transit Publications London/UK

TASNADY, B. (2009): Wo entsteht der Nutzen der Erreichbarkeit? it Studiengang Bauingenieurwissenschaften, Eidgenössische Technische Hochschule Zürich, Institut für Verkehrsplanung und Transportsysteme.

TEC – Transportation Economics Committee (2013): Travel time. In: Transportation Research Board (Ed.): Transportation Benefit-Cost Analysis. http://bca.transportation economics.org/benefits/travel-time (as 2014/20/02).

The World Bank (2013): Data: Country Sheets: Motor Vehicles per 1.000 People. http://data.worldbank.org/indicator/IS.VEH.NVEH.P3 (as of 2014-04-30).

The World Bank (2014a): Data: Country Sheets: GDP. http://data.worldbank .org/indicator/NY.GDP.MKTP.CD (as of 2014-04-30).

The World Bank (2014b): Country Overview: Moldova. http://www.worldbank .org/en/country/moldova/overview (as of 2014-04-30).

ТЕРРИТОРИЯ МОЛДНЕТА (2013a): ГОРОДСКОЙ ТРАНСПОРТ КИШИНЕВА. ТРОЛЛЕЙБУСЫ. [Chisinau online trolleybus timetable information] http://terra.md/ru/timetable/trolley/default.aspx (as of 2014-01-08).

ТЕРРИТОРИЯ МОЛДНЕТА (2013b): ГОРОДСКОЙ ТРАНСПОРТ КИШИНЕВА. АВТОБУСЫ. . [Chisinau online bus timetable information] http://terra.md/ru/timetable/bus/default.aspx (as of 2014-01-08).

ТЕРРИТОРИЯ МОЛДНЕТА (2013c): ГОРОДСКОЙ ТРАНСПОРТ КИШИНЕВА. МАРШРУТНЫЕ ТАКСИ. МАРШРУТКИ. [Chisinau online "mashrutka" timetable information] http://terra.md/ru/timetable/fixed_taxi/default.aspx (as of 2014-01-08).

ТРОЛЛЕЙБУСНЫЙ ЗАВОД (2013): КАТАЛОГ ПРОДУКЦИИ, КАТЕГОРИЯ 'АВТОБУСЫ И ТРОЛЛЕЙБУСЫ. [Trolza/ZiU Trolleybus product catalogue]

TREIBER, M & KESTING, A. (2010): Verkehrsdynamik und Simulation. Daten, Modelle und Anwendungen der Verkehrsflussdynamik. Springer Heidelberg/Germany.

TRM – Teleradio Moldova (2013a): The company's internet presence – section: contact and directions. http://www.trm.md/en/contact (as 2014-02-10).

TRM – Teleradio Moldova (2013b): 41 de intersecţii din Chişinău, monitorizate video. Published 2013-18-10, http://www.trm.md/ro/social/41-de-intersectii-din-chisinau-monitorizate-video (as 2014-03-03).

TSENKOVA, S. (2007): Wind of Change and the spatial transformation of post-socialist cities. Paper by the University of Calgary/Canada.

TSENKOVA, S. & NEDOVIC-BUDIC, Z. (2006): The Urban Mosaic of Post-Socialist Europe. Space, Institutions and Policy. New York City/USA.

UBA – Umweltbundesamt der Bundesrepublik Deutschland (2012): Potentaile des Radverkehrs für den Klimaschutz. Schlussbericht.

UFRRM - Umlandverband Frankfurt Region RheinMain (1999): Verkehrsströme in der Region Frankfurt RheinMain: Die Bedeutung einer einheitlichen Datenbasis für die Verkehrsplanung. Info brochure of the UFRRM, section transport.

UKRSTAT – Ukrainian Buerau of Statistics (2013): Time series of avarage monthly wages by region (1995-2012). http://www.ukrstat.gov.ua/operativ/operativ2006/gdn/prc_rik/prc_rik_e/dszpR_e2006.htm (as 2014/21/02).

UM – Universitatea di stat din Monldova (2014): Web presence of the university. http://usm.md/?page_id=115&lang=ro (as of 2014-03-12)

Umweltbundesamt Österreich (2009): Energieeffiziente Mobilität. http://www.umweltbundesamt.at/umweltsituation/energie/effizienz/effizienzverkehr (as of 2014-03-02)

UNDP – United Nations Development Programme (2014): International Human Development Indicators. http://hdr.undp.org/en/countries (as of 2014-04-04).

UNECE - United Nations Economic Commission for Europe (2004): Overview of the environmental and health effects of urban transport in the Russian Federation and the other countries in eastern Europe, the Caucasus and central Asia. In: Ministry of Transport of the Russian Federation (Ed.): Conference on implementing sustainable urban transport policies in Russia and other CIS states. 30 September – 1 October 2004.

UNECE - United Nations Economic Commission for Europe (2009): Main challenges regarding road safety in Moldova. UNECE presentation and overview.

Unimedia (2013): Cât costă un troleibuz asamblat la Chișinău? http://unimedia.info /stiri/cat-costa-un-troleibuz-asamblat-la-chisinau-67282.html (as 2014-03-11)

UNUP (2013): World Urbanization Prospects, the 2011 Revision. http://esa.un.org/unup/ (as of 2014-ß3-02)

VENTER, C. (2013): The lurch towards formalisation: Lessons from the implementation of BRT in Johannesburg/South Africa. In Centre of Transport Development, Department of Civil Engineering, University of Pretoria (Ed.): Working papers, pp. 1-16.

VTPI – Victoria Transport Policy Institute (2009): Part Value of Travel Time Savings. In: VTPI (Ed.): Transportation Cost and Benefit Analysis. Techniques, Estimates and Implications. Guidebook, Second Edition. Victoria/Canada.

VWI – Verkehrswissenschaftliches Institut Stuttgart GmbH (2010): Standardisierte Bewertung der Breisgau-S-Bahn 2020, im Auftrag der Zweckverband Regio-Nahverkehr Freiburg (ZRF).

WANG, E. C. (2002): Public infrastructure and economic growth: a new approach applied to East Asian economies. In: *Journal of Policy Modelling*. Ed. 24, pp. 411-435.

WHITE, M. W. (1979): Planning of urban transport systems in the Soviet Union: A policy analysis. In: *Transportation Research,* vol. 13, issue 4, pp. 231-240.

WHO – World Health Organisation (2013): Violence and Injury Prevention: Road Safety Country profiles.

WITT, H. (2001): Forschungsstrategien bei qualitativer und quantitativer Sozialforschung. In: *Forum Qualitative Sozialforschung*, vol. 2, no.1, pp. 1-6.

WOLTHERMANN, H.-W. (2013): Stichwort: Say'sches Theorem. In: Gabler (Ed.): Wirtschaftslexikon, Springer Verlag, Heidelberg/Germany.

WRIGHT, L; FJELLSTROM, K (2005): Mass Transit Options. In: GTZ – Gesellschaft für Technische Zusammenarbeit & SUTP – Sustainable Urban Transport Partnership (Ed.): A sourcebook for policy-makers in developing countries, Module 3a.

WRIGHT, L. (2005): Car-free development. In: GTZ – Gesellschaft für Technische Zusammenarbeit & SUTP – Sustainable Urban Transport Partnership (Ed.): A sourcebook for policy-makers in developing countries, Module 3e.

WÜRDEMANN, G. (1999): Siedlungsstrukturen der kurzen Wege. In: KÜHNE, R. (Ed.): Symposium Stadt und Verkehr, vol. 1, pp. 199- 203.

ZAMPARINI, L. & REGGIANI, A. (2007): Meta-Analysis and the Value of Travel Time Savings: A Transatlantic Perspective in Passenger Transport. In: *Networks and Spatial Economics*, vol. 7, issue 4, pp. 377-396.

ZIAI, A. (2010): Postkoloniale Perspektiven auf „Entwicklung". In: *Peripherie*, ed. 120, vol. 30, pp. 399-426.

Erklärung der Selbstständigkeit

Hiermit versichere ich, dass ich die vorliegende Arbeit selbständig und ohne Benutzung anderer als der angegebenen Hilfsmittel angefertigt habe. Alle Stellen, die wörtlich oder sinngemäß aus Veröffentlichungen oder anderen Quellen entnommen wurden, sind als solche eindeutig kenntlich gemacht.

Tübingen, 26.05.2014

Annex

I Interviews

I.I Expert interviews

Interview with Mr Lilian COPACI, Director of transport management of the Municipality of Chisinau, held on: 2014-16-12, 14:10

Cited as: COPACI, L. (2013): Interview with the Director of transport management of the Municipality of Chisinau, Mr. Lilian COPACI. Conducted by LEDWOCH, S. 2013-16-12.

The interview was short and without mark able information on the topic, since the expert promised to answer the prepared questions written and deliver it via email. The content of his answer, which arrived the next day is included without any change or modification in the following. Furthermore the interviewee attached several documents for further information, including:

- Trolleybus operation planning and route network document (MS Word document)
- Conventional operation planning and route network document (MS Word document)
- Minibus route network document (MS Word document)
- Diverse timetable and operational scheduling documents (MS Excel document)

If this information material was used during the study it is also cited as COPACI 2013.

Questions transport directorate// Întrebări pentru direcţia transport

Mr. // Dl. Copaci

Contact: // date de contact

General: // General

Motorization rate // Nr. vehiculelor

Mode share: // divizare pe categorii

	Autobuze	Troleibuze	Microbuze
Nr.	110	336	1757

% private car, // % automobile personale – 239259 un.

% minibus, // % microbuze - 37%

% bus, // % autobuze - 7%

% trolleybus, // % troleibuze - 56%

Average number of trips per person per day // numărul mediu de călători pe zi - Total - 824 000 călătorii/zi

Average trip length // distanţa medie a unei călătorii - 3,5 km

Service: // Servicii

Timetables and travel times all modes // graficul şi itinerarul rutelor pe categorii

Anexă

What are the daily peak hours? // care sunt orele de vîrf, durata lor.

Dimineaţa 07^{00}-09^{00}

Seara 16^{30}-18^{30}

Road safety: // Siguranţa rutieră

Death rates private motorized transport in Moldova (e.g. death/100.000 trips): // Rata mortalităţii categoria transport privat pe Rp.Moldova (nr.decedaţilor/100 000 călătorii)

Death rates public transport Moldova (e.g. death/100.000 trips): // Rata mortalităţii categoria transport public pe Rp. Moldova (nr.decedaţilor/100 000 călătorii)

Death rate minibuses (e.g. death/100.000 trips): // Rata mortalităţii calatorii cu microbuzul (nr.decedaţilor/100 000 călătorii)

Pe parcursul anului 2013 în accidentele cu implicarea transportului public din mun. Chişinău s-a înregistrat un singur deces

Environmental: descrieri

Energy consumption of trolleybus (e.g. Kwh per 100km): // consumul de energie la troleibuze (Kwh / 100 km)

Model ZIU – 2,6 Kwh/km

Model AKSM – 1,8 Kwh/km

Fuel consumption bus (e.g. liter per 100km): consumul de combustibil la autobuze şi microbuze (litri/100 km)

Autobuze	Microbuze
20 – 30 litri	12 – 16 litri

Interview with Mr Gheorghe MORGOCI, Director of Regia Transport Electric Chisinau (RTEC) Trolleybus parc no. 1, held on: 2014-16-12, 17:30

The interview is cited as: MORGOCI, G. (2013): Interview with the Director of Regia Transport Electric Chisinau (RTEC) Trolleybus parc no. 1, Mr. Gheorghe MORGOCI. Conducted by LEDWOCH, S. 2013-16-12.

Attending: Mr Gheoghe Morgoci (interviewee), his secretary (name unknown), Mr Sven Ledwoch (interviewer) and Cristina Balan (translator).

Ledwoch (L): Good afternoon Mr Morgoci, nice to meet you.

Morgoci (M): Yes. Good afternoon.

L: Also I would like to thank you for the opportunity to speak with you. Generally I would like to ask you some questions on the trolleybus operations you manage.

M: Yes.

L: But before I start, I would like to give you some more information on what I intend to do here in Chisinau, as you already know from my assistant [Cristina Balan]. I am a graduate student from the University of Tübingen in Germany, I'm not sure if you have heard of it.

M: I know Germany, but of Tübingen I haven't heared.

L: Yes, it is very a very small university town usually people from Germany can cope with it. Anyway. I am studying geography and transport planning and am conducting my graduation dissertation on the assessment of introduction of, what I call combined priority lanes, in Chisinau. What effects it might have. You might wonder how I have the idea to do it in Chisinau. Well, I know Chisinau quite well, for somebody from Germany at least. I have been here the first time sent by the University of Stuttgart, where I worked as a student researcher. I came here to conduct a study on the Chisinau transport structure and challenges of transport development. We even spoke to the transport minister back then. Well, since I know the city from this time I am interested in it.

M: Ok. Yes, why not I mean.

L: Yes, why not. Still there are some things you might research. Or how do you experience the transport situation in Chisinau?

M: Yes. It is not easy here in Chisinau. We have a lot of problems. Mainly it is congestion of the roads.

L: This is what I want to assess. If it might have a sense to introduce separate express lanes for the busses.

M: Of course it has! This is what we need. In some parts of the city we yet have it, but very few.

L: And not on the main roads. I mean to Botanica and Ciocana and so on. And on Stefan cel Mare!

M: Yes, this is what we need. But I don't know how it could be done.

L: But I analyse if it would be possible also to be used by the minibuses.

M: Hm. I don't know. It could be. Congestion is a difficult subject in Chisinau.

L: The problem will get worse I guess… Even more people getting cars these days.

M: Hm.

L: Besides the large-scale trolley fleet improvement happening the last years, there were no important investments done in public transport, I suppose?

M: Maintenance is done of course, but besides this no large-scale improvements were done, as you can see.

L: Ok, another thing. Do you experience road safety as a major problem?

M: For the buses not. Of course road safety is an issue in Moldova, but public transport is safe.

L: Does this include minibuses?

M: Minibuses have safety issues.

L: How would you describe the operating culture? I mean the drivers.

M: Usually the drivers are alone. Of course it has an influence, selling tickets while driving.

L: And the driving style. Using the minibus I noticed that it is quite aggressive and that traffic laws are violated. I would even say constantly.

M: Yes. But I cannot comment this.

L: Ok, of course. Can I ask you again about the congestion. What would you think, or you know of course, how much is bus traffic delayed in rush hour compared to off-peak service. I mean the overall delay.

M: This is not easy to say as it can be very different. Sometimes busses are stuck for a long time. Of course it dos also depend on the travel direction. In the morning out-side…

L: Yes of course, but maybe you can estimate an average.

M: 30% more maybe.

L: I prepared some fast questions I would like to ask you.

M: Yes.

L: How many of your buses are low-floor buses right now?

M: 133 out of 336

L: What would be the general length of the Chisinau bus network? Do you know it also for each bus system?

M: It would be around 500 km. Right now I cannot tell you how much it would be for each bus system.

L: How much service km do the buses operate per year? Maybe you could distinguish it for the different bus sysetms?

M: No, I really cannot tell you the number for the other busses. For throlleybus it is 16.800M km.

L: Ok, thank you. How many passengers use the buses, or the trolleybus?

M: I is used by 95M passengers per year. Of which 60M buy a ticket. Some groups as seniors residents do not need to pay.

L: And it’s two Lei at the moment.

M: Yes.

L: How many buses do you have in service each day?

M: Around 270.

L: And how is it with the new buses? Do they prove well?

M: Yes, we are very contented.

L: And the passengers?

M: They also I think.

L: Do you had problems with vehicle failure before. I mean brake they down a lot.

M: It is not a problem.

L: How much would be the difference in operating cost?

M: It is quite notable.

L: How much are the operating costs generally?

M: I can't tell you this, company secret.

L: I understand. How is it with the energy consumption? That won't be a secret, no?

M: No. For a new bus it is 1.8 kwh per km, for an old 2.6 kwh per km.

L: This is quite a rise in efficiency. Also considering the better comfort.

M: Yes, we are very happy with them.

L: Ok, Mr Morgoci, I won't hold you up any longer. Thank you for your time than. And the useful information.

I.II Minibus driver intervies

Minibus drivers of the minibus lines 102, 113, 160 (2 drivers), 166, 175 (2 drivers), 192 were questioned, since those routes are of substance for the minibus travel times of the respective routes for CPL. The drivers were asked two questions concerning travel times and a second concerning costs for vehicle investments.

1. What are the travel times of your route between [section of interest for calculation] in peak and off-peak conditions?
2. If you would buy a replacement vehicle, of what type would it be and how much would it cost under Chisinau market conditions?

The answers are listed in Table :

Table 21: Minibus survey results.

Minibus line	Answer Q1 (PH/OP)	Answer Q2 [EUR]
102	15/20	6.500
113	48/65	7.000
160	30/35, 5/7	10.000
160	30/35, 5/5	7.500
166	25/35	8.000 – 9.000
175	25/30	7.500
175	25/35	10.000
192	5/5	8.000

I.III Quantitative survey

Survey sheets

University of Tübingen
Faculty of Science
Working group for Human Geography
and Development Studies
Rümelinstr. 19-23
72070 Tübingen, Germany

EBERHARD KARLS
UNIVERSITÄT
TÜBINGEN

Responsible: Sven LEDWOCH
Contact: ledwoch.sven@gmail.com, Phone MD: +373 (0)681 330531, Phone DE: +49 (0)176 63141451

Project title: Can Combined Priority Bus Lanes, as a Preparatory Step of Bus Rapid Transit (BRT) Implementation, Improve Public Transport Service Performance? Assessing two Bus Route and Layout Options for the City of Chisinau/Moldova.

QUESTIONNAIRE 1: Mode shift and induced traffic

Question Q1: Do you use motorized private transport for any of your regular trips?

YES = 1 NO = 0

If public bus service would be improved with the measure of implementing continuous bus priority lanes throughout the city – as shown on the pictures – bus trips could be speeded up and travel times could be reduced by 15% on average and up to 30% in peak hours. This would for instance mean a travel time benefit of 15 mins. compared to todays bus travel time from Botanica to Centru in peak hours.

Question Q2.1: Considering this case, would you switch some of your regular trips to public transport?

YES = 1 NO = 0

Question Q.2.2: What would be the percentage of the trips switched to public transport?

FEW > 0% … SOME = 33% … MANY = 67% … ALL = 100%

Question Q3.1: Assumed the travel time benefits for public transport would apply, would you undertake more trips than you do today, just because you can reach your destinations more quickly?

YES = 1 NO = 0

Question Q3.2: How many additional trips would this be per week?

[NUMBER]

SEQ. Page of

SEQ.: Name of interviewer: Date: / 12 / 2013

Email: Phone:

Respondent No. [ ]

Q1: [ ] Q2.1: [ ] Q2.2: [ ] % Q3.1: [ ] Q3.2: [ ]

Respondent No. [ ]

Q1: [ ] Q2.1: [ ] Q2.2: [ ] % Q3.1: [ ] Q3.2: [ ]

Respondent No. [ ]

Q1: [ ] Q2.1: [ ] Q2.2: [ ] % Q3.1: [ ] Q3.2: [ ]

Respondent No. [ ]

Q1: [ ] Q2.1: [ ] Q2.2: [ ] % Q3.1: [ ] Q3.2: [ ]

Respondent No. [ ]

Q1: [ ] Q2.1: [ ] Q2.2: [ ] % Q3.1: [ ] Q3.2: [ ]

Respondent No. [ ]

Q1: [ ] Q2.1: [ ] Q2.2: [ ] % Q3.1: [ ] Q3.2: [ ]

Respondent No. [ ]

Q1: [ ] Q2.1: [ ] Q2.2: [ ] % Q3.1: [ ] Q3.2: [ ]

SEQ. Page of

Data collection table

Seq.	No.	Suitable?	Q1	Q2.1	Q2.2	Q3.1	Q3.2
1	1	1	1	1	15	1	1
1	2	1	1	0	n/a	0	n/a
1	3	0					
1	4	1	1	0	n/a	0	n/a
1	5	1	1	0	n/a	0	n/a
1	6	1	1	1	30	1	5
1	7	1	1	1	40	0	n/a
1	8	1	1	0	n/a	0	n/a
1	9	1	1	0	n/a	0	n/a
1	10	0					
1	11	1	1	1	30	1	5
1	12	1	1	0	n/a	0	n/a
1	13	1	1	0	n/a	0	n/a
1	14	1	1	0	n/a	0	n/a
1	15	0					
1	16	1	1	1	3	0	n/a
1	17	1	1	1	80	1	1
1	18	1	1	0	n/a	0	n/a
1	19	0					
1	20	1	1	0	n/a	0	n/a
1	21	1	1	0	n/a	0	n/a
1	22	1	1	0	n/a	0	n/a
1	23	1	1	1	70	0	n/a
1	24	1	1	0	n/a	0	n/a
1	25	1	1	1	30	0	n/a
1	26	1	1	0	n/a	0	n/a
1	27	1	1	1	70	1	5
1	28	1	1	1	20	0	n/a
1	29	1	1	0	n/a	0	n/a
1	30	1	1	0	n/a	0	n/a
1	31	1	1	0	n/a	0	n/a
1	32	1	1	0	n/a	0	n/a
1	33	1	1	0	n/a	0	n/a
1	34	1	1	1	80	0	n/a
1	35	1	1	0	n/a	0	n/a
1	36	1	1	0	n/a	0	n/a
1	37	1	1	1	50	1	1
1	38	1	1	1	30	1	2
1	39	1	1	1	30	1	4
1	40	1	1	0	n/a	0	n/a
1	41	1	1	0	n/a	0	n/a
1	42	1	1	0	n/a	0	n/a
1	43	1	1	1	50	1	1

1	44	1	1	0	n/a	0	n/a
1	45	1	1	0	n/a	0	n/a
1	46	1	1	1	50	1	5
1	47	1	1	0	n/a	0	n/a
1	48	1	1	1	67	0	n/a
1	49	1	1	1	67	1	5
1	50	1	1	0	n/a	0	n/a
1	51	1	1	1	50	0	n/a
1	52	1	1	1	70	1	4
1	53	1	1	0	n/a	0	n/a
1	54	1	1	0	n/a	0	n/a
1	55	1	1	1	75	0	n/a
1	56	1	1	0	n/a	0	n/a
1	57	1	1	0	n/a	0	n/a
1	58	1	1	0	n/a	0	n/a
1	59	1	1	1	67	0	n/a
1	60	1	1	0	n/a	0	n/a
1	61	1	1	1	33	1	1
1	62	1	1	0	n/a	0	n/a
1	63	1	1	1	67	0	n/a
1	64	1	1	0	n/a	0	n/a
1	65	1	1	0	n/a	0	n/a
1	66	1	1	0	n/a	0	n/a
1	67	1	1	1	67	0	n/a
1	68	1	1	0	n/a	0	n/a
1	69	1	1	1	33	0	n/a
1	70	1	1	0	n/a	0	n/a
1	71	1	1	0	n/a	0	n/a
1	72	1	1	0	n/a	0	n/a
1	73	1	1	0	n/a	0	n/a
1	74	1	1	0	n/a	0	n/a
1	75	1	1	1	10	1	1
1	76	1	1	1	17	1	3
1	77	1	1	0	n/a	0	n/a
1	78	1	1	0	n/a	0	n/a
1	79	1	1	0	n/a	0	n/a
1	80	1	1	1	67	0	n/a
1	81	1	1	1	33	1	3
1	82	1	1	0	n/a	0	n/a
1	83	1	1	0	n/a	0	n/a
1	84	1	1	0	n/a	0	n/a
1	85	1	1	0	n/a	0	n/a
1	86	1	1	0	n/a	0	n/a
1	87	1	1	0	n/a	0	n/a
1	88	1	1	0	n/a	0	n/a
1	89	1	1	0	n/a	0	n/a
1	90	1	1	1	33	1	3
1	91	1	1	0	n/a	0	n/a

1	92	1	1	1	10	0	n/a
1	93	1	1	0	n/a	0	n/a
1	94	1	1	1	40	1	1
1	95	1	1	0	n/a	0	n/a
1	96	1	1	1	67	0	n/a
1	97	1	1	1	33	0	n/a
1	98	1	1	0	n/a	0	n/a
1	99	1	1	0	n/a	0	n/a
1	100	1	1	0	n/a	0	n/a
1	101	1	1	1	15	1	3
1	102	1	1	1	25	1	3
1	103	1	1	0	n/a	0	n/a
2	1	1	1	0	n/a	0	n/a
2	2	1	1	1	50	0	n/a
2	3	1	1	1	25	0	n/a
2	4	1	1	0	n/a	0	n/a
2	5	1	1	1	10	1	2
2	6	1	1	1	20	1	3
2	7	1	1	0	n/a	0	n/a
2	8	1	1	1	20	1	2
2	9	1	1	1	33	1	1
2	10	1	1	1	10	0	n/a
2	11	1	1	0	n/a	0	n/a
2	12	1	1	0	n/a	0	n/a
2	13	1	1	0	n/a	0	n/a
2	14	1	1	1	15	1	2
2	15	1	1	0	n/a	0	n/a
2	16	1	1	1	25	0	n/a
2	17	1	1	0	n/a	0	n/a
2	18	1	1	0	n/a	0	n/a
2	19	1	1	1	50	0	n/a
2	20	1	1	0	n/a	0	n/a
2	21	1	1	0	n/a	0	n/a
2	22	1	1	0	n/a	0	n/a
2	23	1	1	1	60	0	n/a
2	24	1	1	1	30	0	n/a
2	25	1	1	1	10	1	1
2	26	1	1	0	n/a	0	n/a
2	27	1	1	0	n/a	0	n/a
2	28	1	1	1	10	1	2
2	29	0					
2	30	1	1	0	n/a	0	n/a
2	31	1	1	0	n/a	0	n/a
2	32	1	1	0	n/a	0	n/a
2	33	1	1	0	n/a	0	n/a
2	34	1	1	1	12	1	2
2	35	1	1	1	20	1	1
2	36	1	1	0	n/a	0	n/a

2	37	1	1	0	n/a	0	n/a
2	38	1	1	1	25	1	4
2	39	1	1	1	30	0	n/a
2	40	1	1	0	n/a	0	n/a
2	41	1	1	0	n/a	0	n/a
2	42	1	1	0	n/a	0	n/a
2	43	1	1	0	n/a	0	n/a
2	44	1	1	1	10	1	1
2	45	1	1	0	n/a	0	n/a
2	46	1	1	0	n/a	0	n/a
2	47	1	1	1	15	1	1
2	48	1	1	0	n/a	0	n/a
2	49	1	1	1	10	0	n/a
2	50	1	1	0	n/a	0	n/a
2	51	1	1	0	n/a	0	n/a
2	52	1	1	1	30	0	n/a
2	53	1	1	0	n/a	0	n/a
2	54	1	1	0	n/a	0	n/a
2	55	1	1	1	20	0	n/a
2	56	1	1	0	n/a	1	2
2	57	1	1	0	n/a	1	1
2	58	1	1	0	n/a	0	n/a
2	59	1	1	1	15	0	n/a
2	60	1	1	1	25	1	1
2	61	1	1	1	40	0	n/a
2	62	1	1	1	30	0	n/a
2	63	1	1	0	n/a	0	n/a
2	64	1	1	0	n/a	0	n/a
2	65	1	1	0	n/a	0	n/a
2	66	1	1	1	30	1	5
2	67	1	1	0	n/a	0	n/a
2	68	1	1	1	30	0	n/a
2	69	1	1	1	40	0	n/a
2	70	1	1	1	10	0	n/a
2	71	1	1	1	10	0	n/a
2	72	1	1	0	n/a	0	n/a
2	73	1	1	0	n/a	0	n/a
2	74	1	1	1	25	1	n/a
2	75	1	1	1	10	1	1
2	76	1	1	0	n/a	0	n/a
2	77	1	1	1	25	0	n/a
2	78	1	1	1	10	0	n/a
2	79	1	1	0	n/a	0	n/a
2	80	1	1	0	n/a	0	n/a
2	81	1	1	0	n/a	0	n/a
2	82	1	1	1	30	0	n/a
2	83	1	1	0	n/a	0	n/a
2	84	1	1	1	10	1	4

2	85	1	1	0	n/a	0	n/a
2	86	1	1	0	n/a	0	n/a
2	87	1	1	0	n/a	0	n/a
2	88	1	1	0	n/a	0	n/a
2	89	1	1	1	20	0	n/a
2	90	1	1	1	n/a	0	n/a
2	91	1	1	1	50	0	n/a
2	92	1	1	1	10	0	n/a
2	93	1	1	0	n/a	0	n/a
2	94	1	1	0	n/a	0	n/a
2	95	1	1	0	n/a	0	n/a
2	96	1	1	1	n/a	1	1
2	97	1	1	0	n/a	0	n/a
2	98	1	1	0	n/a	0	n/a
2	99	1	1	0	n/a	0	n/a
2	100	1	1	0	n/a	0	n/a
2	101	1	1	1	10	1	1
2	102	1	1	0	n/a	0	n/a
2	103	1	1	0	n/a	0	n/a
3	1	0					
3	2	0					
3	3	0					
3	4	0					
3	5	0					
3	6	0					
3	7	0					
3	8	0					
3	9	0					
3	10	0					
3	11	0					
3	12	0					
3	13	0					
3	14	0					
3	15	0					
3	16	0					
3	17	0					
3	18	0					
3	19	0					
3	20	0					
3	21	0					
3	22	0					
3	23	0					
3	24	0					
3	25	0					
3	26	0					
3	27	0					
3	28	0					
3	29	0					

3	30	0					
3	31	0					
3	32	0					
3	33	0					
3	34	0					
3	35	0					
3	36	0					
3	37	0					
3	38	0					
3	39	0					
3	40	0					
3	41	0					
3	42	0					
3	43	0					
3	44	0					
3	45	0					
3	46	0					
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3	55	0					
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3	72	0					
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3	100	0					
3	101	0					
3	102	0					
3	103	0					
3	104	0					
3	105	0					
3	106	0					
3	107	0					
3	108	0					
3	109	0					
3	110	0					
4	1	1	1	1	10	0	n/a
4	2	1	1	0	n/a	1	1
4	3	1	1	0	n/a	0	n/a
4	4	1	1	1	15	0	n/a
4	5	1	1	1	10	1	3
4	6	1	1	1	15	0	n/a
4	7	1	1	1	20	1	3
4	8	1	1	0	n/a	0	n/a
4	9	1	1	0	n/a	0	n/a
4	10	1	1	1	20	0	n/a
4	11	1	1	1	20	0	n/a
4	12	1	1	0	n/a	0	n/a
4	13	1	1	0	n/a	0	n/a
4	14	1	1	0	n/a	0	n/a
4	15	1	1	0	n/a	0	n/a

4	16	1	1	1	30	1	2
4	17	1	1	0	n/a	0	n/a
4	18	1	1	1	35	1	2
4	19	1	1	0	n/a	0	n/a
4	20	1	1	0	n/a	0	n/a
4	21	1	1	0	n/a	0	n/a
4	22	1	1	1	40	0	n/a
4	23	1	1	0	n/a	0	n/a
4	24	0					
4	25	1	1	0	n/a	0	n/a
4	26	0					
4	27	1	1	1	30	1	4
4	28	1	1	0	n/a	0	n/a
4	29	1	1	0	n/a	0	n/a
4	30	1	1	0	n/a	0	n/a
4	31	1	1	0	n/a	0	n/a
4	32	1	1	1	25	0	n/a
4	33	1	1	1	25	0	n/a
4	34	1	1	1	20	0	n/a
4	35	1	1	0	n/a	0	n/a
4	36	1	1	0	n/a	0	n/a
4	37	1	1	0	n/a	0	n/a
4	38	1	1	0	n/a	0	n/a
4	39	1	1	1	50	0	n/a
4	40	1	1	1	33	0	n/a
4	41	1	1	1	30	1	1
4	42	1	1	1	30	0	n/a
4	43	1	1	1	25	1	4
4	44	1	1	1	30	0	n/a
4	45	1	1	0	n/a	0	n/a
4	46	1	1	0	n/a	0	n/a
4	47	1	1	1	n/a	0	n/a
4	48	1	1	1	40	1	2
4	49	1	1	1	40	0	n/a
4	50	1	1	0	n/a	0	n/a
4	51	1	1	0	n/a	0	n/a
4	52	1	1	1	30	0	n/a
4	53	1	1	0	n/a	0	n/a
4	54	1	1	1	30	0	n/a
4	55	1	1	1	20	1	2
4	56	1	1	1	10	1	1
4	57	1	1	1	10	0	n/a
4	58	1	1	1	15	1	1
4	59	1	1	1	40	0	n/a
4	60	1	1	1	20	0	n/a
4	61	1	1	0	n/a	0	n/a
4	62	1	1	1	20	1	1
4	63	1	1	1	10	1	2

4	64	1	1	0	n/a	0	n/a
4	65	1	1	0	n/a	0	n/a
4	66	1	1	0	n/a	0	n/a
4	67	1	1	0	n/a	0	n/a
4	68	1	1	1	10	0	n/a
4	69	1	1	1	20	1	2
4	70	1	1	1	10	1	1
4	71	1	1	0	n/a	0	n/a
4	72	1	1	1	25	1	2
4	73	1	1	1	40	1	3
4	74	1	1	0	n/a	0	n/a
4	75	1	1	1	25	0	n/a
4	76	1	1	1	20	0	n/a
4	77	1	1	1	33	0	n/a
4	78	1	1	1	10	1	1
4	79	1	1	1	10	1	2
4	80	1	1	1	15	0	n/a
4	81	1	1	1	20	0	n/a
4	82	1	1	1	20	0	n/a
4	83	1	1	1	30	0	n/a
4	84	1	1	1	15	0	n/a
4	85	1	1	1	20	0	n/a
4	86	1	1	1	10	1	2
4	87	1	1	1	10	0	n/a
4	88	1	1	1	25	0	n/a
4	89	1	1	1	30	0	n/a
4	90	1	1	1	15	1	1
4	91	1	1	1	10	1	1
4	92	1	1	1	20	0	n/a
4	93	1	1	1	20	0	n/a
4	94	1	1	1	10	0	n/a
4	95	1	1	1	10	0	n/a
4	96	1	1	1	10	0	n/a
4	97	1	1	1	50	1	1
4	98	1	1	1	40	0	n/a
4	99	1	1	1	30	1	4
4	100	1	1	0	n/a	0	n/a
4	101	0					
4	102	1	1	1	10	1	1
4	103	1	1	1	30	1	2
5	1	1	1	0	n/a	0	n/a
5	2	1	1	1	30	0	n/a
5	3	1	1	0	n/a	0	n/a
5	4	1	1	0	n/a	0	n/a
5	5	1	1	0	n/a	0	n/a
5	6	1	1	1	50	1	1
5	7	1	1	1	20	0	n/a
5	8	1	1	1	25	0	n/a

5	9	1	1	0	n/a	0	n/a
5	10	1	1	0	n/a	0	n/a
5	11	1	1	1	50	0	n/a
5	12	1	1	0	n/a	0	n/a
5	13	1	1	0	n/a	0	n/a
5	14	1	1	1	15	1	5
5	15	1	1	0	n/a	0	n/a
5	16	1	1	0	n/a	0	n/a
5	17	1	1	1	30	0	n/a
5	18	1	1	1	30	1	5
5	19	1	1	1	25	0	n/a
5	20	1	1	0	n/a	0	n/a
5	21	1	1	1	50	0	n/a
5	22	1	1	0	n/a	0	n/a
5	23	1	1	0	n/a	0	n/a
5	24	1	1	0	n/a	0	n/a
5	25	1	1	1	30	0	n/a
5	26	1	1	1	30	0	n/a
5	27	1	1	0	n/a	0	n/a
5	28	1	1	1	60	1	3
5	29	1	1	0	n/a	0	n/a
5	30	1	1	0	n/a	0	n/a
5	31	1	1	1	20	0	n/a
5	32	1	1	0	n/a	0	n/a
5	33	1	1	0	n/a	0	n/a
5	34	1	1	0	n/a	0	n/a
5	35	1	1	0	n/a	0	n/a
5	36	1	1	1	25	0	n/a
5	37	1	1	0	n/a	0	n/a
5	38	1	1	1	40	1	1
5	39	1	1	0	n/a	0	n/a
5	40	1	1	1	60	1	1
5	41	1	1	1	40	1	n/a
5	42	1	1	1	40	1	2
5	43	1	1	0	n/a	0	n/a
5	44	1	1	1	25	0	n/a
5	45	1	1	0	n/a	0	n/a
5	46	1	1	0	n/a	0	n/a
5	47	1	1	0	n/a	0	n/a
5	48	1	1	0	n/a	0	n/a
5	49	1	1	1	30	1	4
5	50	1	1	1	20	0	n/a
5	51	1	1	1	20	1	1
5	52	1	1	1	20	0	n/a
5	53	1	1	0	n/a	0	n/a
5	54	1	1	1	30	0	n/a
5	55	1	1	1	20	0	n/a
5	56	1	1	1	10	0	n/a

5	57	1	1	0	n/a	0	n/a
5	58	1	1	0	n/a	0	n/a
5	59	1	1	1	20	0	n/a
5	60	1	1	0	n/a	0	n/a
5	61	1	1	0	n/a	0	n/a
5	62	1	1	0	n/a	0	n/a
5	63	1	1	1	10	1	1
5	64	1	1	0	n/a	0	n/a
5	65	1	1	0	n/a	0	n/a
5	66	1	1	0	n/a	0	n/a
5	67	1	1	1	20	0	n/a
5	68	1	1	0	n/a	0	n/a
5	69	1	1	1	40	1	1
5	70	1	1	0	n/a	0	n/a
5	71	1	1	0	n/a	0	n/a
5	72	1	1	0	n/a	0	n/a
5	73	1	1	1	25	0	n/a
5	74	1	1	0	n/a	0	n/a
5	75	1	1	0	n/a	0	n/a
5	76	1	1	0	n/a	0	n/a
5	77	1	1	0	n/a	0	n/a
5	78	1	1	1	30	0	n/a
5	79	1	1	0	n/a	0	n/a
5	80	1	1	1	40	1	3
5	81	1	1	1	20	1	1
5	82	1	1	1	30	0	n/a
5	83	1	1	1	30	0	n/a
5	84	1	1	1	20	0	n/a
5	85	1	1	0	n/a	0	n/a
5	86	1	1	0	n/a	0	n/a
5	87	1	1	1	20	1	1
5	88	1	1	0	n/a	0	n/a
5	89	1	1	0	n/a	0	n/a
5	90	1	1	0	n/a	0	n/a
5	91	1	1	1	20	0	n/a
5	92	1	1	1	20	0	n/a
5	93	1	1	0	n/a	0	n/a
5	94	1	1	1	40	1	5
5	95	1	1	1	10	0	n/a
5	96	1	1	1	30	1	1
5	97	1	1	0	n/a	0	n/a
5	98	1	1	0	n/a	0	n/a
5	99	1	1	1	25	0	n/a
5	100	1	1	0	n/a	0	n/a
5	101	1	1	1	10	0	n/a
5	102	1	1	1	30	1	1
5	103	1	1	1	25	1	1

Data collection summary

Seq. 1: Name of interviewer: Eugenia Maxim, Location: Botanica

	Suitable?	Q1	Q2.1	Q2.2	Q3.1	Q3.2
"YES"	99	99	37		20	
of total	103	99	99		99	
No.						57
%	96,1	100,0	37,4	43,9	20,2	

Seq. 2: Name of interviewer: Rusano Vschii, Location: Centru

SEQ. 2:	Suitable?	Q1	Q2.1	Q2.2	Q3.1	Q3.2
"YES"	102	102	44		21	
of total	103	102	102		102	
No.						38
%	99,0	100,0	43,1	37,8	20,6	

Seq. 3: Name of interviewer: Ludmila Stratu, Location: Riscani

SEQ. 3:	Suitable?	Q1	Q2.1	Q2.2	Q3.1	Q3.2
"YES"	0	N/A	N/A		N/A	
of total	103	0	0		0	
No.						N/A
%	0,0			N/A		

Seq. 4: Name of interviewer: Alina Ouica, Location: Codru

SEQ. 4:	Suitable?	Q1	Q2.1	Q2.2	Q3.1	Q3.2
"YES"	100	100	65		27	
of total	103	100	100		100	
No.						52
%	97,1	100,0	65,0	26,2	27,0	

Seq. 5: Name of interviewer: Dorina Craiunescu, Location: Buiucani

SEQ. 5:	Suitable?	Q1	Q2.1	Q2.2	Q3.1	Q3.2
"YES"	103	103	48		19	
of total	103	103	103		103	
No.						38
%	100,0	100,0	46,6	33,4	18,4	

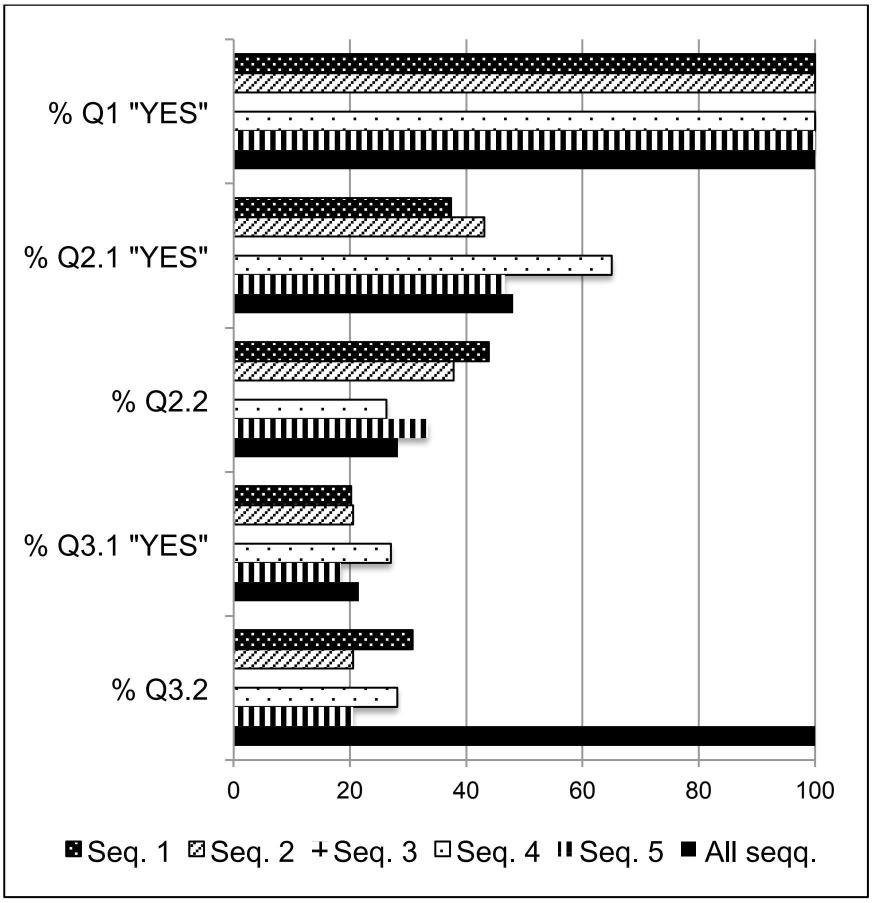
All seqq.:

Overall	Suitable?	Q1	Q2.1	Q2.2	Q3.1	Q3.2
"YES"	404	404	194		87	
of total	515	404	404		404	
No.						185
%	78,4	100,0	48,0	28,3	21,5	

Data analysis

	% Q1 "YES"	% Q2.1 "YES"	% Q2.2	% Q3.1 "YES"	% Q3.2
Seq. 1	100,0	37,4	43,9	20,2	30,8
Seq. 2	100,0	43,1	37,8	20,6	20,5
Seq. 3					0,0
Seq. 4	100,0	65,0	26,2	27,0	28,1
Seq. 5	100,0	46,6	33,4	18,4	20,5
All seqq.	100,0	48,0	28,3	21,5	100

Answer deflection of the distinct survey areas



Mode shift calculation

	% Q2.1 "YES"	% Q2.2	% Shift	Jorneys/day
All seqq.	48	23,3	13,574442	46.240

Induced traffic calculation

	Journeys per week	Journeys per year	
All seqq.	0,0986117	5,0291967	per interviewee
All seqq.	64.817	3.305.690	in examination area[23]

[23] 657.300 inhabitants (DGS 2013: 11)

II Experiments

II.I Travel time measuring experiment

Fig.: The measuring vehicle used for this experiment setup (Source: LEDWOCH).

Table 12: Measured raw data.

Relation	[min]
Bo-1 – Bo-2	3
Bo-2 – Ce-2	5
Bo-2 – Ce-2 via train st.	9
Hi-1 – Hi-2	5
Hi-2 – Bo-1	9
Hi-2 – Ce-3	4
Ce-3 – Ce-1	6
Ce-3 – Ce-2	4
Ce-2 – Ci-2	7
Ce-2 – Ce-1	6
Ce-1 – Bu-2	4
Ce-1 – Ri-2	8
Ri-2 – Ci-2	4
Ri-2 – Ri-1	3
Ci-2 – Ci-1	4
Bu-2 – Bu-1	10

III Calculations

III.I Travel time difference calculation

For the TTD calculation Fig. XY reminds the four-step procedure, described in chapter 5.1.1. For a better understanding data inputs and data calculation outputs have been added.

(Step 1) Journey generation

Inhabitant figures:

Number of total rides: 824.000 (COPACI 2013).

Table 22: Inhabitant no. calculated per zone.

Catchment area	Inhabitants
Botanica*	164.300
Buiucani	111.500
Centru	94.200
Ciocana	118.200
Riscani	138.400
Schinoasa°	30.700
total:	657.300

*includes:	Botanica	172.600
	Codru*0,5	7.500
	less Telecentru	-15.800
°includes:	Codru*0,5	7.500
	Schinoasa	7.400
	Telecentru	15.800

Calculation results for PS1, PS2 and CS are:

Table 23: Traffic zone catchment, inhabitant distribution and the resulting trip generation calculation .

Zone	Sector	Inhabitants	Generation ratio (P_i)	Generated journeys/day
Bo	Botanica/Codru	164.300	0,25	205.969
Bu	Buiucani	111.500	0,17	139.778
Ce	Centru	94.200	0,14	118.090
Ci	Ciocana	118.200	0,18	148.177
Ri	Riscani	138.400	0,21	173.500
Sc	Schinoasa/Codru/Telecentru	30.700	0,05	38.486
	Total inhabitants in examination area	657.300	PT journeys/day	824.000

(Inhabitant data: DGS 2013: 11, Ciorba 2011)

(Step 2) Journey distribution

Qualitative analysis of all traffic zones: Attraction of each zone will be assessed and set into relation with the other zones with qualitative information of chapters 3.2.1 and 5.1, describing functional segregation of the urban sectors in Chisinau. Each zone rated with marks from 0 (no attraction), 1 (very little attraction), 2 (some attraction), 3 (quite attractive) to 4 (very attractive).

Structural data *L* of each (attracting) zone *j* and attraction ratio RL_j for rough quantitative orientation:

$$RL_j = \frac{L_j}{\sum_{j=1}^{6} j}$$

Table 24: Activity indicators *L* and attraction ratios *RL*.

zone	Inhabi- tants	% work- places	Workpl. attraction ratio	Higher Edu. and Univ.	Edu- cation ratio	Retailers	Supply attraction ratio
Bo	164.300	55	0,10	0	0,00	125,00	0,20
Bu	111.500	100	0,18	0	0,00	80,00	0,13
Ce	94.200	230	0,42	28.130	1,00	250,00	0,39
Ci	118.200	55	0,10	0	0,00	75,00	0,12
Ri	138.400	75	0,14	0	0,00	95,00	0,15
Sc	30.700	30	0,06	0	0,00	10,00	0,02

Table 25: Assessment of attraction of Chisinau traffic zones.

Bo	
Description: Botanica is one – and the latgest – of the cities' three peri-urban planned community large housing estate districts. The "homogeneous housing area" (Primaria Municipiului Chisinau 2013a and 2008), is characterized with an almost exclusive residential function.	
Working: Low presence of commerce and industry (DGS 2013: 90) and the cities' lowest workplace ratio (Primaria Municipiululi Chisinau 2004: 36).	very low
Higher education: Beyond general education no supply at all (BNS 2013).	none
Supply: Higher than in other zones of comparable functional structure (Moldindex 2010), with many supermarkets along Bd. Dacia (OSM 2013), and many small retailers and kiosks (own observation).	good
Leisure: No cultural institutions, many dining restaurants in Bd. Decebal (OSM 2013), sports arena (very) with periodic events (Primaria Municipiului Chisinau 2013a).	low
Overall attraction rating: Lowest attraction compared to the other zones, with little bonus in the supply sector.	1,5

Bu	
Description: Buiucani is another peri-urban community, with a higher share of apartment houses it structurally differs from the usual planned community large housing estate districts as Botanica, Ciocana and Riscani (see chapter 4.1.2.1) and the use is a little more mixed with some industrial function as well.	
Working: Especially small and medium-sizes enterprises (SME) are located in Buicani (Primaria Municipiului Chisinau 2013b) and offer a number of workplaces (Primaria Municipiululi Chisinau 2004: 36).	medium
Higher education: Beyond general education no supply at all (BNS 2013).	none
Supply: No web search or OSM evidence of large retailers found. Retailer ratio also low (Moldindex 2010), as OSM retailer density (OSM 2013).	low
Leisure: No cultural institutions worth mentioning could be detected. For sporting activities there is a local stadium (Soccerway 2013).	low
Overall attraction rating: As other attraction categories are low, the high SME share appears as a quite unique feature, compared to the other zones.	2

Ce	
Description: With Chisinau being Moldova's capital, the central district does not only function as a *central place* (CHRISTALLER 1950) within the city limits, but it services the whole country with higher business, education, administrative, culture and supply institutions (Primaria Municipiululi Chisinau 2004: 12). The double role as national and inter-urban central place underlines the city's steep separation of urban functions.	
Working: Many workplaces in tertiary sector services, especially of periodic demand (Primaria Municipiululi Chisinau 2004: 36), followed by a number of quaternary economic sector workplaces and within the extensive administrative and educational sector (ibid).	very high
Higher education: All the city's higher educational institutions (no decentralization or "suburbanization" of educational locations in Chisinau) (UM 2014, BNS 2013) are located here.	very high
Supply: Not only a the highest share of the city's periodic and high-end supply (Moldindex 2010) can be found here, but also the city's central market for daily supply (OSM 2014). Furthermore the large "MallDova" shopping mall is locat-	very high

ed in Ce zone (OSM 2013, REP 2008).	
Leisure: Double role of national and inter-urban *central place* of culture, offering many theatres, an opera, museums and cinemas (OSM 2014). Also the city's gastronomic and nightlife center (ibid.).	very high
Overall attraction rating: Highest attraction in all categories.	4

Ci	
Description: As Bo and Ri, Ciocana is one of the peri-urban large housing estate communities, though it has the distinct attributes of a dormitory suburb (chapter 4.1.2.1). The southern half of the zone is occupied by a former heavy industry industrial site (OSM 2014).	
Working: Very distinct housing function and, amongst Botanica, lowest working place ratio (Primaria Municipiululi Chisinau 2004: 36). The in terms of traffic unproductive (mostly abandoned) industrial site in the south of the zone does not contribute to this (Primaria Municipiului Chisinau 2013c).	very low
Higher education: Beyond general education no supply at all (BNS 2013).	none
Supply: No web search or OSM evidence of large retailers found. Retailer ratio also low (Moldindex 2010), as OSM retailer density (OSM 2013).	low
Leisure: No cultural institutions worth mentioning could be detected.	low
Overall attraction rating: With no exiguous attraction bonus as Bo or Ri, the lowest overall attraction of all peri-urban housing estate zones. The industrial site does not contribute, as it could be expected.	1

Ri	
Description: Riscani is the peri-urban large housing district closest to the city centre.	
Working: The slightly higher share in workplaces in service sector, especially in gastronomy sector might also lead to a statistic work place ratio value between Bo/Ci and Bu (Primaria Municipiululi Chisinau 2004: 36).	medium-low
Higher education: Beyond general education no supply at all (BNS 2013).	none
Supply: OSM shows some small retailers (OSM 2013), though concerning the number of inhabitants supply rate appears low. Statistic retailer ratio also low	low

(Moldindex 2010).	
Leisure: No cultural institutions of importance could be identified. Quite an offer of nightlife and gastronomy (OSM 2013) and the reputation of a nightlife sub-centre.	medium
Overall attraction rating: Ri with its relative bonus in leisure, appears very similar to Bo, with its above-peri-urban-average supply values.	1,5

Sc	
Description Schinoasa/Codru/Telecentu: Heterogeneous zone with suburban population density and characteristics in Schinoasa and the contributing part of Codru, and higher population density with multi-family houses in Telecentru.	
Working: Being mostly suburban housing fuction area, the zone offers almost no work places at all, with the exception of the TRM (Teleradio Moldova), with its headquarter being located partly in Sc zone, with the bigger share in Ce zone though (TRM 2013a).	low
Higher education: Beyond general education no supply at all (BNS 2013).	none
Supply: No web search or OSM evidence of large retailers found (OSM 2013). Retailer ratio also low (Moldindex 2010).	very limited
Leisure: No cultural institutions at all could be detected.	very low
Overall attraction rating: Except from the partial influence of TRM no relevant work places, education or leisure. In comparison with other zones structurally the less attractive zone (note: not considering the attraction of bus long-haul station “Gara de Sud” as none of this connecting nodes are being considered (see chapter 4.2).	0,5

Table 26: Attraction rating results of Chisinau traffic zones [min].

from \ to	Bo	Bu	Ce	Ci	Ri	Sc
Bo	n/a	2	4	1	1,5	0,5
Bu	1,5	n/a	4	1	1,5	0,5
Ce	1,5	2	n/a	1	1,5	0,5
Ci	1,5	2	4	n/a	1,5	0,5
Ri	1,5	2	4	1	n/a	0,5
Sc	1,5	2	4	1	1,5	n/a

Table 27: Attraction coefficient a_j matrix [min].

from \ to	Bo	Bu	Ce	Ci	Ri	Sc
Bo	n/a	0,2280	0,4559	0,1140	0,1710	0,0570
Bu	0,1710	n/a	0,4559	0,1140	0,1710	0,0570
Ce	0,1710	0,2280	n/a	0,1140	0,1710	0,0570
Ci	0,1710	0,2280	0,4559	n/a	0,1710	0,0570
Ri	0,1710	0,2280	0,4559	0,1140	n/a	0,0570
Sc	0,1710	0,2280	0,4559	0,1140	0,1710	n/a

Table 28: Origin/destination matrix [min].

from \ to	Bo	Bu	Ce	Ci	Ri	Sc
Bo	n/a	46.955	93.910	23.478	35.216	11.739
Bu	23.899	n/a	63.731	15.933	23.899	7.966
Ce	20.191	26.921	n/a	13.461	20.191	6.730
Ci	25.335	33.780	67.561	n/a	25.335	8.445
Ri	29.665	39.553	79.106	19.777	n/a	9.888
Sc	6.580	8.774	17.547	4.387	6.580	n/a

(Step 4) Route assignment and travel time calculation

Schematic network

In order to allow a systematic data collection and compare times systematically the relevant CPL/current comparison network was divided in a scheme of nodes and links, with the nodes named after the transport zone (Fig.). The nodes *Xi*-1 are the starting/end point of a CPL corridor.

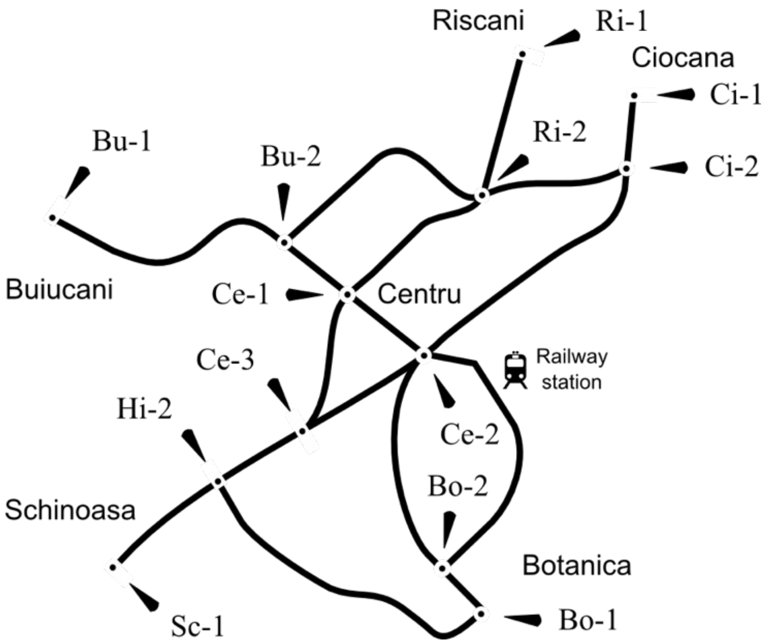


Figure 30: Schematic comparable route network (Graphic: LEDWOCH).

The nodes can be found in Chisinau on the following locations:

Ce-1: Corner Bulevardul Ștefan cel Mare și Sfînt / Strada A. Pușkin (one direction) / Strada Mitropolit Gavriil Bănulescu-Bodoni (other direction)

Ce-2: Corner Bulevardul Ștefan Cel Mare și Sfînt / Strada Ismail

Ce-3: Roundabout Șoseaua Hînceşti / Strada Pantelimon Halippa / Strada Vasile Alecsandri

Ci-1: End of Bulevardul Mircea cel Bătrîn

Ci-2: Corner Strada Meșterul Manole / Strada Vadul lui Vodă

Bo-1: Corner Bulevardul Dacia / Strada Valea Crucii / Strada Grădina Botanică

Bo-2: Corner Bulevardul Dacia / Bulevardul Decebal

Bu-1: Corner Strada Alba-Iulia / Şoseaua Balcani

Bu-2: Corner Bulevardul Ștefan Cel Mare și Sfînt / Strada Mihai Viteazul

Sc-1: Șoseaua Hînceşti / Șoseaua Hînceşti

Sc-2: Corner Șoseaua Hînceşti / Strada Mioriţa

Ri-2: Corner Bulevardul Moscova / Strada Bogdan Voievod

(Step 4.1) Shortest travel time calculation – Current Case

Table 9: Trolleybus timetable raw data for bus travel time calculation.

Relation	Serviced by bus line no.	[min]	Relation	Serviced by bus line	[min]
Bo-1 - Ce-1	18	31	Bu-1 -Bo-1	4 direct	76
Bu-1 - Ce-1	(14) 22	45	Bu-1 -Ri-1	21+14	46
Ci-1 - Ce-1	24	46	Bu-1 -Ci-1	21+26	58
Ri-1 - Ce-1	10 (14)	32	Ci-1 - Ri-2	24	21
Sc-1 - Ce-1	9+10	40	Ri-1 - Ri-2	10	7
Sc-1 - Bo-1	17	38	Ce-2 - Ci-1	13	54
Sc-2 - Ce-2	9+10	28	Bo-1 -Ce-2	18	20

Table 10: Shortest PH travel time connections for Trolleybus [min].

Bus: CS-PH	Bo-1	Bu-1	Ci-1	Ri-1	Sc-1
Bo-1	n/a				
Bu-1	99	n/a			
Ci-1	96	75	n/a		
Ri-1	82	60	36	n/a	
Sc-1	49	111	107	94	n/a

Table 11: Shortest OP travel time connections for Trolleybus [min].

Bus: CS-OP	Bo-1	Bu-1	Ci-1	Ri-1	Sc-1
Bo-1	n/a				
Bu-1	76	n/a			
Ci-1	74	58	n/a		
Ri-1	63	46	28	n/a	
Sc-1	38	85	82	72	n/a

Table 12: Shortest LS travel time connections for Trolleybus [min].

Bus: CS-LS	Bo-1	Bu-1	Ci-1	Ri-1	Sc-1
Bo-1	n/a				
Bu-1	61	n/a			
Ci-1	59	46	n/a		
Ri-1	50	37	22	n/a	
Sc-1	30	68	66	58	n/a

Table 13: Timetable raw data for minibus travel time calculation.

Relation	Serviced by mini-bus line no.	OP/PH [min]	Remark
Bo-1 - Ci-1	113	48/65	direct, via. Str. Ismail (Ce-2)
Bo-1 - Ce-1	160	30/35	east via railway station
Bo-1 - Ce-1	175	25/30	west via str. Bucuresti
Ci-1 - Ce-1	166	25/35	also Ci-1 - Ri-2 (12/15min)
Bu-1 - Ce-1	160	32/45	also direct Bu-Bo (60/80min)
Sc-1 - Ce-1	192	28/36	
Ri-1 - Ce-1	175	20/25	also Ri-1 - Ri-2 (5/5min)
Sc-1 - Bo-1	192+102+160	25/30	
Bu-1 - Bo-1	160+175	57/75	

Table 14: Shortest PH travel time connections for Minibus [min]**.**

Minibus: CS-PH	Bo-1	Bu-1	Ci-1	Ri-1	Sc-1
Bo-1	n/a				
Bu-1	75	n/a			
Ci-1	65	80	n/a		
Ri-1	60	75	20	n/a	
Sc-1	30	81	71	61	n/a

Table 15: Shortest OP travel time connections for Minibus [min]**.**

Minibus: CS-OP	Bo-1	Bu-1	Ci-1	Ri-1	Sc-1
Bo-1	n/a				
Bu-1	57	n/a			
Ci-1	48	62	n/a		
Ri-1	46	55	17	n/a	
Sc-1	25	60	53	48	n/a

Table 16: Shortest LS travel time connections for Minibus [min]**.**

Minibus: CS-LS	Bo-1	Bu-1	Ci-1	Ri-1	Sc-1
Bo-1	n/a				
Bu-1	57	n/a			
Ci-1	48	57	n/a		
Ri-1	46	55	17	n/a	
Sc-1	25	60	53	48	n/a

Furthermore both travel time data sets were evaluated for the shortest connections in terms of travel time, as this value is the relevant for TTD calculation (see the results in annex C.P). Naturally, for almost all relations the minibus offered the fastest connection, except for those, which did not feature a directly rivalling minibus course.

Table 17: Relevant PH travel times for CS [min].

Shortest t: CS-PH	Bo-1	Bu-1	Ci-1	Ri-1	Sc-1
Bo-1	n/a				
Bu-1	75	n/a			
Ci-1	65	**75**	n/a		
Ri-1	60	**60**	20	n/a	
Sc-1	30	81	71	61	n/a

Table 18: Relevant OP travel times for CS [min].

Shortest t: CS-OP	Bo-1	Bu-1	Ci-1	Ri-1	Sc-1
Bo-1	n/a				
Bu-1	57	n/a			
Ci-1	48	**58**	n/a		
Ri-1	46	**46**	17	n/a	
Sc-1	25	60	53	48	n/a

Table 19: Relevant LS travel times for CS [min].

Shortest t: CS-LS	Bo-1	Bu-1	Ci-1	Ri-1	Sc-1
Bo-1	n/a				
Bu-1	57	n/a			
Ci-1	48	**46**	n/a		
Ri-1	46	**37**	17	n/a	
Sc-1	25	60	53	48	n/a

(Step 4.2) Shortest travel time calculation – PS1 and PS2

Each link of the systematic network (Figure) was measured at least once regardless of the direction, assuming that travel times are the same for both directions.

From results free flow travel time matrices $t_{ij,free}$ were calculated for the shortest connection in terms of travel times.

Table 20: PS1 free flow matrix. Shortest connection (travel time), same travel times for both directions [min].

PS1	Bo-1	Bo-2	Bu-1	Bu-2	Ce-1	Ce-2	Ce-3	Ci-1	Ci-2	Ri-1	Ri-2	Sc-1	Sc-2
Bo-1	n/a												
Bu-1	28*	25*	n/a										
Bu-2	18*	15*	10	n/a									
Ce-1	14*	11*	14	4	n/a								
Ce-2	8*	5*	20	10	6	n/a							
Ce-3	12*	9*	20	10	6	4	n/a						
Ci-1	22*"	19*"	30	20	16	14	18	n/a					
Ci-2	18*"	15*"	26	16	12	10	14	4	n/a				
Ri-1	25*	22*	25	15	11	17	17	11	7	n/a			
Ri-2	22*	19*	22	12	8	14	14	8	4	3	n/a		
Sc-1	14°	17°^	29	19	15	13	9	27*"	23*"	26	23	n/a	
Sc-2	9*	12^	24	14	10	8	4	22*"	18*"	21	18	5	n/a
	*direct		°via Sc-2		"via Ce-2		^via Bo-1		No note if no alternative route				

Table 21: PS2 free flow matrix. Shortest connection (travel time), same travel times for both directions [min].

PS2	Bo-1	Bu-1	Ce-1	Ce-2	Ci-1	Ri-1	Ri-2	Sc-1
Bo-1	n/a							
Bu-1	32	n/a						
Ce-1	18	14	n/a					
Ce-2	12	20	6	n/a				
Ci-1	34	30	16	22	n/a			
Ri-1	29	25	11	17	11	n/a		
Ri-2	26	22	8	14	8	3	n/a	
Sc-1	25	33	19	13	35	30	27	n/a

(Step 4.3) Congesting network (PS1 and PS2)

Capacity restraint (CR) function to calculate travel time delays for higher capacity utilizatioscenarios:

Table 22: Value table for the CR function with different congestion steps.

$\boldsymbol{u}$	0,2	0,5	1
$\boldsymbol{f(u) = t_{ij,free}(1 + 0{,}8 \cdot u^{2,5})}$	1,014	1,141	1,8

The free flow matrix values were multiplied with the obtained result for the delay/minute per service type:

Table 23: Relevant travel times for PS1 (LS/OP/PH) [min].

PS1	Bo-1	Bu-1	Ci-1	Ri-1	Sc-1
Bo-1	n/a				
Bu-1	28/32/50	n/a			
Ci-1	22/25/40	30/34/54	n/a		
Ri-1	25/29/45	25/29/45	11/13/20	n/a	
Sc-1	14/16/25	29/33/52	27/31/49	26/30/47	n/a

Table 24: Relevant travel times for PS2 (LS/OP/PH) [min].

PS2	Bo-1	Bu-1	Ci-1	Ri-1	Sc-1
Bo-1	n/a				
Bu-1	33/37/58	n/a			
Ci-1	35/39/61	30/34/54	n/a		
Ri-1	29/33/52	25/29/45	11/13/20	n/a	
Sc-1	25/29/45	34/38/59	36/40/63	30/34/54	n/a

Table 25: Relevant travel times for CS (LS/OP/PH)[24] [min].

[min]	Bo-1	Bu-1	Ci-1	Ri-1	Sc-1
Bo-1	n/a				
Bu-1	57/57/75	n/a			
Ci-1	48/48/65	46/58/75	n/a		
Ri-1	46/46/60	37/46/60	17/17/20	n/a	
Sc-1	25/25/30	60/60/81	53/53/71	48/48/61	n/a

(Step 4.4) TTD calculation

- Share of PAX experiencing TTD is not equal for each service type, e.g. more passengers may experience TTD in peak-hour than at late service.
- For Chisinau no data available on PAX share per service type, nor did requests at the at the respective interview partner bring a result.

[24] Many travel times within this table show similar values for late- and off-peak services. Please note, that as shortest connections being relevant for TTD calculation, those are often offered by minibus. Due to the special characteristics of this transport system, it features the same travel times for late- and off-peak services (see (4.1) within this same chapter).

=> Estimation in accordance with the available service frequency data. (Assumed, that the relation of service frequency for different service hour types, also gives information on the ratio of overall passengers using the transportation offer at a special service time[25]). Though the remaining values for this calculation are of acceptable quality and this special estimation should not disperse the result in a manner, that no general statement to the TTS be made.

For percentage of PAX Q per service type s, or the ratio of the same $RP_s = Q_s/ 100$, service frequency values u_{LS}, u_{OP} and u_{PH} (hence u_s) were used from congestion calculation above in the same step, as they are understood to determine the proportion of service for each service type:

$$RP_s = \frac{u_s \cdot d_s}{\sum_{s=1}^{3}(u_s \cdot d_s)}$$

With the results:

Table 26: Results for the PAX per service type ratio.

Service type	Duration [h]	RP_s	journeys/service type
LS	4,5	0,079	65.053
OP	13	0,570	469.825
PH	4	0,351	289.123
	total	1	824.000

Results of only 8% of the total PAX carried per day travel in late hours, 57% in off-peak and 35% in peak-hours seam plausible, compared to other XY cities (SOURCE).

In the following step TTD were summarized for all service types on each route:

$$\Delta t_{ij} = \sum_{s=1}^{3}\left(\Delta t_{s,ij} \cdot RP_s\right)$$

[25] This means, that if in one hour of peak service PT service frequency is twice as high as in one hour of off-peak service, the double amount of passengers would be transported. Of course this argumentation is not very precise, transport vehicles might for example have a higher occupancy rate in a peak- than in an off-peak hour.

Table 27: LS TTS of PS1 compared with PS2 [min] per O/D rotation.

PS2-LS - PS1-LS	Bo-1	Bu-1	Ci-1	Ri-1	Sc-1
Bo-1	n/a				
Bu-1	4,1	n/a			
Ci-1	12,2	0	n/a		
Ri-1	4	0	0	n/a	
Sc-1	11,2	4,1	8,1	4	n/a

Table 28: OP TTS of PS1 compared with PS2 [min] per O/D rotation.

PS2-OP - PS1-OP	Bo-1	Bu-1	Ci-1	Ri-1	Sc-1
Bo-1	n/a				
Bu-1	4,6	n/a			
Ci-1	13,7	0	n/a		
Ri-1	4,6	0	0	n/a	
Sc-1	12,5	4,6	9,1	4,5	n/a

Table 29: PH TTS of PS1 compared with PS2 [min]per O/D rotation.

PS2-PH - PS1-PH	Bo-1	Bu-1	Ci-1	Ri-1	Sc-1
Bo-1	n/a				
Bu-1	7,2	n/a			
Ci-1	21,6	0	n/a		
Ri-1	7,2	0	0	n/a	
Sc-1	19,8	7,2	14,4	7,2	n/a

Table 30: LS TTS of PS1 compared with CS [min] per O/D rotation.

CS-LS - PS1-LS	Bo-1	Bu-1	Ci-1	Ri-1	Sc-1
Bo-1	n/a				
Bu-1	28,6	n/a			
Ci-1	25,7	15,6	n/a		
Ri-1	20,6	11,6	5,8	n/a	
Sc-1	10,8	30,6	25,6	21,6	n/a

Table 31: OP TTS of PS1 compared with CS [min] per O/D rotation.

CS-OP - PS1-OP	Bo-1	Bu-1	Ci-1	Ri-1	Sc-1
Bo-1	n/a				
Bu-1	25,1	n/a			
Ci-1	22,9	23,8	n/a		
Ri-1	17,5	17,5	4,4	n/a	
Sc-1	9	26,9	22,2	18,3	n/a

Table 32: PH TTS of PS1 compared with CS [min] per O/D rotation.

CS-PH - PS1-PH	Bo-1	Bu-1	Ci-1	Ri-1	Sc-1
Bo-1	n/a				
Bu-1	24,6	n/a			
Ci-1	25,4	21	n/a		
Ri-1	15	15	0,2	n/a	
Sc-1	4,8	28,8	22,4	14,2	n/a

Table 33: LS TTS of PS2 compared with CS [min] per O/D rotation.

CS-LS - PS2-LS	Bo-1	Bu-1	Ci-1	Ri-1	Sc-1
Bo-1	n/a				
Bu-1	24,5	n/a			
Ci-1	13,5	15,6	n/a		
Ri-1	16,6	11,6	5,8	n/a	
Sc-1	-0,4	26,5	17,5	17,6	n/a

Table 34: OP TTS of PS2 compared with CS [min] per O/D rotation.

CS-OP - PS2-OP	Bo-1	Bu-1	Ci-1	Ri-1	Sc-1
Bo-1	n/a				
Bu-1	20,5	n/a			
Ci-1	9,2	23,8	n/a		
Ri-1	12,9	17,5	4,4	n/a	
Sc-1	-3,5	22,3	13,1	13,8	n/a

Table 35: PH TTS of PS2 compared with CS [min] per O/D rotation.

CS-PH - PS2-PH	Bo-1	Bu-1	Ci-1	Ri-1	Sc-1
Bo-1	n/a				
Bu-1	17,4	n/a			
Ci-1	3,8	21	n/a		
Ri-1	7,8	15	0,2	n/a	
Sc-1	-15	21,6	8	7	n/a

- Now average TTD Δt of each journey *ij* for the **whole** PT lineis known.
- Not every PAX would use PT line to its full extend: Calculation from average dwelling distance of *dist* = 3,5 km (COPACI 2013), which is already known.
- Average TTD per km for each route needed, to maintain each route's special travel time characteristics.
- Result per day per route (term divided by 60 for more handy results).

$$\Delta t_{all,ij} = \frac{\Delta t_{ij}}{dist_{ij}} \cdot dist_{av} \cdot P_{ij} \div 60$$

Table 36: TTS of PS1 compared to PS2 for all O/D circulations per day.

PS2 - PS1	Bo-1	Bu-1	Ci-1	Ri-1	Sc-1
Bo-1	n/a	1.505	10.953	888	4.340
Bu-1	762	n/a	0	0	678
Ci-1	2.358	0	n/a	0	1.247
Ri-1	953	0	0	n/a	819
Sc-1	3.647	1.117	4.874	640	n/a

Table 37: TTS of PS1 compared to CS for all O/D circulations per day.

CS - PS1	Bo-1	Bu-1	Ci-1	Ri-1	Sc-1
Bo-1	n/a	5.420	12.638	2.145	1.749
Bu-1	2.759	n/a	5.936	1.324	2.703
Ci-1	2.717	2.504	n/a	418	2.019
Ri-1	2.310	2.799	2.122	n/a	2.031
Sc-1	1.468	4.467	7.924	1.587	n/a

Table 38: TTS of PS2 compared to CS for all O/D circulations per day.

CS - PS2	Bo-1	Bu-1	Ci-1	Ri-1	Sc-1
Bo-1	n/a	4.237	3.103	1.384	-1.234
Bu-1	2.159	n/a	5.585	1.210	2.170
Ci-1	671	2.356	n/a	418	880
Ri-1	1.494	2.558	2.122	n/a	1.389
Sc-1	-1.038	3.590	3.437	1.086	n/a

Summarized for all PT lines within the research area Δt_{all} :

$$\Delta t_{all} = \sum_{ij=1}^{20} (\frac{\Delta t_{ij}}{dist_{ij}} \cdot dist_{av} \cdot P_{ij}) \div 60$$

Detailed this is:

$$\Delta t_{all} = \sum_{ij=1}^{20} (\frac{\sum_{s=1}^{3} \left(\Delta t_{s,ij} \cdot \frac{u_s \cdot d_s}{\sum_{s=1}^{3}(u_s \cdot d_s)}\right)}{dist_{ij}} \cdot 3{,}6 \cdot P_{ij}) \div 60$$

with

i	Zone of journey origin	*P*	Journeys
j	Zone of journey destination	*s*	Service type (LS, OP, PH)
dist	Distance	*t*	Travel time
u	Network capacity utilization, as calculated from service frequency		

With the summarized results of TTD between the comparison cases per year:

Table 39: Travel time differences between the comparison cases.

Comparison case	TTD [h/year]
PS2 – PS1	34.781
CS – PS1	67.040
CS – PS2	37.578

III.II Sensitivity analysis

Actual weighting

Category	Category weighting	Indicator	Sub-level weighting	Overall weighting	Part-worth utilities PS1	Part-worth utilities PS2	Weighted PW utilities PS1	Weighted PW utilities PS2
Transport	**25%**	Shift to more sustainable modes	40%	0,100	4,0	3,2	0,400	0,320
		Transport capacity	40%	0,100	2,0	1,2	0,200	0,120
		Induced traffic	20%	0,050	-0,7	-0,6	-0,035	-0,030
User	**25%**	Service frequency increase	40%	0,100	2,0	1,2	0,200	0,120
		Reliability improvements	30%	0,075	2,5	2,0	0,188	0,150
		Travel safety and passenger services	20%	0,050	1,5	1,2	0,075	0,060
		Amenity and travel comfort	10%	0,025	2,0	1,2	0,050	0,030
Economical	**20%**	Value of travel time savings	80%	0,160	4,0	2,5	0,640	0,400
		Costs for accidents	20%	0,040	3,0	2,4	0,120	0,096
Social	**15%**	Accessibility improvements	50%	0,075	-1,0	-0,8	-0,075	-0,060
		Costs for community	45%	0,068	4,0	2,3	0,270	0,155
		Benefit for third parties	5%	0,008	-3,0	-2,4	-0,023	-0,018
Environmental	**15%**	Reduction of local emissions	40%	0,060	3,0	2,4	0,180	0,144
		Energy consumption benefits	30%	0,045	4,0	3,2	0,180	0,144
		Effect on urban space consumption	30%	0,045	0,0	0,0	0,000	0,000
Total	**100%**			**1,000**			2,370	1,631
							PS1 utility	PS2 utility

Sensitivity test 1

Category	Category weighting	Indicator	Sub-level weighting	Overall weighting	Part-worth utilities PS1	Part-worth utilities PS2	Weighted PW utilities PS1	Weighted PW utilities PS2
Transport	**25%**	Shift to more sustainable modes	50%	0,125	4,0	3,2	0,500	0,400
		Transport capacity	30%	0,075	2,0	1,2	0,150	0,090
		Induced traffic	20%	0,050	-0,7	-0,6	-0,035	-0,030
User	**25%**	Service frequency increase	40%	0,100	2,0	1,2	0,200	0,120
		Reliability improvements	30%	0,075	2,5	2,0	0,188	0,150
		Travel safety and passenger services	20%	0,050	1,5	1,2	0,075	0,060
		Amenity and travel comfort	10%	0,025	2,0	1,2	0,050	0,030
Economical	**20%**	Value of travel time savings	80%	0,160	4,0	2,5	0,640	0,400
		Costs for accidents	20%	0,040	3,0	2,4	0,120	0,096
Social	**15%**	Accessibility improvements	50%	0,075	-1,0	-0,8	-0,075	-0,060
		Costs for community	45%	0,068	4,0	2,3	0,270	0,155
		Benefit for third parties	5%	0,008	-3,0	-2,4	-0,023	-0,018
Environmental	**15%**	Reduction of local emissions	40%	0,060	3,0	2,4	0,180	0,144
		Energy consumption benefits	30%	0,045	4,0	3,2	0,180	0,144
		Effect on urban space consumption	30%	0,045	0,0	0,0	0,000	0,000
Total	**100%**			**1,000**			2,420	1,681
							PS1 utility	PS2 utility

Sensitivity test 2

Category	Category weighting	Indicator	Sub-level weighting	Overall weighting	Part-worth utilities PS1	Part-worth utilities PS2	Weighted PW utilities PS1	Weighted PW utilities PS2
Transport	**25%**	Shift to more sustainable modes	40%	0,100	4,0	3,2	0,400	0,320
		Transport capacity	40%	0,100	2,0	1,2	0,200	0,120
		Induced traffic	20%	0,050	-0,7	-0,6	-0,035	-0,030
User	**25%**	Service frequency increase	30%	0,075	2,0	1,2	0,150	0,090
		Reliability improvements	30%	0,075	2,5	2,0	0,188	0,150
		Travel safety and passenger services	30%	0,075	1,5	1,2	0,113	0,090
		Amenity and travel comfort	10%	0,025	2,0	1,2	0,050	0,030
Economical	**20%**	Value of travel time savings	80%	0,160	4,0	2,5	0,640	0,400
		Costs for accidents	20%	0,040	3,0	2,4	0,120	0,096
Social	**15%**	Accessibility improvements	50%	0,075	-1,0	-0,8	-0,075	-0,060
		Costs for community	45%	0,068	4,0	2,3	0,270	0,155
		Benefit for third parties	5%	0,008	-3,0	-2,4	-0,023	-0,018
Environmental	**15%**	Reduction of local emissions	40%	0,060	3,0	2,4	0,180	0,144
		Energy consumption benefits	30%	0,045	4,0	3,2	0,180	0,144
		Effect on urban space consumption	30%	0,045	0,0	0,0	0,000	0,000
Total	**100%**			**1,000**			2,358	1,631
							PS1 utility	PS2 utility

Sensitivity test 3

Category	Category weighting	Indicator	Sub-level weighting	Overall weighting	Part-worth utilities PS1	Part-worth utilities PS2	Weighted PW utilities PS1	Weighted PW utilities PS2
		Shift to more sustainable modes	40%	0,100	4,0	3,2	0,400	0,320
Transport	**25%**	Transport capacity	40%	0,100	2,0	1,2	0,200	0,120
		Induced traffic	20%	0,050	-0,7	-0,6	-0,035	-0,030
		Service frequency increase	40%	0,100	2,0	1,2	0,200	0,120
User	**25%**	Reliability improvements	30%	0,075	2,5	2,0	0,188	0,150
		Travel safety and passenger services	20%	0,050	1,5	1,2	0,075	0,060
		Amenity and travel comfort	10%	0,025	2,0	1,2	0,050	0,030
Economical	**20%**	Value of travel time savings	80%	0,160	4,0	2,5	0,640	0,400
		Costs for accidents	20%	0,040	3,0	2,4	0,120	0,096
		Accessibility improvements	40%	0,060	-1,0	-0,8	-0,060	-0,048
Social	**15%**	Costs for community	50%	0,075	4,0	2,3	0,300	0,173
		Benefit for third parties	10%	0,015	-3,0	-2,4	-0,045	-0,036
		Reduction of local emissions	40%	0,060	3,0	2,4	0,180	0,144
Environmental	**15%**	Energy consumption benefits	30%	0,045	4,0	3,2	0,180	0,144
		Effect on urban space consumption	30%	0,045	0,0	0,0	0,000	0,000
Total	**100%**			**1,000**			2,393	1,643
							PS1 utility	PS2 utility

Sensitivity test evaluation

Actual weighting Ranking PS1		Ranking PS2		Test 1 Ranking PS1		Ranking PS2		Test 2 Ranking PS1		Ranking PS2		Test 3 Ranking PS1		Ranking PS2	
0,64	VTTS	0,4	VTTS	0,64	VTTS	0,4	Shift	0,64	VTTS	0,4	VTTS	0,64	VTTS	0,4	VTTS
0,4	Shift	0,32	Shift	0,5	Shift	0,4	VTTS	0,4	Shift	0,32	Shift	0,4	Shift	0,32	Shift
0,27	Costs comm	0,155	Costs comm	0,27	Costs comm	0,155	Costs comm	0,27	Costs comm	0,155	Costs comm	0,3	Costs comm	0,173	Costs comm
0,2	Trans cap	0,15	Reliability	0,2	Serv freq	0,15	Reliability	0,2	Trans cap	0,15	Reliability	0,2	Transport cap	0,15	Reliability
0,2	Serv freq	0,144	Emissions	0,188	Reliability	0,144	Emissions	0,188	Reliability	0,144	Emissions	0,2	Serv. freq.	0,144	Emissions
0,188	Reliability	0,144	ECB	0,18	Emissions	0,144	ECB	0,18	Emissions	0,144	ECB	0,188	Reliability	0,144	ECB
0,18	Emissions	0,12	Trans cap	0,18	ECB	0,12	Serv freq	0,18	ECB	0,12	Trans cap	0,18	Emissions	0,12	Transport capacity
0,18	ECB	0,12	Serv freq	0,15	Trans cap	0,096	Accidents	0,15	Serv freq	0,096	Accidents	0,18	ECB	0,12	Serv freq
0,12	Accidents	0,096	Accidents	0,12	Accidents	0,09	Trans cap	0,12	Accidents	0,09	Serv freq	0,12	Accidents	0,096	Accidents
0,075	Safety/serv	0,06	Safety/serv	0,075	Safety/serv	0,06	Safety/serv	0,113	Safety/serv	0,09	Safety/serv	0,075	Safety/serv	0,06	Safety/serv
0,05	Comfort	0,03	Comfort	0,05	Comfort	0,03	Comfort	0,05	Comfort	0,03	Comfort	0,05	Comfort	0,03	Comfort
0	Space cstn	0	Space cstn	0	Space cstn	0	Space cstn	0	Space cstn	0	Space cstn	0	Space cstn	0	Space cstn
-0,023	3rd parties	-0,018	3rd parties	-0,023	3rd parties	-0,018	3rd parties	-0,023	3rd parties	-0,018	3rd parties	-0,035	3rd parties	-0,03	3rd parties
-0,035	Induced t	-0,03	Induced t	-0,035	Induced t	-0,03	Induced t	-0,035	Induced t	-0,03	Induced t	-0,045	Induced t	-0,036	Induced t
-0,075	Accessibil-ity	-0,06	Accessibil-ity	-0,075	Accessibil-ity	-0,06	Accessibil-ity	-0,075	Accessibility	-0,06	Accessibil-ity	-0,06	Accessibil-ity	-0,048	Accessibil-ity
2,37	**Rating result**	**1,631**	**Rating result**	**2,42**	**Rating result**	**1,681**	**Rating result**	**2,358**	**Rating result**	**1,631**	**Rating result**	**2,393**	**Rating result**	**1,643**	**Rating result**