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Economics of Road Safety – What does it imply under the 2030 Agenda for Sustainable Development?

(Background Paper for Plenary Session-10)

Final

This background paper has been prepared by Prof. Jac Wismans et al. for the Tenth Regional EST Forum in Asia. The views expressed herein are those of the authors only and do not necessarily reflect the views of the United Nations.

Economics of Road Safety – What does it imply under the 2030 Agenda for Sustainable Development?

FINAL Version

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Background paper for the 10th Regional Environmentally Sustainable Transport (EST) Forum in Asia, 14-16 March 2017 in Vientiane, Lao PDR

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Executive Summary

Road traffic accidents and injuries are a major public health problem and leading cause of death in the Asia EST region (comprises South and Southeast Asia, People's Republic of China, Japan, Republic of Korea, Mongolia and the Russian Federation). This paper aims to:

- Review the Road Safety problem in the EST region, including the economic impact
- Review of the role of the UN and its entities in the field of road safety, including the 2015 Sustainable Development Goals
- Introduce the basics of economics of road safety and the methodology of cost benefit assessment (CBA) and cost-effectiveness analysis (CE)
- Review of the status of road safety measures in the EST region and analysis of the importance of investment in road safety in Asia
- Develop recommendations on the most cost-effective road safety measures

The total number of death due to road accidents in the Asian EST region in 2013 was almost 700.000, which is 55% of the global number of death. The majority of these death were found in China (38%) and India (30%). Compared to the year 2010 the number of death decreased in 2013 by 5,5%. Vulnerable Road Users (VRU's: pedestrians, cyclists and motor cyclists combined) are particular at risk. Globally the number of death in road accidents of VRU's is about 50%, but in most Asian EST countries this is more than 60% and in five countries (Lao, Sri Lanka, Singapore, Thailand and Cambodia) it is even more than 80%, which is largely due to the high number of fatalities among motorized 2 and 3- wheelers in these countries.

An overview of UN activities in road safety has been given including the role of various UN bodies like WHO, UNECE, UNESCAP and UNCRD. Important global UN milestones in the field of road safety are the establishment in 2011 of the UN Decade of Action for Road Safety (2011-2020) with a goal to stabilize and reduce the predicted levels of road traffic fatalities around the world and the adoption in 2015 of the sustainable development goals (SDGs) with the important road safety related target SDG 3.6: "By 2020, halve the number of global deaths and injuries from road traffic accidents". For ASIA the adoption of UNESCAP recommended road safety goals, targets and performance indicators by the Third Session of the Ministerial Conference on Transport in Moscow, 5-9 December 2016 is an important achievement.

In Chapter 3 the principles behind the valuation of the economic impact of traffic accidents and estimates for the cost of road accidents in Asia are presented. It is shown that road safety has a major impact on economies of Asian countries. The total resulting cost estimate for road accidents in the Asian EST countries in 2010 is 735 Billion US$ of which almost half in China. The average % GDP loss in the Asian Est region is 3.3% with the highest value (>4%) for the South Asia region. These cost estimates may be conservative since they exclude major cost components like property damage costs, costs of minor injuries, medical costs and administrative costs. Chapter 3 also includes a brief introduction in cost-benefit and effectiveness analyses and examples of benefit-cost ratios are included in Chapter 3 and 4.

In Chapter 4 it is shown that the SDG 3.6 target to halve by 2020 the number of global deaths and injuries from road traffic accidents implicates for the Asian EST countries, if met, a saving of more than 340.000 lives annually and a reduction of the burden on the economy with more than 350 billion US$ per year, or equivalent to a growth in GDP of more than 1,5%. Such targets are extremely ambitious, but on the other hand examples from other parts of the world have shown that significant improvements are possible.

Executive Summary

In Chapter 4, a dashboard of road safety in Asia is presented which is based on the road safety performance indicators developed by UNESCAP and the use of data in the WHO 2015 Global status report. In this Chapter the Safe System Approach is introduced as the policy frame work for strengthening both government and private investments in road safety and the most relevant road safety investments were discussed with the focus on the most sensitive groups in transportation - children, old persons, girl and women, youth, poor, and physically disabled persons in low and middle income countries. Chapter 4 concludes with a section on the importance of ITS for future road safety and includes examples of ITS implementations in Asia.

In Chapter 5 the main findings of this paper are summarized and a number of recommendations are given, among other concerning the reliability of valuation of the economic impact of traffic accidents and the need for further analysis in this field, the need for accurate accident data systems in a country, the most cost effective road safety measures, the importance of safe public transport, future extensions of the proposed dashboard on road safety in Asia, possible updates of the UNESCAP goals, targets and indicators, the cost benefit of ITS implementations and the applicability of global cost-benefit studies to Asia. This Chapter concludes with a discussion on funding opportunities for road safety.

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Abbreviations and acronyms

ADB	Asian Development Bank
ASV	Advanced Safety Vehicle
AV	Automated Vehicles
BAC	Blood Alcohol Content
CAT	Connected and automated transportation
CBA	Cost Benefit Analysis
CE	Cost-effectiveness
C-ITS	Cooperative-ITS
EC	European Commission
EU	European Union
ERP	Electronic Road Pricing Systems
ESC	Electronic Stability Control (vehicle system)
ESCAP	Economic and Social Commission for Asia and the Pacific
EST	Asian Environmentally Sustainable Transport initiative
Euro NCAP	European New Car Assessment Programme
GDP	Gross Domestic Product
GTR	Global Technical Regulation
HC	Human Capital
HIC	High Income Country
HSHO	Head Safe Helmet On
IAEG-SDGs	Inter-Agency and Expert Group on Sustainable Development Goal Indicators
IHME	Institute for Health Metrics and Evaluation
iRAP	International Road Assessment Programme
ISO	International Organization for Standardization
ITS	Intelligent Transportation System
LMIC	Low and Middle Income Country
MDG	Millennium Development Goals
NCAP	New Car Assessment Program
NMT	Non-Motorized Transport
OECD	Organization of Economic Cooperation and Development
RIA	Regulatory Impact Analysis
SAFER	Vehicle and Traffic Safety Centre at Chalmers (Sweden)
SDG	Sustainable Development Goal
SWOV	Dutch Institute for Road Safety Research
TRL	Transport Research Laboratory in the United Kingdom
UN	United Nations
UNCRD	United Nations Centre for Regional Development
UNECE	United Nations Economic Commission for Europe
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNRSC	United Nations Road Safety Collaboration
VRU	Vulnerable Road User
VSI	Value of Statistical Injury
VSL	Value of Statistical Life
WHO	World Health Organization
WTP	Willingness-To-Pay

1 Background and Introduction

Road traffic accidents and injuries are a major public health problem and leading cause of death globally. The World Health Organisation (WHO) estimates that in 2013, 1.25 million people died worldwide due to road accidents, which is a number that has plateaued since 2007 [1]. This means that every day more than 3000 people die because of road crashes. 90% of the fatalities occur in developing countries [2] and therefore, many poor families may be driven deeper into poverty by the loss of a family breadwinner and the expenses of medical care and rehabilitation.

The yearly number of people that are injured in road accident, frequently resulting in long-term disabilities, is much higher. The WHO [1] estimates that up to 50 million people yearly are injured and a study from the Institute for Health Metrics and Evaluation (IHME) - World Bank results in even much higher estimates: 78.2 million persons needed medical care in 2010 due to a road accident, of which 9.2 million requiring hospital admission [3].

Globally, road traffic accidents are the main cause of death among those aged 15–29 years [1], so this tragedy affects many who are entering their most productive years. Road traffic injuries are currently the ninth leading cause of death across all age groups and this is, in an as usual scenario, expected to become the seventh leading cause of death by 2030 [1], in particular due to increasing death rates on roads in emerging economies, linked to increasing urbanization and motorization. Accident data show that globally about 50% of all crash victims are pedestrians, cyclists, and motorcyclists but in Asian developing countries, pedestrians, cyclists, and motorcyclists take an even much higher share (see section 1.1).

Road accidents are also a major economic burden for countries. They are estimated to cost $1.85 trillion yearly for the global economy [4], which is 3% of the GDP [1]. See for more details Chapter 3 on the economics of road safety.

1.1 Road Safety in the Asian EST countries

The Asian Environmentally Sustainable Transport (EST) Initiative, which is a joint initiative of the United Nations Centre for Regional Development (UNCRD) and the Ministry of the Environment-Japan, was launched in 2004. It aims to build a common understanding across Asia on the essential elements of a sustainable transport system and the need for an integrated approach at local and national level to deal with multi-sectorial environment and transport issues [5]. Road Safety is one of the three core elements within this Asian EST-Initiative. Currently 24 Asian countries, referred to as EST countries or EST region, are participating in the Asian EST initiative. The EST region represent 56% of the world population and comprises **South Asia** (Afghanistan, Bangladesh, Bhutan, India, the Maldives, Nepal, Pakistan and Sri Lanka), **Southeast Asia** (Brunei, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Singapore, Thailand, Timor-Leste and Vietnam), People's Republic of China, Japan, Republic of Korea, Mongolia and the Russian Federation.

In the Asian EST region, every hour almost 80 people are killed in road accidents and more than 5000 injured (based on estimates in [6]). For more information on the Asian EST initiative concerning road safety see section 2.4.

Table 1 shows a comparison for all EST countries of WHO death estimates in 2010 (from the 2013 Global status report [7]) and 2013 (from the 2015 report [1]). The total number of death in the Asian EST region was estimated 686.046 in 2013, which is 55% of the total number of deaths due to road accidents worldwide. The largest number of death among the EST countries are in China (38% in 2013) and India (30% in 2013). In the period 2010-2013 the number of death has decreased in the EST region

by 5,5%, with highest decreases in Singapore (-23,9%), Afghanistan (-23,8%) and Lao PDR (-23,3%). Largest increases in road traffic fatalities in this period are in the Maldives (+100%, but the total number of death is very low), Myanmar (+50,6%), Sri Lanka (+29,3%) Bangladesh (+23,3%) and Philippines (+22,1%). In China, the number of death has decreased by 5,3% and in India by 10,2%.

Table 1 includes also the estimated death rate due to road accidents per 100.000 population. The countries with the largest death rates in the EST countries in 2013 are Thailand (36,2), Vietnam (24,5), Malaysia (24) and Myanmar (20,3). Fig 1 shows the death rate in 2013 for various countries and regions (unweighted rates). The high-income countries in the Asia Pacific (Japan, Singapore and Rep. of Korea) show the lowest values, followed by South Asia with a rate more than twice as high and the highest values for China, the Russian Federation and Southeast Asia (excluding Singapore).

Fig 1 also includes the world average death rate and the average death rate for low-, middle and high-income countries in the world [1]. The average death rate for the Asian EST countries was 15,6 in 2013 (Table 1), which is slightly below the world average value of 17,4. There is a strong dependency with the income status of a country as shown in Figure 1. In low- and middle income countries in the world, the rate on the average is twice as high as in high-income countries. Comparing regions in the world, Africa has the highest fatality rate of 26,6 death per 100.000 population [1], which is in the same order of magnitude as the countries with the highest death rates in the Asian EST region. In Europe the 5 best performing countries have a death rate below 3.1 [8]. The best performing countries in the Asian EST region are Japan with a death rate of 4,7, Singapore with 3,6 and Maldives with 3,5 in 2013.

Vulnerable road users (pedestrians, cyclists and motor cyclists combined) are in particular at risk in the Asian EST countries as is shown in Figure 2. This figure shows, for those Asian EST countries for which data were available in the Global Status Report 2015 [1], the percentage of pedestrians, cyclists, and riders of motorized 2 and 3- wheelers that were killed in road accidents. Also, the total of killed pedestrians, cyclists, and riders of motorized 2 and 3- wheelers is included. As was mentioned earlier, globally about 50% of all crash victims are pedestrians, cyclists, and motorcyclists. But as can be seen this percentage is much higher in many of the Asian EST countries. In five of the countries it is even more than 80%: Lao (80%), Sri Lanka (81%), Singapore (82%), Thailand (83%) and Cambodia even 86%. This is largely due to the high number of fatalities among motorized 2 and 3- wheelers in these countries.

Also in other countries in the Asian EST region very high percentages among killed pedestrians, cyclists, and riders of motorized 2 and 3- wheelers can be observed: in most countries above 60%, except for Bangladesh, India, Mongolia, and the Russian Federation.

The total costs of fatalities and serious injuries in the Asian EST countries, calculated as a loss to the economy, is estimated to 735 billion US$ or 3,3% of GDP [6]. In 8 countries (Bangladesh, Bhutan, India, Malaysia, Nepal, Pakistan, Thailand and Vietnam) the percentage was more than 4% of the GDP. Chapter 3 will discuss in detail this topic of economics of road crashes.

1.2 United Nations and Road Safety

The United Nations (UN) has been actively involved in addressing global road safety as a major development issue already since its start after World War II. Chapter 2 will give an overview of UN activities, including the role of various UN entities. An important UN milestone is the establishment in 2011 of the UN Decade of Action for Road Safety (2011-2020) with a goal to stabilize and reduce the predicted levels of road traffic fatalities around the world [9].

Table 1 Estimated number of death due to road accidents in the Asian EST countries for the years 2010 and 2013, change in road death between 2010 and 2013 and estimated number of death per 100.000 population based on data in the Global Status Reports on Road safety 2013 [7] and 2015 [1]

	Estimated number of road traffic deaths		Change %		Estimated road traffic death rate (per 100 000 population)	
	2010	2013			2010	2013
Afghanistan	6.209	4.734	-23,8		26,1	15,5
Bangladesh	17.289	21.316	23,3		7,9	13,6
Bhutan	96	114	18,8		12,6	15,1
Brunei *	27				9,7	
Cambodia	2.431	2.635	8,4		17,1	17,4
China	275.983	261.367	-5,3		20,7	18,8
India	231.027	207.551	-10,2		20,6	16,6
Indonesia	42.434	38.279	-9,8		22,5	15,3
Japan	6.625	5.971	-9,9		6,6	4,7
Lao PDR	1.266	971	-23,3		18,8	14,3
Malaysia	7.085	7.129	0,6		19,7	24
Maldives	6	12	100,0		5,5	3,5
Mongolia	491	597	21,6		20,9	21
Myanmar	7.177	10.809	50,6		17,2	20,3
Nepal	4.787	4.713	-1,5		13,5	17
Pakistan	30.131	25.781	-14,4		13,5	14,2
Philippines	8.499	10.379	22,1		9,2	10,5
Republic of Korea	6.784	5.931	-12,6		15,2	12
Russian Federation	26.567	27.025	1,7		21,0	18,9
Singapore	259	197	-23,9		4,2	3,6
Sri Lanka	2.854	3.691	29,3		13,2	17,4
Thailand	26.312	24.237	-7,9		33,4	36,2
Timor-Leste	219	188	-14,2		13,7	16,6
Viet Nam	21.651	22.419	3,5		21,6	24,5
Total EST countries	**726.209**	**686.046**	**-5,5**		**16****	**15,6****

*For Brunei no data for 2013 are available
** unweighted average

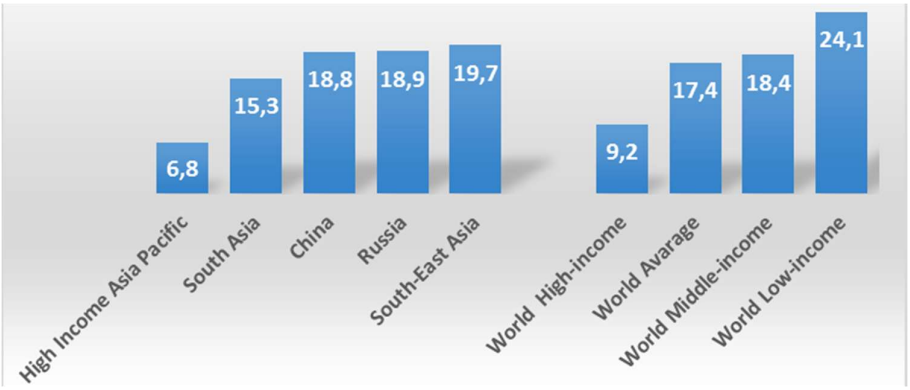

Figure 1 Death rate due to road accidents per 100.000 population in different countries and regions of Asia, together with average values for low, middle- and high-income countries in the world as well as the world average [WHO, 2015]

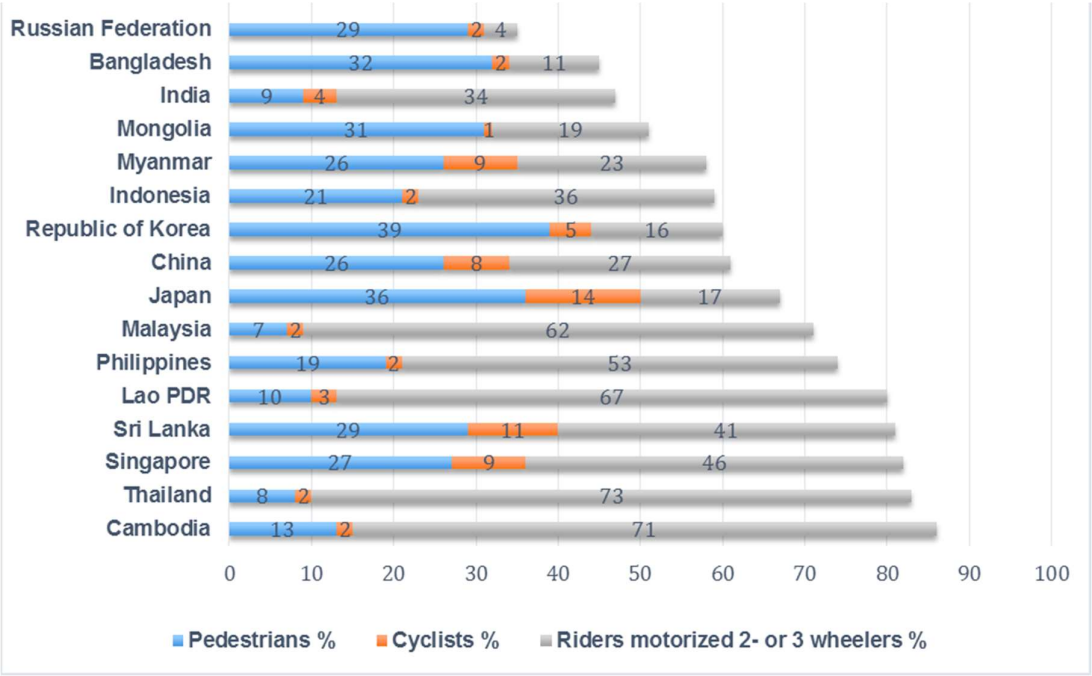

Figure 2 Death by Road user category in % of total number of road fatalities in the Asian EST countries (based on data in [1])

Another important UN milestone is the adoption in 2015 of the post-2015 development agenda [10]. This agenda contains 17 Sustainable Development Goals (SDGs) and 169 related targets. Through adoption of the Agenda, the member states have acknowledged the importance of road safety in achieving the SDGs. Out of the 17 Goals, two of them include specific road safety targets: SDG 3.6 "By 2020, halve the number of global deaths and injuries from road traffic accidents" and SDG 11.2 "by 2030, provide access to safe, affordable, accessible, and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women and children, persons with disabilities and older persons" (see Chapter 2 for more details).

1.3 Objectives of this study

Road traffic accidents resulting in fatalities and injuries have enormous impact on public health, social inclusions, national productivity, economic progress, and overall sustainable development. The current levels of road death and injuries are unacceptable in terms of human suffering as well as societal and economical costs. The road safety target in the SDG's to reduce by 2020 the number of global deaths and injuries by 50% is a major global challenge and for the Asian EST countries this would translate into a saving of almost 350.000 fatalities and 25 million injuries per year. Investments to reach such large road safety improvements will have a large positive impact on public health and economy [2].

This study aims to develop a comprehensive background paper on "Economics of Road Safety – What does it imply under the 2030 Agenda for Sustainable Development?" to better guide and support Asian countries for the implementation of road safety in overall transport policy, planning, infrastructure, and services in line with the SDG's.

Specific objectives of this study are:

- A brief analyses of the Road Safety problem in the EST region (this Chapter, section 1.1)
- Review of the UN role in road safety, including the Decade of Action for Road safety 2011-2020, the 2015 Sustainable Development Goals and "road safety goals, targets and indicators" introduced

in Asia (Chapter 2)

- Introducing the basics of economics of road safety and the economic impact of road safety in the EST region (Chapter 3)
- Introduction into cost benefit assessment (CBA) and cost-effectiveness analysis (CEA) illustrated by examples (Chapter 3 and 4)
- Review of the status of road safety measures in the EST region and analysis of the importance of investment in road safety in Asia (Chapter 4)
- Give a brief overview of the use and benefits of intelligent transport systems (ITS) in Asia (Chapter 4)
- Develop recommendations on the most cost-effective road safety measures considering also that there will be competing priorities for investments in other domains of the 2030 Agenda for Sustainable Development (Chapter 4 and 5)

The methodology used for this study consists of a review and analyses of data in literature concerning the road safety problem and efforts to reduce the problem including reports form the WHO, World Bank and other international (UN) organizations, review of recent scientific publications, consolidation of methods concerning the economics of road accidents (cost benefit analysis etc., discussions with experts and review of best practices, cases studies etc.

2 Road safety & Sustainable Development Goals

The United Nations has recognized the importance of road safety already soon after its establishment in 1945. In 1950 an Ad Hoc Working Group on the prevention of road accidents was set up within the United Nations Economic Commission for Europe (UNECE). The activities of this WG were later succeeded by the Group of Experts on Road Traffic Safety (GE.20) and later (in 1988) by the UNECE's Road Safety Forum (WP.1) and the World Forum for Harmonization of Vehicles Regulations (WP.29) both with participants coming from all over the world [11][12]. The United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) has also been working on road safety since 1951 [13].

As a result of the work several international agreements have been established in the United Nations system in which road safety - in addition to facilitating trade - is an important focus. Examples are the 1949 Convention on Road Traffic and the 1969 Convention on Road Traffic (Vienna Convention), the 1957 Agreement on Transport of Dangerous Goods, the 1958 Agreement on Technical Vehicle Regulations, the 1968 Convention on Road Signs and Signals, the 1997 Agreement on Periodic Technical Inspection of Vehicles and the 1998 Agreement on Global Technical Regulations (GTRs) [14]. Many countries across the world have become contracting parties to such agreements and the related legal instruments on vehicle and road safety.

The year 2004 was an important year for road safety. The "World report on road traffic injury prevention" developed by the World Health Organisation (WHO) in cooperation with the World Bank, was launched [14]. This report described the magnitude and impact of the road traffic injury problem, major causes and risk factors, prevention strategies, the role of the various stake holders in the prevention of road traffic injuries and recommendations on what countries can do to reduce road traffic injuries. In 2004 also the United Nations Road Safety Collaboration (UNRSC) was established to strengthen global activities in road traffic injury prevention. WHO was invited, working in close cooperation with the regional commissions, to coordinate these activities within the United Nations system [16]. This UN resolution underlined the need for the further strengthening international cooperation, considering the needs of developing countries, to deal with issues of road safety.

2.1 Decade of Action for Road Safety

A breakthrough for international recognition of road injuries as a major public health problem and development challenges [17] was the declaration of the decade 2011-2020 as the Decade of Action for Road Safety, by the United Nations General Assembly in March 2010 (resolution 64/255). Main objective of the Plan for the Decade of Action was to stabilize global road accident fatalities until 2020 and then reducing the forecasted levels of global road fatalities by increasing road safety improvement activities at national, regional, and global levels [9]. Based on the Safe System approach the Commission for Global Road safety defined five pillars for a road safety policy framework, which were used in the Global Plan for the Decade of Action for Road Safety 2011-2020. Table 2 shows these 5 pillars from the Global Plan together with important activities within each pillar. In the Global Plan special emphasis has been put on 5 risk factors: speed, drunk–driving, not wearing motorcycle helmets, not wearing seat-belts and not using child restraints in cars (included in Table 2 under 4. Safe road users).

2.2 Sustainable Development Goals (SDG's)

June 2012, the United Nations conference on sustainable development (Rio+20) - The Future We Want, was held in Rio de Janeiro. The Member States agreed to launch a process to develop a set of Sustainable Development Goals (SDG's) as a replacement for the Millennium Development Goals (MDGs) that would expire in 2015.

Table 2 Summary of important actions within the 5 pillars of the Global Plan for the Decade of Action for Road Safety [1]

Pillars	Important activities
1: Road safety management	• establishment of a national lead agency • establishment of a national road safety plan with safety targets and budgets • setting-up monitoring systems for accident data and other indicators of safety improvement.
2: Safer roads and mobility	• elimination of high risk roads by 2020 • safety impact assessments as part of all planning and development decisions • speed management and speed sensitive design of the road network • ensuring work zone safety • set minimum safety ratings for new road investments that ensure the safety needs of all road users • encouragement of education and R&D in the field of safe road infrastructure
3: Safe vehicles	• implementation of UN vehicle safety regulations and New Car Assessment Programmes (NCAPs), recommendations for inclusion of technologies such as ESC and ABS. • discouragement of import and export of new or used cars that have inferior safety levels • increased research into safety technologies designed to reduce risks to vulnerable road users • encouragement of managers of governments and private sector fleets to purchase vehicles that offer advanced safety technologies and high levels of occupant protection
4: Safe road users	• implementation (if not done yet) and enforcement of laws and/or standards concerning the five risk factors *speed, drunk-driving, and the usage of helmet, seatbelts and child restraints*, combined with public awareness/education concerning these risk factors. • introduction of policies and practices to reduce work-related road traffic injuries in the public, private and informal sectors • establishment of Graduated Driver Licensing systems for novice drivers.
5: Post-crash response	• the implementation of a single countrywide telephone number for emergencies • development of hospital trauma care systems • early rehabilitation and support to injured patients • encouragement of research and development into improving post-crash response.

The United Nations summit for the adoption of the post-2015 development agenda was held from 25 to 27 September 2015, in New York. During this meeting the United Nations General Assembly adopted "Transforming our World: The 2030 Agenda for Sustainable Development" [10], which is a new framework for a sustainable development of our world for the period till 2030. In this Agenda 17 universal goals and 169 targets are defined, which focus on various global issues such as poverty and environmental issues. They build on the achievements of the Millennium Development Goals (MDGs. The SDG's are, in contrast to the MDG's universal, so they apply to all countries.

Progress in a number of the SDG's is strongly related and dependent on advances in sustainable transport. For a broad discussion on this see the report from the UN secretary-general's High-Level Advisory Group on sustainable transport [19]. Accomplishing the SDGs will rely on advances in for example reductions in greenhouse gasses (climate change) and emissions, food security and healthcare, safe and efficient transport to schools, safe and accessible transport for disabled and elderly people, resilient infrastructures, responsible production etc.. [19]. The High-Level Advisory Group adopted the Avoid-Shift-Improve approach as the framework for selecting appropriate measures for advancement in sustainable transport [19]. The Avoid-Shift-Improve was developed early 1990 in Germany and implemented within the Asian EST initiative, among other to develop and structure the twenty sustainable Transport Goals for 2010-2020 included the 2010 Bangkok declaration [21].

Road safety is explicitly addressed in two of the SDG's namely Goal 3 with target 3.6 and Goal 11 with target 11.2, see Table 3.

Table 3 Road Safety goals and target in the SDG's

Goals	Targets
3: ensure healthy lives and promote well-being for all at all ages	**3.6**: by 2020, halve the number of global deaths and injuries from road traffic accidents.
11: make cities and human settlements inclusive, safe, resilient, and sustainable	**11.2**: by 2030, provide access to safe, affordable, accessible, and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women and children, persons with disabilities and older persons.

These goals are a strong mandate for action to promote road safety. In particular, the ambitious target for 50% reductions of both road crash fatalities and injuries is a significant challenge to all governments and other stakeholders worldwide. According to the Global Status Report on Road Safety - 2015, the number of road fatalities - 1.25 million in 2013 - is rather constant since 2007, despite the increase in global motorization and population [1]. To fulfil the 50% fatality reduction goal the number of fatalities needs to be reduced by more than 600,000 annually worldwide in 2020. The number of road traffic injuries has to be reduced by 40 million, taking the IHME/World Bank injury estimates discussed in Chapter 1 as the reference.

Figure 3 shows the predicted trends in road transport deaths worldwide in the 2011-2020 Plan for the Decade of Action for Road Safety, in case no actions are taken (upper boundary) and if actions are taken in line with the Plan (lower boundary), as well as the new SDG 3.6 target. This SDG target indicates an almost 300.000 additional death reduction target compared to the Plan.

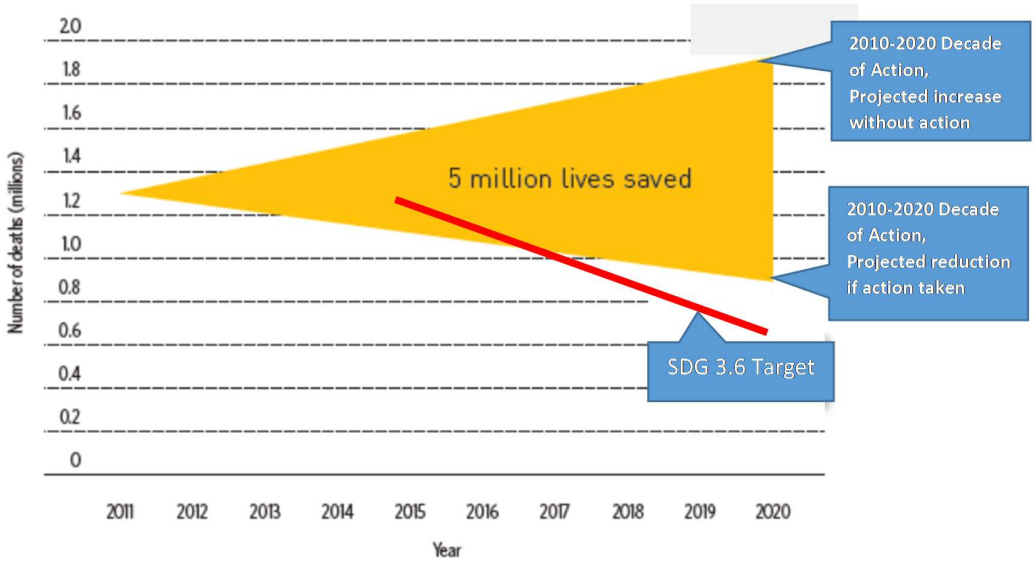

Figure 3 SDG 3.6 Target "by 2020, halve the number of global deaths from road traffic accidents", together with predictions in the Plan for the Decade of Action for Road Safety in case of no action (upper boundary) and if actions are taken in line with the goal of the Plan (lower boundary)

November 2015 the **2nd Global high-level conference on road safety** was held in Brasilia with more than 2,200 participants from 136 countries. The meeting adopted the Brasilia Declaration which confirmed support for the Global Goals target to halve of deaths and injuries caused by road accidents by 2020. Among its objectives was to evaluate the progress of initiatives to reduce road traffic deaths and injuries worldwide. At the end of the conference the **Brasilia Declaration on Road Safety** was

adopted [2]. The declaration consists of 30 actions organised in 7 groups of which 5 groups are equivalent to the 5 pillars of the Global Plan (see Table 2) and 2 separate groups, one of them dealing specifically with vulnerable road users (which include children, youth, older and disabled persons, gender issues and motorcyclists) and one on strengthening cooperation and global road safety coordination. Most actions in the Declaration are largely a recommitment and/or strengthening of the actions included in the Global Plan for the Decade of Action for Road Safety. New or partially new actions in the Declaration include:

- New risk factors which lead to distracted or impaired driving due to medicines, narcotic or psychotic drugs, distraction by cell phones and other causes (Action OP4)
- Introduction of new technologies in traffic management and intelligent transport systems to mitigate road traffic crash risk and maximize response efficiency (Action OP9)
- Actively protect and promote pedestrian safety and cycling mobility, such as pedestrian walkways and bicycle lanes and/or tracks, adequate lighting, speed cameras, road signs etc.. (Action OP12)
- Introduction of legislation and policies on motorcycles, including training, driver licensing, vehicle registration, work conditions, and the use of helmets and personal protection equipment by motorcyclists (Action OP19)
- Creation of new funding possibilities to improve road safety (Action OP28)
- Development, under coordination of the WHO of detailed national, regional, and global targets and indicators to reduce road traffic crashes and fatalities in view of the SDG targets (Action OP29)

The **United Nations Conference on Sustainable Urban Development and Housing - Habitat III**, held in Quito, Ecuador, in October 2016, stressed the importance of SDG 11 "make cities and human settlements inclusive, safe, resilient and sustainable". The New Urban Agenda adopted at this conference [22] included several actions dealing with road safety, as an integrated component of a sustainable urban transport system, with the focus on Non-Motorized Transport (NMT) and vulnerable road users through measures like safe public spaces, sidewalks, cycling lanes, safe public transport etc.

2.3 Global Road Safety Targets and Indicators

The implementation of quantified road safety targets is crucial in the development of effective road safety programmes [23]. The project "Improving global road safety: setting regional and national road traffic casualty reduction targets" in 2008-2009, was set up to assist governments in low and middle income countries to develop regional and national road safety targets and to exchange experiences on good practices for achieving these targets [23]. The emphasis in the project was on knowledge transfer from high-income countries (where progress had already been made with the use of targets) to low and middle-income countries. One of the conclusions of the study was that target setting should be used as a component of a process of building a Safe System approach. Targets on their own do not save lives but they are effective through their activity raising potential within a programme of interventions to achieve them [23]. The importance of setting performing targets was recognized and stressed at many occasions since then including for instance in the Brasilia declaration in Nov. 2015 (Action OP29) [2] and UN General Assembly Resolution A/70/260 (April 2016).

Concerning the high-level SDG targets, the UN Statistical Commission has created the Inter-Agency and Expert Group on Sustainable Development Goal Indicators (IAEG-SDGs) to develop an indicator framework that aligns with the targets. The IAEG-SDGs announced a total of 230 indicators to measure achievement of the SDG 169 targets [24]. For the Road safety SDG target 3.6: "*By 2020, halve the number of global deaths and injuries from road traffic accidents*", the proposed quantified target is the age-standardised death rate due to road traffic injuries, per 100 000 population [24]. The IAEG-SDGs has set no specific indicators for reduction of injuries in this target and also not concerning Target 11.2.

The WHO has started on request of the UN in 2016 in collaboration with other parties a process to develop a set of detailed global performance targets and indicators for road safety. This process is expected to lead early 2017 into a first discussion paper and to be finalized May 2018 by a report submitted to a meeting of the Wold Health Assembly.

Detailed road safety targets exist already for many years at national and regional levels. For example, Sweden introduced a target of 50% reduction in fatalities between 1996 and 2007, together with several sub-targets like reducing travel speeds and increasing seat belt use. In the 2011 White Paper – "Roadmap to a Single European Transport Area" the EU aimed at a further reduction of 50% of road fatalities from 2011 until 2020 and for 2050 to move close to zero fatalities [25]. In the next section the status of specific goals, targets and indicators in Asia will be reviewed.

2.4 Road safety goals, targets and indicators in Asia

The Asian Environmentally Sustainable Transport (EST) Initiative, which was briefly introduced in section 1.1, adopted in 2005 the Aichi Statement on sustainable transport. Several objectives in this statement dealt directly with road safety, including the importance of addressing traffic safety in land use planning, increasing safety for NMT, the need for safe and affordable urban transport systems and formulation and implementation of multi-stakeholder integrated road safety action plans [6]. An important milestone in the development of the Asian EST initiative was the Bangkok 2020 Declaration, adopted in 2010, in which twenty sustainable Transport Goals for 2010-2020 were defined. Goal 13 specifically dealt with road safety: "*Adopt a zero-fatality policy with respect to road, rail, and waterway safety and implement appropriate speed control, traffic calming strategies, strict driver licensing, motor vehicle registration, insurance requirements, and better post-accident care oriented to significant reductions in accidents and injuries"* [21].

The Bangkok Declaration for 2020 is a voluntary high-level agreement that does not contain specific targets or indicators to monitor the progress on achieving the goals. Todd Litman [26] in a review of the status of implementation of the Bangkok Declaration recommended the following 3 performance indicators to measure the progress on Goal 13:

1. Reductions in number of traffic accidents
2. Reductions in number of transport-related injuries and deaths
3. Adoption of a zero-accident policy framework

The importance of road safety as a core element of a sustainable transport system in Asia was stressed in 2013 by the Bali Declaration, an output from the 7th Regional EST Forum in Asia in Bali in 2013 [20]. The "Vision Three Zeros - Zero Congestion, Zero Pollution, and Zero Accidents - towards Next Generation Transport Systems in Asia" was adopted in this conference [20]. Working towards the Vision Three Zeros is expected to lead to strong improvements in productivity and human development through proper implementation of a sustainable transport system in Asia [6].

In Asia and the Pacific UNESCAP has played a central role in the coordination of the development of regional goals, targets and indicators for toad safety. In Nov. 2006 UNESCAP organized a ministerial conference on transport in Busan, Republic of Korea, in which Ministers adopted a Declaration on Improving Road Safety in Asia and the Pacific which formed the start of the development of targets and indicators by UNESCAP member countries [23]. The declaration adopted in this meeting included the general goal "*to save 600,000 lives and to prevent a commensurate number of serious injuries on the roads of Asia and the Pacific over the period 2007 to 2015*". The meeting resulted in 8 goals with corresponding targets and indicators for monitoring achievements [27]. These goals, targets and indicators were further refined and updated at different occasions since then, to align with the targets and indicators of the Decade of Action for Road Safety 2011-2020 and more recently with the SDG's.

The latest update resulted from the "Regional Meeting on Renewing Regional Road Safety Goals, Targets and Indicator for Asia and the Pacific", held on 28-29 July 2016, Seoul, Republic of Korea and adopted in the Third Session of the Ministerial Conference on Transport organised by UNESCAP in Moscow, 5-9 December 2016 [28]. In line with the SDG target 3.6, as overall objective was defined: "50 per cent reduction in fatalities and serious injuries on the roads of Asia and the Pacific over the period 2011 to 2020". Note that the reference year here is 2011, where for SDG 3.6 this is assumed to be 2015. So the target for Asia and the Pacific, although still very ambitious, has been set slightly less ambitious than the SDG global target. The 8 goals included in this latest revision are identical to the original goals defined in 2006 and are shown in Table 4, together with the 5 Pillars of the Decade of Action, in order to show how the goals and pillars are linked to each other.

Table 4 The 8 UNESCAP goals and how they are related to 5 pillars of the Decade of Action

	Pillar 1 Road Safety Management	**Pillar 2 Safer Roads and mobility**	**Pillar 3 Safe vehicles**	**Pillar 4 Safe road users**	**Pillar 5 Post-Crash response**
Goal 1: Making road safety a policy priority					
Goal 2: Making roads safer for vulnerable road users, including children, elderly people, pedestrians, non-motorized vehicle users, motorcyclists and persons with disabilities					
Goal 3: Making roads safer and reducing the severity of road crashes ("self-explaining" and "forgiving roads")					
Goal 4: Making vehicles safer and encouraging responsible vehicle advertising					
Goal 5: Improving national and regional road safety systems, management and enforcement					
Goal 6: Improving cooperation and fostering partnerships					
Goal 7: Developing the Asian Highway network as a model of road safety					
Goal 8: Providing effective education on road safety awareness to the public, young people and drivers					

Next to the 8 goals, 30 underlying targets were defined as well as 40 indicators to monitor the progress on the goals and targets. Examples of indicators are reduction in fatalities and serious injuries in total, per 100.000 habitants and for specific road user groups, adoption of regulations, implementation and enforcement of laws concerning risk factors (like helmets, speed etc.), infrastructure improvements like separate pedestrian and cycle tracks and information on national road safety plans and their implementation. Annex 1 shows the complete list of the UNESCAP goals, targets and indicators. For 16 (out of the 40) indicators relevant data for the Asian EST countries are available from the Global Status reports 2013 [7] and 2015 [1]. In Table 11 of Chapter 4 this information will be summarized in a dashboard of Asian Road Safety Indicators.

3 Economics of road safety

3.1 Introduction

The aim of this chapter is to provide insight in the relevance of the economics of road safety under the 2030 Agenda for Sustainable Development and more specifically how investments in road safety will contribute to the important target 3.6 of the SDG's to halve by 2020 the number of global deaths and injuries from road traffic accidents (see Chapter 2).

The main question to be discussed is what the economic impact is of road safety investments and which types of measures are the most cost effective ones to be able to set priorities for policy makers (evidence-based policy making). For this purpose, first in section 3.2, a brief overview of methods for the valuation of the economic costs of road safety will be presented, based on a review of various methods available. These costs consist of **direct** costs like medical and property damage costs and **indirect**, less tangible, costs due to loss of production and income of someone injured or killed in an accident as well as immaterial costs like suffering, pain, and loss of quality of life, further referred here to as Human costs.

Different methods have been considered in economic literature to determine the costs of road accidents. The two main methods used nowadays for this purpose are the Human Capital (HC) method (section 3.2.1) and the more recent Willingness-To-Pay (WTP) method (section 3.2.2). The WTP method builds on the HC method and uses the same calculations for the direct costs (medical, administration and property damage). The WTP method has been specifically developed to deal in a more reliable way with the less tangible value a person puts on his own reduction of fatality and injury risk and is the recommended method by economists nowadays to estimate the human costs.

Due to the complexity of applying the WTP method in developing countries, iRAP [29] have proposed a simpler "Rule of Thumb" approach derived from the two main methods, further referred to here as the iRAP method (see section 3.2.3).

An overview of estimates for the costs of road accidents in Asian EST countries will be given in section 3.3. The overview is based on different sources including work done by the Asian Development Bank in the 2000-2005 period, the 2015 WHO global status report and the results of our estimates presented at the 2014 Regional EST Forum in Colombo, which were based on the iRAP method.

In section 3.4 an introduction into cost benefit assessment (CBA) and cost-effectiveness analysis (CE) will be given, illustrated in section 3.5 by examples of the cost-effectiveness of various safety measures in the field of road infrastructure, enforcement, human behavior and vehicle safety.

3.2 Methods for the calculation of the economic impact of road safety

3.2.1 Human Capital (HC) Method

Within the HC method (sometimes also referred to as Gross Output method) estimates are made for all cost categories related to road accidents. In international guidelines dealing with the costs of road accidents five main cost categories can be distinguished (see for example [30][31][32][33]). Table 5 shows an overview of these categories, with a brief description of each cost category according to the SWOV [30]. For the computation of costs a monetary value must be put on each component based on the available data in a country and, if data are not available, assumptions have to be introduced to make estimates for these components. Table 5 includes an overview of potential data sources to determine the costs within each category based on TRL guidelines [31].

Table 5 Five main road safety cost categories [30][31]

Cost Categories	Description	Potential data sources
Medical costs	Costs resulting from the treatment of casualties like costs of hospital stay, rehabilitation, medicines and adaptations and appliances for the handicapped	• Hospital expenditure estimates over the entire time the person needs medical treatment. • Insurance (or social security) payments. • Individual hospital studies. • Road traffic casualty surveys.
Administrative costs	Costs like police services, fire brigade services, law courts and administrative costs of insurers	• Data from the police service, courts, and insurance companies
Property damage cost	Damage to vehicles, freights, roads, and fixed roadside objects	• Insurance companies/claims assessors • Fleet owners • Motor repair businesses • Owner surveys.
Production loss	Loss of production and income resulting from the temporary or permanent disability of the injured, and the complete loss of production of fatalities	• Amount of productive time lost, based on the actual age of a victim, future retirement ages, hospital data, household casualty surveys etc. • Average future wages of casualties based on national income statistics etc.
Human costs	Immaterial costs through suffering, pain, sorrow, and loss of life or of quality of life	

Medical and administrative costs usually constitute a small proportion of the total costs of crashes [30][31]. On the other hand, medical costs will often be the first and most tangible economic burden experienced by a traffic accident victim [31]. In some cases, the medical treatment may continue over many years ahead, in the worst cases over the whole lifetime, and therefore it is necessary to estimate the present value of future medical treatments. This value is rather straight forward to estimate if good records on hospital and medical costs exists.

The largest portion of **property damage costs** stems from damage to vehicles and since a large portion of the road accidents are crashes with only damage to the vehicles the cumulative cost of vehicle damage constitutes a significant proportion of total costs of crashes in a country as will be shown in 3.3.

Production loss is a very (and in many countries the most) important cost category and it refers to the loss to the economy of the productive capacity from those affected by a crash. Road traffic accidents are a leading cause of death among young people and the main cause of death for people at the ages 15 – 29 years [1]. When a person aged 20 dies in a traffic accident it is both a tragedy, and a loss of up to 50 years of future contribution to the growth of society. The skewed age profile of road traffic fatalities together with the huge number of victims explains the significant contribution of production loss in total road safety costs.

Three types of production losses can be distinguished: due to premature death, due to reduced working capacity and due to days of illness [34]. To calculate the loss of production, estimates for the working time lost and on future wages have to be available [31]. The amount of working time lost for a fatal casualty is the time the crash victim could have spent working in the future, and it is measured from the time of death to the age of retirement. For seriously and slightly injured casualties, it is the amount of working time lost someone would have spent working if they had not been disabled, or whilst recovering in hospital or at home [31]. In addition, for the calculation of production loss, estimates are needed on

future wages. National income statistics have been the traditional source for such estimates as well as sometimes casualty reviews.

Calculation of production loss is done in a similar way in all countries. However, important differences can occur, like that some countries also put a value on domestic work and that various assumptions regarding the growth of incomes are used [31]. Some countries correct the production loss for expected future consumption: gross production loss is the production loss including the value of future consumption and net production loss without future consumption [35], see also 3.2.2.

The 5th category: **human costs** deals with immaterial costs like suffering, pain, sorrow, and loss of life or of quality of life. Therefore, in the Human Capital method an economical value reflecting these human costs, defined as "pain grief and suffering" [31], is added to the overall estimate of road accident costs. The amount to add to reflect pain grief and suffering within the HC method is essentially a political decision and the greater the amount added, the higher the value society would place upon the prevention of crashes [31]. For a detailed discussion on this and the large impact of road accidents on poor families please refer for instance to [31].

An earlier TRL study [36] contained recommendations to add the following values for "pain, grief and suffering":

- 28% of total costs for a fatal crash.
- 50% of total costs for a serious crash.
- 8% of total costs for a slight crash
- 0% of total costs for a damage only crash.

Several countries, also in Asia (see 3.3), where the HC method has been used have adopted these recommended values or equivalent values in their calculations. The WTP method, which will be discussed in the next section, has been developed with the objective of valuing **human costs** more realistically.

3.2.2 Willingness-To-Pay method (WTP)

A major objection against the HC method described above is that most people do not value their life primarily for their output to the society (economic impact), but because it has intrinsic value to them and their relatives [37]. This value, often referred to as the **Value of Statistical Life (VSL)**, can be estimated by determining the amount of money that people are willing to pay to reduce the risk of being killed in an accident. The VSL is estimated by the WTP method, which has been adopted in many high-income countries in the meantime, replacing the HC method. A huge literature on methodology and Meta studies exists today [30][38][39] concluding that although the WTP methodology is not flawless it is more suitable than the alternatives.

Various WTP methods have been developed, where the two most important ones are the Revealed Preference (RP) and the Stated Preference (SP) method. RP methods value risk reductions based on actual behaviour, for example on how much money is spent on safety provisions, while in SP methods people are asked how much they are willing to pay for safety provisions [35]. The following example concerning risk of dying from air pollution presented in [40] illustrates how a VSL value can be derived from a WTP-SP survey:

The survey finds an average WTP of USD 30 for a reduction in the annual risk of dying from air pollution from 3 in 100 000 to 2 in 100 000. This means that each individual is willing to pay USD 30 to have this 1 in 100 000 reduction in risk. In this example, for every 100 000 people, one death would be prevented with this risk reduction. Summing the individual WTP values of USD 30 over 100 000 people gives the VSL value – USD 3 million in this case. It is important to emphasise that the VSL is not the value of an identified person's life, but rather an aggregation of individual values for small changes in risk of death.[40]

When adding VSL to the other cost components discussed above, double counting may occur. In addition to immaterial costs for suffering, pain, sorrow, and loss of life or of quality of life, VSL includes a value on the future consumption that would have taken place if the person had not died [35]. But this loss of consumption is also part of the 4th cost category: production loss. The production costs calculated through the HC method results in the gross production loss, i.e. including future consumption loss. Subtracting the future consumption loss from the gross production costs results in the net production costs. Figure 4 illustrates this schematically where the total costs and the cost components resulting from the HC and WTP approach are presented.

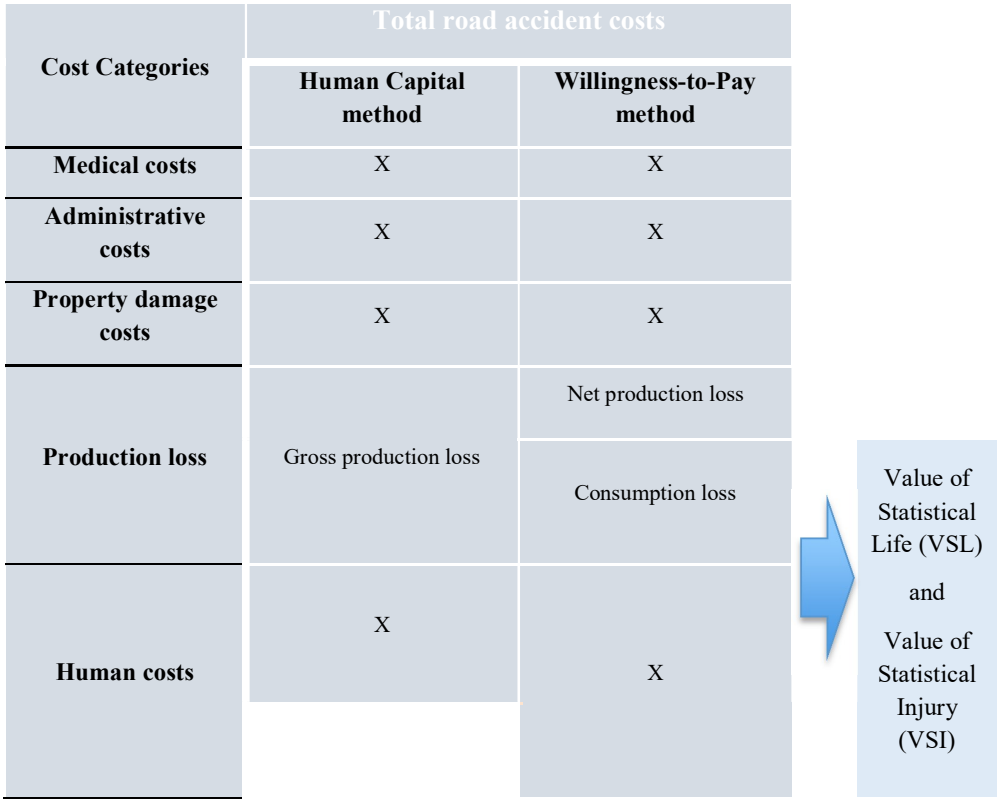

Figure 4 Schematic overview of different cost categories

The cost estimates resulting from the WTP approach are usually (much) higher than those resulting from the HC approach [37][30].

The WTP method can also be applied to determine the value for a person not being fatally injured in an accident indicated as **Value of Statistical injury (VSI)** [41]. There are few estimates of the value of reducing the risk of nonfatal accidents in High Income Countries (HIC's). As nonfatal accidents become

relatively more important, as mortality risk reduces, it is necessary to improve the understanding of the benefit of a reduction in nonfatal accidents. It is well known that commonly used definitions such as severe and light injury hide a broad variation in valuation [42]. The wide-ranging variation makes a single value questionable and targeted study for all possible outcomes of nonfatal states impossible.

3.2.3 iRAP "Rule of Thumb" method

The WTP method is costly and requires sophisticated survey techniques, due to which adoption of the WTP methodology in developing countries may be less viable [29]. Therefore, iRAP investigated an alternative approach based on results from available WTP and HC studies from a range of countries. The basic assumption in the method is that the income in a country (GDP) is the primary determining factor for the VSL [29]. From the available VSL data collected from the involved countries, ratios of VSL to GDP per capita were calculated. Table 6 shows the VSL/GDP ratio for Asian EST countries present in the iRAP database, including the year for which the ratio was calculated and the method used (HC or WTP). For most of these countries the HC method was used, where for the estimation of human costs a value was added based on the TRL percentages mentioned in 3.2.1.

Similar calculations were carried out for several high-income countries showing that HIC countries tend to have higher VSL/GDP ratios than Low and Middle Income Countries (LMIC's). Also countries using the WTP method (more represented within the HIC group of countries) showed larger ratios than countries using the HC Capital method. The iRAP study concluded that as a "rule-of-thumb" method a ratio of 70 can be used for all countries to make an estimate for the VSL as function of GDP per capita. This value of 70 is slightly below the Malaysia WTP based value of 76 but higher than most of the other ratios found for Asian EST countries. For a more detailed discussion on the relationship between VSL and GDP and differences between LMIC's and HIC's and dependency on methodology used to determine the human costs, interested readers are referred to [41][30].

Table 6 Values for VSL / (GDP per capita) in some of the Asian EST countries including year for which the calculation was made calculation method (HC = Human Capital and WTP = Willingness-to-Pay) [29].

Country	VSL/GDP-per-capita	Year	Method
Bangladesh	55	2002	HC
Cambodia	60	2002	HC
India	56	2004	WTP
Indonesia	30	2002	HC
Lao	14	2003	HC
Malaysia	76	2003	WTP
Myanmar	33	2003	HC
Philippines	42	2003	HC
Thailand	32	2002	HC
Vietnam	21	2003	HC

For the valuation of **serious injuries** (VSI for serious injuries being hospitalized) similar calculations were carried out by iRAP based on data available for a few HIC's and this resulted in a recommended VSI/GDP-per-capita ratio of 17, so about 25% of the VSL value. It was noted in the iRAP study that this VSI estimation is less robust that the VSL estimation since it is derived from much less data. Note that these iRAP ratios are just for the VSL and VSI components in the costs (see Figure 4) and do not count for the net production loss, property damage costs etc.

If the number of serious injuries is not known in a country, iRAP proposes to use a ratio of 10 serious injuries for each fatality, based on different data sources. For less severe and minor injuries iRAP has made no "rule-of-thumb" estimates for the VSI.

3.3 Costs of road accidents in Asia

3.3.1 Distribution of total accident costs among cost components

A large study concerning the costs of road accidents – the ADB-ASEAN Regional Road Safety Project in Asia - was carried out by the Asian Development Bank (ADB) in the Southeast Asian countries. [43]. In this study, domestic consultants recruited by ADB carried out an accident costing exercise for each country using the HC method and using guidelines from TRL included in 3.2.1 to estimate the human cost component. One exception was Malaysia that already had adopted the WTP approach.

Wijnen and Stipdonk from the Dutch Institute for Road Safety Research (SWOV) [30] made an analysis of the ADB data together with data from other sources from HIC's. They showed that in the Asian LMIC's property damage has the largest share (39% average) in the total costs, followed by production loss and then human costs, but with large variations between the several countries. It was noted in the analysis that the number of crashes with only property damage is uncertain because of (very) incomplete crash reporting. The estimation for human costs (40% average) in HIC's are about twice as high as in LMIC's (18% average), which was partly explained by the more frequent use of the WTP method in HIC's than in LMIC's.

3.3.2 Costs per casualty

The costs per casualty based on the ADB data for resp. a fatal crash, a crash with a serious injury, a casualty with a minor injury and a damage only crash is shown in Table 7. Large variations in costs between various countries can be seen and in particular in the costs for a fatal casualty. For example, the costs in Thailand are a factor 10 higher than in Cambodia and even a factor 25 higher than in Lao PDR.

Table 7 Total cost per casualty (price level 2012 in US$) for fatalities, serious injuries, minor injuries and damage only casualties (based on analysis of ADB data by SWOV [30])

	Cambodia	Indonesia	Lao PDR	Myanmar	Philippines	Thailand	Vietnan
	US $	US $	US$	US$	US$	US$	US$
Fatalities	31.800	229.800	13.000	60.100	176.000	319.500	119.700
Serious injuries	12.500	15.000	3.800	19.800	19.600	15.900	30.900*
Minor injuries	1.000	4.300	700	4.400	5.400	2.400	
Property damage only	800	500	500	7.700	4.700	2.200	800

*serious and minor injuries combined

3.3.3 GDP loss data due to road accidents

At the 2014 Regional EST forum, we presented estimates for the Asian EST countries for the accident costs expressed as a % of GDP loss in the year 2013. These estimates were based on the following steps and assumptions [6]:

- Number of fatalities in 2010 based on the average of the number of fatalities reported in the 2013 Global Status report and the IHME/World Bank 2014 report [3]
- Serious injury estimates in 2010 based on the IHME/World Bank 2014 report [3] and defined as injuries requiring hospital admission
- Costs of minor injuries, property damage, medical costs, administration costs and production loss due to injuries were neglected
- For human costs the iRAP "rule of thumb" of 70*GDP/capita for fatalities and 17*GDP/capita for serious injuries was adopted and calculated for the year 2010 (2014 US$ values).
- Gross production loss for fatalities was calculated as described in [6] and corrected for future consumption loss since future consumption loss is also part of the human costs as calculated according to the iRAP method. The resulting net production loss was small (about 0,1% GDP loss) and therefore neglected. So the costs reported in the 2014 study [6] were the VSL and VSI estimates.

The resulting GDP losses (total and % of GDP) for the Asian EST countries are shown in Table 8 together with the GDP loss data (%) from the 2015 Global Status report [1] and the estimates resulting from the ADB data [30]. Most of the WHO estimates were based on national studies in the various countries and for different years. The WHO Global status report does not describe how these GDP losses were achieved (like using HC vs WTP, which data were used for fatalities and injuries etc.) and whether all cost categories and all type of casualties (fatal up to property damage only) have been considered. Unfortunately, an analysis of the underlying national studies would be out of the scope of our current paper.

The total resulting costs of road accidents in the Asian EST countries in 2010 from our 2014 estimate is 735 Billion US$. A division over various countries and regions in in Asia is shown in Figure 5 showing that almost halve of the costs occur in China followed by the high-income countries in the Asia Pacific (Japan, Rep. of Korea and Singapore) and South Asia (which includes India). Figure 6 shows the loss due to road accidents in 2010 as a % of GDP in various countries and regions[1] in Asia with the lowest values (<2%) in the high-income countries and the highest (>4%) in South Asia. The average % GDP loss in the Asian EST region is 3,3% (Table 8).

Our results for the % of GDP loss due to road accidents is for most countries are higher than the ADB and WHO percentages of GDP loss estimates. This will largely be due to the different methodology we have used, i.e. the rule of thumb iRAP approach which may lead to higher estimates for the human costs, as well as the use of more accurate injury estimates than in other studies. These injury estimates are based on the IHME/World Bank data that became available in 2014. Note that on the other hand, our estimates are also conservative since they exclude major cost components like the property damage costs, the costs of minor injuries, medical costs and administrative costs.

[1] For definition of South Asia and Southeast Asia see section 1.1

Table 8 Estimated costs of road accidents in Asian EST countries based on different studies.

	Country GDP	Wismans et al [6]		ADB [30]	WHO 2015 [1]
Year	**2010**	**2010**		**< 2005**	**2000 ...2013**
	(billion US$)	(billion US$)	(% GDP loss)	(% GDP loss)	(% GDP loss)
Afghanistan	21,3	0,72	3,4 %		
Bangladesh	123,3	5,21	4,2 %		1,6%
Bhutan	1,8	0,08	4,4 %		
Brunei Dar.	15,4	0,31	2,0 %		
Cambodia	14,3	0,55	3,8 %	1,8 %	2,1%
P. R. of China	9182,2	351,74	3,8 %		
Indonesia	833,6	31,60	3,8 %	2,9 %	2,9-3,1 %
India	1835,7	80,23	4,4 %		3,0%
Japan	4870,6	95,67	2,0 %		1,3%
Republic of Korea	1251,7	31,00	2,5 %		1,0%
Lao PDR	10,2	0,36	3,5 %	2,7 %	2,7%
Malaysia	298,6	14,59	4,9 %		1,5%
the Maldives	2,1	0,06	3,0 %		
Mongolia	11,2	0,39	3,5 %		
Myanmar	62,6			1,1 %	0,5%
Nepal	20,8	0,92	4,4 %		0,8%
the Philippines	255,1	6,83	2,7 %	2,6 %	2,6%
Pakistan	225,5	10,06	4,5 %		
Russian Fed.	2088,9	71,75	3,4 %		2,2% - 2,6%
Singapore	446,2	4,35	1,0 %		
Sri Lanka	68,4	2,21	3,2 %		
Thailand	399,5	16,18	4,1 %	2,1 %	3,0%
Timor-Leste	1,5	0,06	4,0 %		
Viet Nam	167,9	11,01	6,6 %	2,0 %	2,9%
Total	**22208**	**735,87**	**3,3 %**		

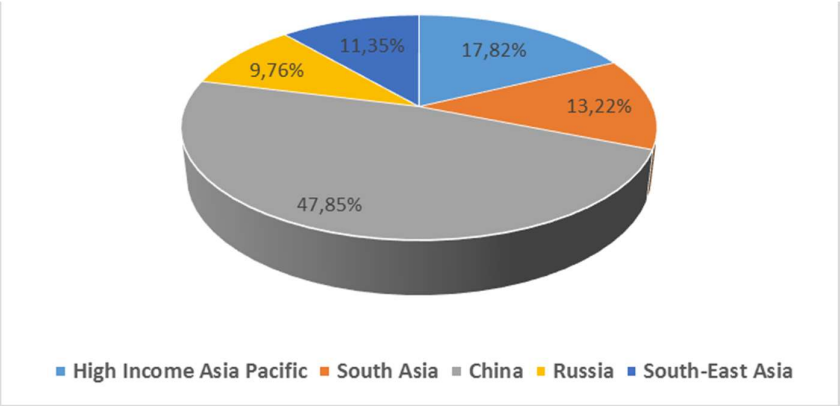

Figure 5 Distribution of estimated costs road accidents in 2010 over various countries and regions in Asia

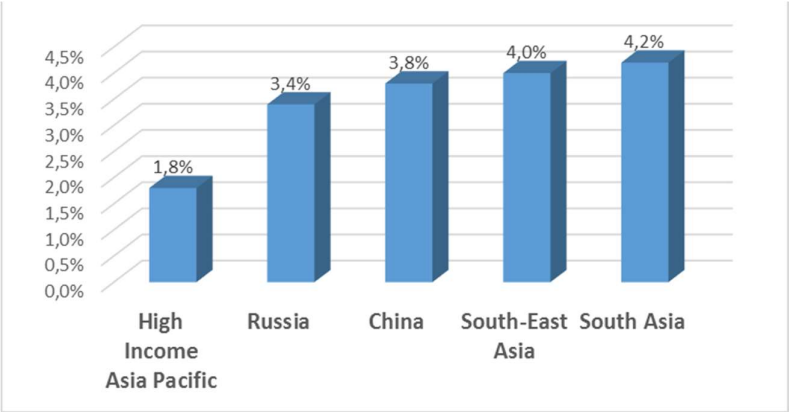

Figure 6 % GDP loss due to road accidents in 2010 in various countries and regions (unweighted %) in Asia

3.4 Cost benefit analysis and cost effectiveness

Many road safety measures may be on the agenda, but with limited resources it is necessary to choose between them and advocate the best choice. Road safety measures are often considered within a road budget that has a number of different objectives to fulfill: accessibility, environmental improvements in addition to road safety. It is necessary to take also these other objectives into account in the choice of measures.

Cost Benefit Analysis (CBA) was introduced more than 150 years ago and a large amount of literature gives insight into the method (see e.g. [45]). In a CBA, when comparing various alternatives, all effects that are taken into account need to be expressed in a common unit, which is a monetized value. Methods for valuation of non-market goods have been developing fast the last decade [46]. All monetized effects of a project are summarized over the lifetime of the project and discounted as a present value (PV) to a common year. The present value of benefits (PVB) is compared to the present value of costs (PVC) and expressed as a benefit-cost ratio (PVB/PVC). A benefit-cost ratio > 1suggests that the project is a good use of scarce resources.

The CBA methodology is based on welfare economic theory and is based on a number of principles: "consumer sovereignty", "potential compensation" and "neutral to income distribution". "Consumer sovereignty" means that the value for all affected persons should be assessed; the use of VSL, based on willingness-to-pay, is compatible with this [44]. The principle of "potential compensation" says that for a project where the benefit is greater than the costs "the winners of the project *can* compensate the looser and still be better off" [47]. This principle is different from a common market transaction which takes place only if all are winners. The principle is necessary to be able to summaries a large number of effects in a CBA. "Income neutrality" articulates that a CBA (usually) gives the same weight to a benefit for high- as for low-income people. The two latter principles mean that a CBA often should be supplemented with an analysis of the distribution of winners and losers between different groups of society in a distribution analyses [45].

With a **Cost effectiveness** approach (CE), there is no need to use a monetized value of safety. All costs and all other (non-safety) benefits are summarized in monetary terms and compared with the physical number of lives saved and reduction of injuries achieved. CE is a good way to prioritize measures where a single goal (safety) is at hand, which can be expressed in a single unit (fatality and injuries). The same principles of "potential compensation" and "income neutrality" are found in a CE analysis. To compare different policy alternatives with different objectives (reduced travel time or less emissions for example) a CBA is a more appropriate tool. The steps to be taken in a CBA can be generally summarized as shown in Table 9.

Many road safety measures are based on governmental regulations. CBA is an important analytical tool within a so-called **Regulatory Impact Analysis (RIA)**. RIA is a process of systematically identifying

and assessing the expected effects of regulatory proposals and setting priorities. By performing RIA, the risk of imposing a proposal that is inefficient or leads to sub-optimization is reduced. The Organization of Economic Cooperation and Development (OECD) has developed a Handbook that provides guidance on how to implement RIA as a way to improve the regulatory quality and many OECD countries and also many developing countries have introduced some kind of RIA within their regulatory development process [49]. In the EU regulatory process RIA was introduced in 2002.

Table 9 Steps in a CBA

1.	Decide on the base case – business as usual – and the alternative measures or programs to assess
2.	Identify all effects that are different between the base case and the alternative(s)
3.	Measure the effects in physical units
4.	Value the measured effects in monetary units
5.	Discount the monetized effects into a common year
6.	Assess if the present value of benefits is greater than the present value of costs
7.	Assess who bears the benefit and costs and, if necessary, conduct a distribution analyses
8.	Perform a sensitivity analyses

3.5 Benefit of various road safety measures

Decades of research have created a huge amount of scientific knowledge on the costs and benefit of various traffic safety measures. As an example, an overview of the benefit to cost ratios of a selection of road safety measures in Norway is given in Table 10 [50]. Examples are shown from the field of road design, vehicle safety, enforcement and user behaviour. Many of the road safety measures included in the Table 10 show a high benefit-cost ratio. This overview is based on work done in Norway as described among others in the Handbook of Road Safety Measures [51], in which the results of a systematic search of the literature on traffic safety by means of a meta-analysis is summarized. The meta-analysis approach is a statistical methodology that combines the results of multiple scientific studies, in order to minimise the contribution of subjective factors, which are often included in traditional literature surveys.

Many of the cost benefit studies have been carried out in Europe and the US which may limit however the applicability to other parts of the world. The latest version of the handbook in English is from 2009 (printed version only) and a Portuguese version (also as an e-book) was published in 2015. The handbook contains measures within all 5 pillars of road safety including, policy instruments, road design and maintenance, traffic control, vehicle design and protective devices, vehicle inspections, driver requirements and training, education, enforcement and first aid. For each measure problems and objectives are described as well as description of the measure, effect on accidents, mobility and environment and finally, where available, cost and a cost-benefit analysis.

Several of the measures with high benefit-cost ratios included in Table 10 concern speed (lowering speed limit on hazardous roads, intelligent speed adaptions, speed enforcement and camera's, feedback signs for speed). In the following section the importance of speed measures will be discussed in more detail. Furthermore, motorcycle helmets will be discussed which were not included in Table 10.

3.5.1 Speed and speed enforcement

Speed has been identified as a key risk factor in road traffic injuries, influencing both the risk of a road crash as well as the severity of the injuries that result from crashes. Increased speed reduces safety margins as the driver needs a greater distance before he reacts to a hazard, and because the error margins are smaller. To ensure a proper tradeoff between speed and safety, speed limits are almost universally applied. Section 4.1 includes an overview of the status of speed regulations and enforcement in the Asian EST countries.

Change of speed limits affects traffic safety by affecting the average speed, which in turn affects the number of accidents and injured and killed persons. Many studies have investigated the relationship between actual vehicle speed and certain accident types [52][53]. Figure 7 illustrates the global cumulative relationship between vehicle impact speed and fatality risk for different collision types: pedestrians impacted by a vehicle front, side impact collisions and frontal impacts (car-car or against a hard object) [49]. All car occupants are belted. The larger the speed the higher the fatality risk and above a certain impact speed the risk of being killed approximates 100%. Car occupants are much better protected for the same impact speed than pedestrians and in frontal impacts car occupants can withstand higher impacts speeds than in side impacts.

Table 10 Examples of Benefit-Cost ratios of road safety measures in Norway [50]

Road safety measure	Benefit-cost ratio		Benefit-cost ratio
Road-related safety measures		**Enforcement-related safety measures**	
Bypass roads	1.38	Speed enforcement	1.49
Pedestrian bridge or tunnel	1.47	Speed cameras	2.11
Converting T-junction to roundabout	1.86	Section control (co-ordinated speed cameras)	1.58
Converting X-junction to roundabout	2.62	Feedback signs for speed	2.35
Roadside safety treatment	2.77	Drink-driving enforcement	1.80
Reconstruction and rehabilitation of roads	1.57	Alcohol interlock for drivers convicted of drink-driving	8.75
Guardrails (along roadside)	2.53	Seat belt enforcement	2.44
Median guard rails on undivided roads	1.40	Technical inspections of heavy vehicles	1.41
Median rumble strips (1 metre wide)	2.41	Service- and rest hour enforcement	1.45
Horizontal curve treatments	2.37	Bicycle helmet law	1.02
Road lighting	1.94	Law requiring pedestrian reflective devices	3.49
Upgrading substandard road lighting	2.75		
Follow up road safety inspections	2.48		
Traffic signals in T-junctions	5.17		
Traffic signals in X-junctions	3.95		
Lowering speed limit on hazardous roads	14.29		
Upgrading pedestrian crossings	2.36		
Vehicle-related safety measures		**Road user-related safety measures**	
E-Call	1.61	Accompanied driving	1.25
Event recorders	2.15	Elderly driver retraining	1.85
Electronic stability control	3.98		
Front and side air bags	1.01		
Enhanced neck injury protection	20.25		
Seat belt reminders	16.21		
4 or 5 stars in Euro NCAP	1.24		
Intelligent speed adaptation (ISA-systems)	1.95		
Design of car front to protect pedestrians	4.52		
Front impact attenuators on heavy vehicles	2.12		

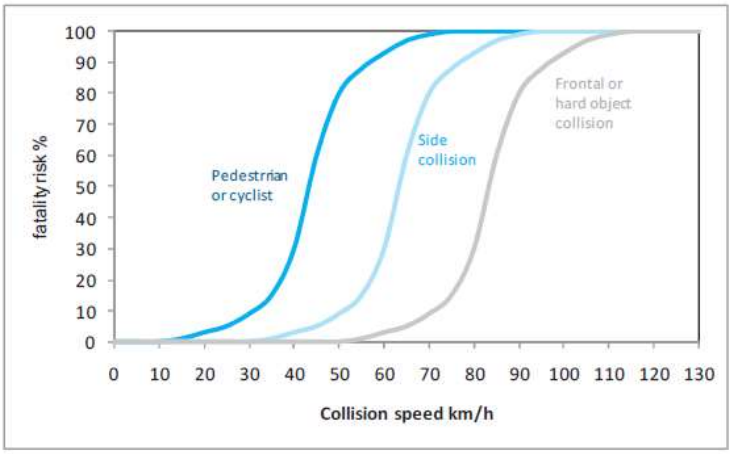

Figure 7 Relationship between impact vehicle speed and fatality risk for different collision types [49]

The "optimal" speed limit, from an economic point of view, can be calculated as the balance between increased travel time and reduced accident and environmental costs, as the speed changes. Although such calculations are made, real speed limits are often set (much) higher than what would be optimal.

To ensure that speed limits affect the average speed on the road, it is necessary that the speed limits are enforced. Doubling the level of speed enforcement has a benefit-cost ratio of almost 6 [55]. Experience for example in France has shown that increasing speed enforcement is very effective in the reduction of fatalities and injuries [54].

3.5.2 Helmets

It is well documented that the use of a helmet on motorcycles reduces the risk of serious head injuries. A meta-analysis from 2008 by Liu et al. [69] has summarized results from 61 studies from the years 1977-2006 by the effect of motorcycle helmet. The results are fairly consistent between studies. The best studies in this meta-analysis show overall that the motor cycle helmet reduces the risk of being killed with 42% and the risk of head injuries with 69% (Liu et al., 2008). The effect of the helmet on neck and facial injuries was less consistent between the various studies. The best studies found insufficient evidence to estimate the effect of motorcycle helmets compared with no helmet on facial or neck injuries while other, poorer quality studies, suggested that helmets have no effect on the risk of neck injuries and are protective for facial injury. More recent studies with control for multiple variables have found even greater effects of the helmet. For example, a study from Taiwan [70] showed that a helmet use reduces the risk of being killed with 74%.

Helmets do not affect travel speed or environment. The reduction in accident risk is thus only weighted against the cost of a helmet. Elvik et al. [71] showed that the benefits of using the helmet on the moped and motorcycle is far greater than the costs, with a benefit-cost ratio of about 17. There is no reason to believe that the helmet has become less cost-beneficial over time.

In spite of the effectiveness of a helmet the non-use of a helmet is still a problem. A study in Lao found that the main reasons for not using a helmet were because the motorcyclist did not like how adult helmets feel or made them look [72]. In another study in Iran reported in [73], physical discomfort (which can include heat related issue) was the main reason for not using a helmet. Therefore, comfort must be taken on-board by helmets manufacturers to help increase the helmets use.

4 Investments for road safety in Asia

The SDG 3.6 target to halve by 2020 the number of global deaths and injuries from road traffic accidents implicates for the Asian EST countries a saving of more than 340.000 lives annually (based on WHO estimates for fatalities in 2013 [1] and a reduction of 3 million hospital admissions (based on IMHE/World Bank estimates for hospital admissions in 2010 [3]. The average number of fatalities per 100 000 population in the Asian EST countries was 15.6 in 2013 (see Table 1). A reduction of 50% equals a target of 7.8 fatalities per 100 000 population by 2020 which is slightly below the current level for high-income countries (see Figure 1). The total costs of fatalities and serious injuries in the Asian EST countries, calculated as a loss to the economy, was estimated to 735 billion US$ or 3,3% of GDP [see Chapter 3]. When the SDG target 3.6 would be reached the burden on the economy would be reduced with more than 350 billion US$ per year, or equivalent to a growth in GDP of more than 1,5%. Such targets are extremely ambitious, but on the other hand examples for some individual countries in Europe have shown that significant improvements are possible in a short period, where in particular, strategies adapting best practices from other, better performing countries have shown to be very successful [57].

4.1 Status of measures to improve road safety in Asian countries

In Section 2.4 the goals, targets and indicators for Asian countries have been introduced. In total 40 indicators were defined by UNESCAP (see Annex A) and for 16 of these indicators relevant data for the Asian EST countries (except Brunei) can be found in the Global Status report on Road Safety, 2015 [1]. Concerning the high-level EST goals formulated in the Bangkok declaration, Todd Litman [26] proposed 3 indicators of which 2 indicators (reductions in number accidents and injuries) are similar to the UNESCAP indicators 1 and 2 and EST-indicator 3 (Adoption of a zero-accident policy framework) relates to UNESCAP indicator 3. Therefore we will further concentrate here on the more comprehensive UNESCAP indicators.

In this section information on the 16 UNESCAP indicators for which information is available from the 2015 Global Status Report will be summarized and briefly reviewed by means of a dashboard of performance indicators shown in Table 11. The dashboard is split over 2 pages and contains general data on road safety management, infrastructure, promotion of NMT, introduction of UNECE regulations, availability of emergency access numbers and data on the risk factors: speed, drunk–driving, not wearing motorcycle helmets, not wearing seat-belts, not using child restraints in cars and mobile phone use during driving.

Concerning **number of death in road accidents** and number of death per 100.000 population reference is made to section 1.1, Table 1 for all road victims and to Figure 2 for pedestrian and motorcyclist deaths. Table 1 also includes a comparison for 2010 and 2013 data for all countries. For an analysis of trends in the Asian EST countries from 2010-2013, please refer to the discussion in section 1.1. Note that estimates for **serious injuries** (UNESCAP indicator 2) for the year 2010 in the Asian EST countries are available from the IHME/World Bank 2014 report [3] and have been summarized in [6].

All countries have a designated **lead agency on road safety** - the name of this agency is included in the WHO status report. Most countries have a national road safety strategy (except Afghanistan, Pakistan, Maldives and Sri Lanka) and many of the countries with a national road safety strategy have introduced **targets for fatality reduction** like, for example, a 50% fatality reduction by 2020 (Bangladesh, Cambodia, Indonesia, Malaysia, Mongolia and Philippines).

Formal **audits for new road construction projects** are carried out in 19 of the 24 EST countries and **regular inspections of existing road infrastructure** in 14 countries. **Policies to promote walking or**

cycling on a national level exist in 8 countries, but **policies to separate road users and protect Vulnerable Road Users (VRUs)** in only 6 countries, although in some countries they may exist on a sub-national level.

For 3 **UNECE vehicle safety regulations**, resp. on Frontal Impact protection, Electronic Stability Control (ESC) and Pedestrian protection, information is included in the dashboard concerning introduction in the Asian EST countries. Three countries (Japan, Russia, and Rep. of Korea) have accepted all these regulations. China has adopted the Frontal Impact protection standard, Thailand the Pedestrian protection standard and Malaysia both the Frontal Impact and Pedestrian protection standard. Note that the UNECE requirements are minimum requirements and usually less demanding than requirements in New Car Assessment Programs (NCAP), like the various NCAP programs introduced in Asia [6].

An **Emergency access telephone number** has been introduced in all countries, except for Afghanistan, Pakistan, and Bangladesh. Except for a few countries, the numbers are different in each country and in some countries also multiple numbers are used. Examples of emergency numbers used in the Asian EST area are: 110, 103, 112, 113, 115, 119, 120, 192, 999 and 991.

All Asian EST countries, except Afghanistan, have **helmet laws** for motorcycles. For helmet laws to be effective they should [1]:

- apply for both drivers and passengers (not the case for Cambodia and Maldives)
- require that helmets be worn in all traffic and weather conditions and apply for all engine types
- specify that helmets need to be always fastened, which is not the case in 13 of the countries.
- require helmets to meet an adequate helmet standard like ECE 22 [74], which is not the case in 7 countries. Without an adequate standard, the risk of using a helmet without sufficient protection increases.

The wearing rate for helmets is available for 12 countries and appears to be high (75% and more wearing rate) in Indonesia (drivers), Malaysia (all), Philippines (drivers), Rep. of Korea, and Vietnam (all). The enforcement level is also included and countries will a high enforcement level show usually high wearing rates and countries with a low enforcement level (Mongolia and Pakistan) show very low wearing rates.

Child restraint systems for cars are required in only 7 countries and the usage rate and enforcement level is very low in all countries except for Japan. All countries have a **national seatbelt law** except for Afghanistan, Bangladesh, and Myanmar, but in only 10 countries this law applies to both front and back seats. For most countries information on the enforcement level of seat belt wearing is available and this level is rated high (7 and higher) in seven countries including China, which had a very low enforcement level in the 2013 Global status report [6]. In 5 countries, the enforcement level is low (3 or below). Wearing rates are available for 10 countries and they are low in China (only 37% of the drivers) and India (only 26% of the drivers). Eighteen countries have a national law for **mobile phone** use during driving, which in most countries prohibits hand-held mobile phone use.

Drunk-driving laws exist in all countries except Maldives (where alcohol consumption is legally prohibited). Most countries have specified Blood Alcohol Content (BAC) limits, usually 0.05 or 0.08 g/dl but also sometimes lower like 0.02 in China. In countries where alcohol consumption is legally prohibited like Afghanistan, Pakistan, Bangladesh no BAC limits are specified. Also in Indonesia and Nepal no BAC limits are specified. In most countries with BAC levels random breath testing is carried out. Some countries have specified lower BAC numbers for novice drivers (not included in the dashboard). Some countries show high enforcement levels for drunk-driving including Brunei, China, Japan, Rep. of Korea and Singapore and others having very low enforcement levels, including countries

Table 11 Dashboard of UNESCAP Road Safety Indicators based on information in 2015 Global Status Report [1]. Note that enforcement levels are rated on a scale from 1-10 (10 = highest).

UNESCAP Indicator see Annex	Related WHO 2015 indicator see Global Status report on road safety 2015	Afghanistan	Bangla-desh	Bhu-tan	Brunei WHO 2013	Cam-bodia	China	India	Indo-nesia	Japan	Lao	Ma-laysia	Maldives
1	Number of road death and /100,000 pop.	See Table 1											
7	Numbers of pedestrian deaths	**See Figure 2**											
9	Number of motorcyclist deaths												
3	National Road Safety strategy?												
	Fatility reduction target?		50% (2011-2020)	< 1.0 / 10000 vehicles (2011-2020)		50% (2011-2020)	< 2.2 / 100000 veh. (2011-2015)		50% 2020	<3000 / year in 2015	50% (2011-2020)	50% (2020)	
4	Name of designated lead agency on road safety												
16	Formal audits for new road construction projects												
	Regular inspections of existing road infrastructure												
	Policies to promote walking or cycling												
	Policies to separate road users and protect VRUs												
21	Frontal impact standard (UNECE)?												
	Electronic Stability Control standard (UNECE)?												
	Pedestrian protection standard (UNECE)?												
30	Emergency acces tel. Number												
	Risk Factors												
10, 25	National Motorcycle Helmet law?												
	Helmet standard?												
	Required for Drivers and Passengers?												
	Helmet to be fastened?												
	Wearing rate % drivers/passenger					64/6	20	60/-	80/52			97/89	
	Enforcement level		4	10	10	5	6	4	8	9	7	5	7
12	Law for child restraints in cars?												
13	Usage and enforcement of child seat restraints?												
26	National seat belt law												
	Applies to drivers and passengers												
	Enforcement level			3	6	5	8	4	8	8	2	4	4
	Seatbelt wearing rate, front/rear in %				72/-		37/-	26/-		98/68		77/13	
	National Law mobile phone use during driving?												
27, 28	National drink-driving law?												
	BAC limit g/dl general population			<0.08	<0.08	<0.05	<0.02	<0.03		<0.03	<0.05	<0.08	
	Random Breath testing?												
	Enforcement level drunk-driving	1	2	5	9	4	9	4	5	9	2	5	
	% death involving drunk driving				9	15	4	5		6		23	
	Urban speed limit km/hr		No	30	80	40		No	70	60	40	90	30
	Rural speed limit km/hr	90	112	50		90		No	100	60	90	90	30
	Motorway speed limit km/hr		No	50		100	120	No	No	100		110	No
	Speed Enforcement	1	3	5	6	4	8	3	5	7	4	6	6

No

Yes

Alcohol consumption legally prohibited

Sub-national but actual information not available

Table 11 (Cont.) Dashboard of UNESCAP Road Safety Indicators based on information in 2015 Global Status report [1]. Note that enforcement levels are rated on a scale from 1-10 (10 = highest).

UNESCAP Indicator Annex 1	**Related WHO 2015 indicator** see Global Status report on road safety 2015	Mon-golia	Myan-mar	Nepal	Pakis-tan	Philip-pines	Rep. of Korea	Rus-sia	Singapo re	Sri Lanka	Thai-land	Timor-Leste	Viet-nam
1	Number of road death and /100,000 pop.	See Table 1											
7	Numbers of pedestrian deaths	**See Figure 2**											
9	Number of motorcyclist deaths												
3	National Road Safety strategy?												
	Fatility reduction target?	50% (2012-2020)	50% (2011-2015)	35% (2013-2020)		50% (2011-2020)	<4000 / year by 2017	8000 reducti on by 2020			<10 /100000 pop. (2010-2020)		5-10% annuall y (2012-2020)
4	Name of designated lead agency on road												
16	Formal audits for new road construction projects												
	Regular inspections of existing road infrastructure												
	Policies to promote walking or cycling												
	Policies to separate road users and protect VRUs												
21	Frontal impact standard (UNECE)?												
	Electronic Stability Control standard (UNECE)?												
	Pedestrian protection standard (UNECE)?												
30	Emergency acces tel. Number												
	Risk Factors												
10, 25	National Motorcycle Helmet law?												
	Helmet standard?												
	Required for Drivers and Passengers?												
	Helmet to be fastened?												
	Wearing rate % drivers/passenger	7/-	48-51		10	87/51All	74				52/20		96/83
	Enforcement level	1	5	9	3	6	6	6	9	7	6	6	9
12	Law for child restraints in cars?												
13	Usage and enforcement of child seat restraints?												
26	National seat belt law												
	Applies to drivers and passengers												
	Enforcement level	3		5	3	5	7	7	8	8	6	2	6
	Seatbelt wearing rate, front/rear in %	42/-				80/-	84/19	70/24			54/-		
	National Law mobile phone use during driving?												
27, 28	National drink-driving law?												
	BAC limit g/dl general population	<0.04	<0.08			<0.05	<0.05	<0.03	<0.08	<0.08	<0.05	<0.05	...-0.05
	Random Breath testing?												
	Enforcement level drunk-driving	3			3	1	8	6	8	6	6	4	5
	% death involving drunk driving	20				1	14	9	11		26		34
	Urban speed limit km/hr	60	40	80	90	40	80	60	70	50	80	50	50
	Rural speed limit km/hr	80	80	80	110	80	80	90		70	90	90	80
	Motorway speed limit km/hr	100	No	No	130	No	120	110	90	No	120	120	No
	Speed Enforcement	2	5	7	4	5	8	8	8	4	3	5	6
	No		Alcohol consumption legally prohibited										
	Yes		Sub-national but actual information not available										

with BAC limits (Lao, Philippines) and without BAC limits (Mongolia Afghanistan, Pakistan, Bangladesh). For several countries information of the percentage of death linked to alcohol is included in the Table, showing high values for Malaysia, Thailand and Vietnam (23% and higher).

High speed is the most important risk factor. All countries have national maximum speed laws (in India on a sub-national level). A distinction is made between roads in urban areas, in rural areas and highways. Some countries have national speed limits for roads only in one or two of these areas. In urban areas national speed limits vary from 30 km up to a very high level of 80 or 90 km/hr. In rural areas speed of more than 110 km/hr. are seen. The effectiveness of enforcement of speed laws was rated high (7 or higher) in Rep. of Korea, China, Nepal, Japan, Russia and Singapore and low (3 or below) in Afghanistan, Bangladesh, India, Mongolia and Thailand.

4.1.1 Road safety in Iran

The data in the road safety dashboard concern 24 Asian EST conference. In 2017 Iran joined the Asian EST initiative as the 25th country. The death rate in Iran in 2013 due to road accidents per 100.000 population was 32,1 according to WHO estimates, which is one of the highest in the Asian EST region [1]. Only Thailand has a higher estimated death rate of 36,2 in 2013 as was shown in Table 1. Vulnerable road users (pedestrians, cyclists and motorcyclists) concern 45% of the road fatalities in Iran, which is one of the lowest percentages in the Asian EST region (comparable with the Russian Federation and Bangladesh - see Figure 2). The motorization level (4-wheeled cars) is relatively high for the Asian EST region and is comparable to Thailand (about 200 cars per 1000 people). Iran has a fatality reduction target of 10% annually (2011–2020). It has introduced national speed limits (60 km/h urban, 95 km/h rural and 125 km/h on motorways) and also has laws for helmet and seat belt usage and a drink driving law. The helmet wearing rate for motorcycle drivers is 35% and seat belt wearing for car drivers is 85%. The enforcement level for the various risk factors is relatively high compared to a number of other countries in the Asian EST region: 5 for helmet wearing, 7 for speed limits and belt wearing and 8 for drunk driving. All these data are based on the WHO global Status report 2015 [1].

4.2 Policy frame work

The aim of this section is to recommend a policy framework for strengthening both government and private investments towards implementation of effective road safety strategies, keeping in mind the most sensitive groups in transportation - children, old persons, girl and women, youth, poor, and physically disable. First briefly the Safe System approach will be introduced here as the high-level holistic framework for a road safety strategy in a country. Then we will discuss road safety measures and investments focusing on the most sensitive groups in transportation.

4.2.1 The Safe System approach

The road safety policy framework which is widely accepted nowadays for defining accident and injury prevention strategies and used as the framework to define the actions in the Decade of Action for Road Safety 2011-2020, is the "**Safe System Approach**". The Safe System Approach has replaced largely the earlier policy framework called the Haddon Matrix developed in 1968, which identified 3 phases in a crash: pre-event, event and post-event, as well as 3 components: human (behavior and tolerance), vehicle and infrastructure (environment). This Haddon Matrix approach has led to many successful safety improvements within all elements of the Matrix, but the approach is limited in that neither the concept of exposure nor the importance of interactions between the elements of the Matrix are addressed [6].

In Sweden the Safe System Approach was called "Vision Zero" [107] and adopted by the Swedish parliament in 1997 as the main road safety strategy. The ultimate target of the Vision Zero strategy is to

eliminate all fatalities and severe injuries due to road accidents. The elimination of the severe injuries and fatalities is a very strong ethical statement indicating that in the long run there is little support to balance mobility and safety. Safety should instead be a prerequisite for mobility [6].

The Safe System Approach is illustrated in Figure 8 and similar concepts were developed in other countries like in the Netherlands, where it was called "Sustainable Safety". It would be out of the scope of this paper to present in detail the concept of the Safe System approach here, but a few important characteristics are described below. Background information on the Safe System approach can be found, among others, in: [17][75][107][108].

The cornerstone of the Safe System Approach is that the transport system should be made such that it absorbs human errors and mistakes, instead of trying to adapt the road users to the system and that errors and mistakes should not result in fatalities and serious injuries. So the biomechanical tolerance of a road user is an important element in the system. Modern traffic has developed in a way that exposes us to energies and forces exceeding by far what we were used to before motorized transport became available. Therefore we need to manage speeds and/or protect the road users in a way assuring that the energy levels are on tolerable levels. Figure 7 in section 3.5.1 illustrated the relation between vehicle speed and fatality risk for different type of accidents (pedestrian/cyclists hit by a car, side collisions and front-front collisions or with a rigid object) which gives an indication of maximum speed levels that should be allowed on different types of roads.

Table 12 summarizes max. speed recommendations for paved roads proposed in [76] as part of the Dutch Sustainable Transport approach and adopted later by others [77][17]. For example in built-up areas, where motorized and non-motorized traffic is mixing the maximum speed level should be 30 km/h or below to protect pedestrians and cycling, playing children etc.

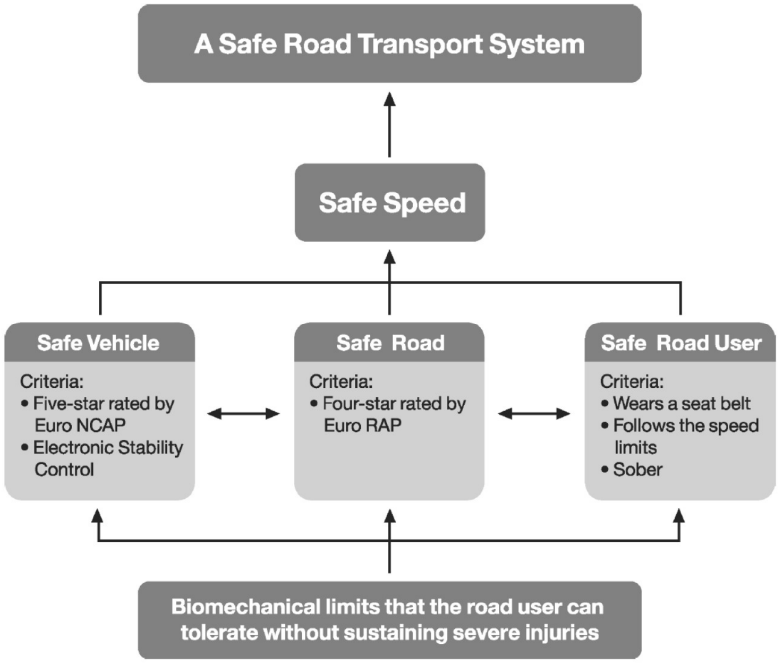

Figure 8 Safe System Approach illustrated with some criteria used in Europe [108]

Table 12 Safe speeds for different situations [76][77][17]

Road and section types combined with road users	Target Safe System speed
Roads and sections used by cars and vulnerable users	30 km/h
Intersections with possible side-on conflicts between cars	50 km/h
Roads with possible frontal conflicts between cars	70 km/h
Roads with no possible frontal or side-on conflicts between vehicles and no vulnerable road users	>100 km/h

The three components in the Safe System approach – human, vehicle and infrastructure - are similar as the components used in the Haddon Matrix. For the **Human** it concerns safe and responsible behavior, which includes for example that road users to the best of their ability comply with traffic rules and regulations. It includes also personal protection systems like helmets. **Vehicles** should be designed to avoid accidents in case of potential conflicts (crash avoidance technologies) and if an accident happens to protect road users in- and outside the vehicle (crashworthiness of the vehicle, protective equipment like seatbelts and airbags, safe pedestrian fronts etc.). **Roads** should be designed to minimize the risk of accidents and injuries for all road users, including for example the use of separate lanes for vulnerable road users and public transport, forgiven road infrastructure like guard rails and road barriers and speed measures.

An important principle of the Safe System approach is that safety is a shared responsibility of several governmental and private actors including road authorities, vehicle manufacturers, insurance companies, police etc. and that managing the complex interactions of the elements in the system requires a holistic approach. Another principle is that all parts of the system must be strengthened in combination with the other parts in the system to reach a better overall safety level and if one part fails, then still the risk of fatalities and serious injuries should be minimal.

Implementation of the Safe System approach in a country requires a number of elements where the most important ones are (see e.g. [77]):

1. A highly ambitious **vision** for road safety with commitment on the highest level of government
2. Strengthening of the **road safety management system** including capacity building and knowledge transfer among the various actors
3. A reliable **accident data collection system**
4. Setting of ambitious **targets** and use of **safety performance indicators** to monitor progress to these targets
5. Adoption of proven **road safety measures for early gains**
6. **Investments** in road safety

Examples of ambitious **visions** are the “Vision Zero” in Sweden and the “Vision Three Zeros - Zero Congestion, Zero Pollution, and Zero Accidents - towards Next Generation Transport Systems in Asia”, adopted at the 2013 Regional EST Forum in Asia in Bali [20].

For background on **road safety management** and the importance of reliable **accident collection systems**, see [6].

Examples of ambitious road safety **targets** and **safety performance indicators** have been introduced in Chapter 2, including SDG target 3.6 “By 2020, halve the number of global deaths and injuries from road traffic accidents” and the UNESCAP Regional Road Safety Goals and Targets and Indicators for Asia and the Pacific 2016-2020 shown in Annex 1.

Good examples of **proven road safety measures for early gains** are measures concerning the five risk factors: speed, drunk–driving, not wearing motorcycle helmets, not wearing seat-belts and not using

child restraints in cars, described in the Plan of the UN Decade of Action for Road Safety (2011-2020).

The next section will focus on road safety measures and related **investments** in Asia for the most sensitive groups in transportation - children, old persons, girl and women, youth, poor, and physically disabled persons.

4.2.2 Investments in road safety in Asia for the most sensitive groups in transportation

In this section investments in road safety will be discussed with the focus on the most sensitive groups in transportation - children, old persons, girl and women, youth, poor, and physically disabled persons and particularly in low and middle income countries. These groups often do not have a driver's license or are not able to own and drive a car. They largely rely for their transport and mobility needs on the use of non-motorized transport (NMT), in particular walking and cycling, and on the use of public transport. The goals and targets summarized in Table 13 is a selection from the UNESCAP "Regional Road Safety Goals, Targets and Indicators for Asia and the Pacific 2016-2020", presented in Annex 1 and directly or indirectly concern these sensitive groups. The Table provides an indication of which type of measures are relevant for them.

A number of the measures (2c, 2d and 5d) relate to the risk factors mentioned earlier and can often be introduced quite fast and relatively easy and investments needed for this have high benefit-cost ratio's as was shown in section 3.5.

Table 13 Selection of goal/targets from the UNESCAP "Regional Road Safety Goals, Targets and Indicators for Asia and the Pacific 2016-2020", directly or indirectly related to sensitive groups in transportation

Goal 2: "Making roads safer for vulnerable road users, including children, elderly people, pedestrians, non-motorized vehicle users, motorcyclists, and persons with disabilities", with the following targets:
2a: Reduce by one third the pedestrian death rate in road crashes
2b: Increase the number of safe crossings for pedestrians
2c: Make the wearing of helmets the norm and ensure minimum helmet quality, in order to reduce the motorcyclist death rate by one third
2d: Ensure minimum child safety measures, in order to reduce the child death rate by one third (focus is on child restraints and child helmets)
2e: Equip all school children with basic road safety knowledge
2f: Ensure safe transportation access to elderly people and people with disabilities
Goal 3: Making roads safer and reducing the severity of road crashes ("self-explaining" and "forgiving roads")
3a: Integrate road safety audit in all stages of road development starting at the design stage, road safety inspection, carry out necessary improvement works, and improve hazardous locations
3b: Increase separate/secure road space for pedestrians and cyclists in urban and suburban areas (where space permits)
Goal 4: Making vehicles safer and encourage responsible vehicle advertising
4b: Ensure safety requirements for new vehicles to be in line with international standards.
Goal 5: Improving national and regional road safety systems, management and enforcement
5c: Aim to provide road safety at the stage of the road network planning
5d: Introduction of laws and regulation to ensure compliance with mandatory helmet, seat-belt use, drinking and driving, use of mobile phone and speed limits

Target 4b relates to safety provisions of new vehicles which should be in line with international standards. Unfortunately this is not the case yet in many low and middle income countries where cars with suboptimal safety provisions are sold. Safety provisions like emergency braking in case of a potential crash with a vulnerable road user and safe vehicle fronts protecting vulnerable road users in case of a crash are nowadays standard technologies on new cars and should be required in all markets. The investments per vehicle are relatively small with high benefit to cost ratios for the society, as was shown in section 3.5 and will be done by the buyers of new cars. Note that according to the Safe System Approach it is important to take biomechanical limits into account in the design of protection methods

and that biomechanical limits of children, elderly and for certain situations also females are different from average male road users which are often used as the standard in safety regulations.

Most of the people killed in accidents in low and middle income countries are road users mixing with motorized transport, walking or cycling along the road and when crossing roads. A number of the goals/targets in Table 13 are related to this (2a, 2b, 3a, 3b, 5c). An analysis by iRAP, based on case studies around the world, showed that more than 90% of serious injuries and fatalities among pedestrians walking along the road, can be prevented by cost-effective infrastructure measures like footpaths, safety barriers and paves shoulders and in case of pedestrians crossing the road almost halve of all fatalities could be avoided [17]. It was also shown in this iRAP study that at intersections cost-effective road engineering solutions are more difficult to achieve. Reduced speed limits which are actively enforced are often the most cost effective solutions. As was mentioned in section 4.2.1 in existing infrastructures, where vulnerable road user's mix with motorized transport, strict speed measures (e.g., below 30 km/h) should be introduced.

Target 5c: "aim to provide road safety at the stage of the road network planning" stresses the importance to take in future road planning road safety into account. Therefore it is recommended that in any cost benefit analysis or road infrastructure project next to mobility and environmental aspects, the costs and benefit of road safety should be included in the analysis. The large costs of road crashes indicate the high potential benefits of investments in road safety measures and in particular for infrastructure for NMT. This holds also for investments in safe public transport which as such can be a much safer form of transport than private means of motorized transport [6]. Safe public transport is addressed in target 2f concerning elderly and people with disabilities, but safe public transport is important for all road users, including other sensitive groups in transportation. Note that it is important that NMT networks are integrated with public transport, in order to optimize usage of both NMT and public transport networks, where walking and cycling are best suited for shorter distances up to 3 km and 15 km respectively and where public transport expands the range of travel distance (see e.g. [78]).

In the next section examples of safety investments will be shown including investments in safe roads, use of motorcycle helmets, public transport and work related accidents. Examples related to ITS applications are given in section 4.4.

4.3 Examples of road safety investment strategies

4.3.1 Benefit of investments in safe roads

iRAP developed a business case for the amount of investments needed in road infrastructure, in order to improve the 10% highest risk roads in the world to a 3 star or higher level (on a scale from 1 – 5, where 5 is highest) [17][79]. The proposed investments in road infrastructure of almost 681 billion US$ worldwide (which is less than 1% of global yearly GDP) would result in a saving of more than 3,6 million fatalities in 20 years. The return on investment (Benefit-Cost ratio) was estimated 8 on a global level and even higher (11) in LMIC's, see Table 14. In other words in LMIC's for every dollar invested in road safety infrastructure there would be a return of investment of 11 dollars in 20 years, due to a reduction in trauma and economic costs. The benefit estimates for fatalities and serious injuries were based on the iRAP "Rule of the Thumb" method presented in section 3.2.3.

Table 14 The business case for investments in safer roads [17][79]

What could be achieved	Low-income countries	Lower-middle income countries	Upper-middle income countries	High-income countries	All
Improve 10% of highest risk roads	108 000 km	610 000 km	992 000 km	1 546 000 km	3 255 000 km
Build viable countermeasures (USD)	8 billion	61 billion	149 billion	464 billion	681 billion
Reduction in fatalities over 20 years	384 000	1 483 000	1 528 000	283 000	3 678 000
Reduction in fatalities and serious injuries over 20 years	4 224 000	16 313 000	16 808 000	3 113 000	40 458 000
Economic benefit over 20 years (USD)	83 billion	663 billion	2 766 billion	2 202 billion	5 715 billion
Benefit cost ratio	11	11	19	5	8

4.3.2 Increasing helmet wearing in Cambodia

Motorcycle use is a major mode of transport in Cambodia and represents 80% of total motorized vehicle fleet in 2012 [80]. The fatality and injury consequences are serious and motorcycles account for 71% of fatalities on the road (see Figure 2). In 2015 legislation was introduced in Cambodia for mandatory passenger helmet use on motorcycles. The Asia Injury Prevention (AIP) Foundation has initiated a two-year program "Head Safe Helmet On" (HSHO) aiming to increase motorcycle passenger helmet use in six target districts in Cambodia from an average of 10% in 2014 (baseline) to 60% in 2016 [80]. The program includes among others a primary school based program with free helmets, a behavior change campaign in mass media and improved enforcement of the passenger helmet law. The costs of this program are 1.1 million US$.

An increased helmet use will reduce the expected number of casualties. Figure 9 depicts the calculated avoided accident costs over the period of the program as a function of the helmet use of motorcycle passengers [80]. The "total cost avoided" includes all elements discussed in section 3.2: medical, administrative, property damage, production loss and human costs. In the "economic cost avoided", human costs is excluded. For the intervention to have higher benefits than costs (breakeven point) the helmet use must increase above 37% in case the human costs are included and 48% if the human costs are excluded. With a target result of 60% helmet use the measure has significant higher benefits than costs.

4.3.3 Public transport

Examples in literature of well documented cost benefit studies of investments in public transport where safety investments and benefits are included in the analyses (next to environmental impact, improved mobility, social etc.) are difficult to find. However a few studies have been carried out where road safety audits were conducted to improve the safety of new mass transit projects in the design phase of the project [81]. For example studies carried out by EMBARQ in Brasil suggest that audit costs as such are less than 1% of the cost of a project and have a benefit-cost ratio of 10 [81]. EMBARQ also conducted road safety audits of several existing bus rapid transit corridors in Brazil including the BRT Transcarioca in Rio de Janeiro, where a high number of 50 injury crashes per kilometer annually were reported. The costs of these crashes were estimated about USD 12.5 million per year. The audit projected a reduction in crashes of 30% per year representing USD 3.75 million saved [81].

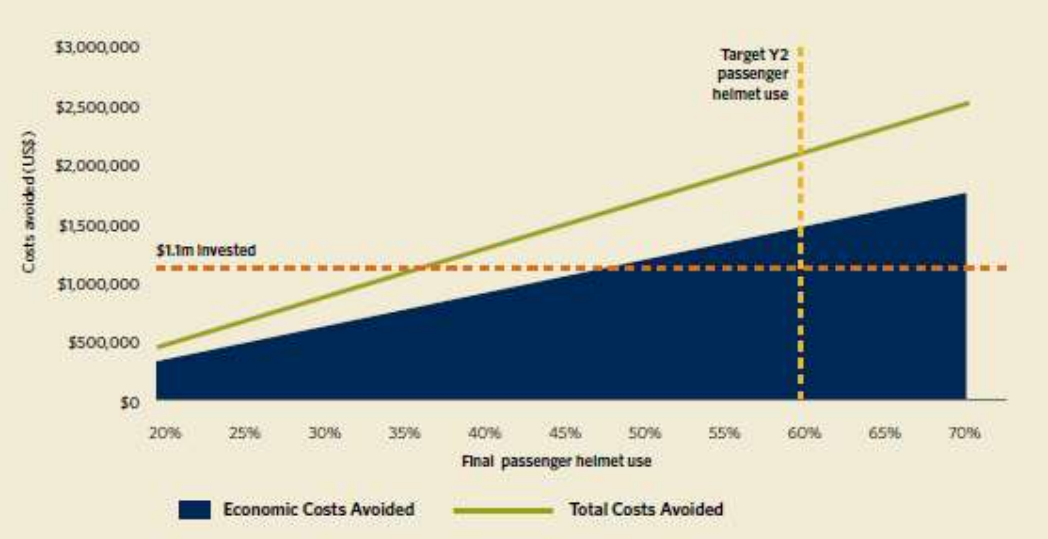

Figure 9 Investments costs of the HSHO motorcycle passenger helmet program versus avoided costs due to reduced fatalities and serious injuries as a function of actual helmet usage

Since safe public transport is much safer per km travelled then other forms of private motorized and non-motorized transport, the effect of mode shifts from less safe to safer forms of transport should be taken into account in the analyses, which most likely would show additional safety benefits of investments in high quality public transport. Therefore it is highly recommended to take a systems approach (city level or higher) and to consider these and other dynamic effects to secure an overall positive outcome of a shift towards public transport [6]. Information on methodologies to quantify the environment, social and economic benefit of bus rapid transit systems is available from a report of a workshop organized in 2014 in Kuala Lumpur where among other the importance of a system level approach is stressed in a presentation given by Binoy Mascarenhas of EMBARQ India **Fout! Verwijzingsbron niet gevonden.**.

4.3.4 Work-related road accidents

Work-related road accidents represent a significant part of all road accidents: dependent on the region up to one third of all road casualties and even 50% if commuting to work is included [82]. This includes professional transport, driving during work hours (for example, truck, bus and van drivers as well as sales people), and workers on the road (for instance road maintenance crews). That's why many companies nowadays are promoting policies and practices to improve the safety of their workers when driving for work. The importance of this is also expressed in SDG 12 "ensure sustainable consumption and production patterns" by the targets 12.6 and 12.7:

- Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle
- Promote public procurement practices that are sustainable, in accordance with national policies and priorities

An example of a European project in the field or work related road accidents is the PRAISE project (Preventing Road Accidents and Injuries for the Safety of Employees) that aims to promote best practice in order to help employers secure high road safety standards for their employees [84]. In 2014 the report "The business case for managing road risk at work" was published [85]. This report describes the Work-Related Road Risk Management (WRRRM) program and shows that the benefit for companies who implement this program can be larger than the costs of implementation. Other benefits like increasing efficiency of the management, competitive advantage and fulfilling legal compliance obligations are

also addressed. The report covers a list of possible costs and the importance of introducing measures to reduce them. A number of examples from several companies are included which could also apply to Asian countries. In the report the International Standard Organization (ISO) standard 39001 for road traffic safety management (see also [6]) is promoted as a framework for reviewing and developing a continuous improvement process for road safety in an organization (see Figure 10).

Figure 10 Benefits associated with the implementation of the ISO 39001 road safety management system [85]

4.4 Intelligent transport system (ITS)

With increasing number of populations and motorization, Asian countries are facing higher demands than ever to increase their abilities to provide more effective, safer, and greener transport for their citizens. The Ministerial Conference on Transport in Dec. 2016 in Moscow recognized that Intelligent Transport Systems (ITS) could play an important role in improving future road safety and in increasing the share of public transport [28].

In this section, the challenges and some of the benefits of early ITS applied in some Asian countries will be reviewed in light of the regional road safety goals and targets for 2016-2020 (see Annex 1). Furthermore, new ITS applications that potentially could really help Asian countries to provide safer and more sustainable transport from socio-economic and environmental point-of-view will be suggested.

4.4.1 Description of ITS

There are various definitions of ITS, such as "Applications of advanced and emerging technologies (computers, sensors, controls, communications and electronic devices) in transportation systems to save lives, time, money, energy and the environment; and the integration of information and communication technology with transportation infrastructure, vehicles and users" [86]. Other definitions along the same lines also include traffic and mobility management applications [87].

The technologies used by ITS often involve sensors, cameras, computers, electronics, and communication technologies. Examples of ITS include navigation positional aids for vehicles, coordinated traffic control systems, cooperative warning systems, traveller information systems, electronic toll systems, advanced public transportation systems, and parking guidance systems. Other examples are systems that give automatic notifications of crashes.

4.4.2 Examples of ITS applications in Asia

Various forms of ITS have been used in parts of Asia since the 1990's, often with safety as one of the driving forces. Already in 1991 Japan started an Advanced Safety Vehicle (ASV) project using sensors and telecommunication to collect information which formed the basis for warnings to help the driver drive safely. Three additional phases followed, and in ASV 4 (2006-2010) automated technologies were tested on public roads to allow a market introduction in 2010 [88]. South Korea proposed its first National ITS Master Plan in 1997 with a revised version in the year 2000 for a period of 20 years. The prime goal is to enhance safety and reach the country's target of zero deaths by 2030 [89]. Other objectives are to increase transportation efficiency, improve driving comfort and reduce environmental pollution [90].

The fact that most Asian countries have to deal with big population size and often poor infrastructure and economic conditions has led to stronger needs for applications that can reduce congestion and increase efficiency of road network. For example, Singapore has been using Electronic Road Pricing Systems (ERP) since 1998 that automatically charge all vehicles passing a gantry (an ERP entry point). Although not directly affecting road safety, this system has managed to keep traffic flows and the revenues generated from this system have been re-invested to improve transportation infrastructure. Furthermore, the system also generates a lot of accurate and reliable data on traffic throughout the city. Integrated with other data, such as from expressway monitoring and advisory systems, traffic cameras images, and car park lots availability information, these are used to give real-time traffic information to drivers via roadside displays, web sites, and mobile devices for trip planning. Jakarta is in a preparation stage for implementing this at small scale soon [91].

Although road charging is widely implemented in Asia, it is mainly in the form of toll charge rather than pure congestion charge. Toll charge is often related to expressway (controlled-access road) and is used to pay for the road construction and/or maintenance cost (in particular if the road is run by a private company), while congestion charge could be applied to all types of roads. ITS applications to collect the toll charges automatically, without drivers having to stop, have been used for many expressways in China [92], India [93], Japan [94], Singapore (using ERP), Malaysia [109] and Korea. However, for most Asian cities, toll charges are still collected manually by paying cash or tapping a pre-paid card manually at the toll gate. Automatic collection of toll charges and/or congestion charges, without drivers having to stop and pay manually with cash or card, could indirectly increase road safety, as they eliminate the need for rapid deceleration and rapid acceleration (particularly near the toll gates). Traffic accident rates per vehicle-km were found to be influenced by mean speeds and the changes in mean speeds [101].

Intelligent traffic light control and coordination systems can be found in several countries. They are typically computerized systems that dynamically adjust the duration of the green light based on traffic demand and coordinates neighbouring traffic light signals (i.e., the start of green signal) to allow drivers going from one junction to another without stopping. Implementations can be found in e.g. China [92], Malaysia [86] and Singapore [95] .

ITS applications more directly addressing road safety are e.g. the Green Man + used in Singapore, which can extend the length of green man time for elderly pedestrians and pedestrians [96]. The application helps to address one of the regional road safety goals (i.e., making roads safer for elderly people and persons with disabilities).

Cooperative-ITS (C-ITS) applications are being increasingly used also in Asia. Examples include ITS-Spot in Japan, a vehicle-infrastructure cooperative system that can be used to provide optimal route options by analysing the real-time traffic situation, safe driving support, and electronic toll collection services [97]. By giving information about congestion ahead of Sangubasi curve, one of the most

dangerous accident spots on the metropolitan expressway system in Japan, the number of accidents could be reduced by 60% [98].

Insurance telematics, or usage-based insurance, is a rather new application that enables insurance companies to base the premium cost on the customer's usage of the vehicles in terms of time, distance, as well as driver behaviour (e.g., how driver speeds, brakes, etc.). Such insurance schemes attempt to reward safer drivers with lower insurance cost, and it could help reduce reckless behaviour. It has been trial in parts of Asia e.g., in Bangkok [99] and Singapore [100].

4.4.3 Cost benefit of ITS systems

Several of the benefit-cost ratios introduced in Table 10 of Chapter 3 relate to ITS applications (e-Call, feedback signs for speeds, intelligent speed adaption etc.) and all show that the benefits exceed the costs. But these benefit-cost ratios are determined for European conditions and may not apply to Asia. A literature study in China [92] analyzed several (mostly European) reports on cost/benefit for Vehicle-to-Vehicle (V2V), Vehicle-to-Infrastructure (V2I) and C-ITS. The C-ITS systems with highest safety benefit were found to be those that warn drivers of excessive speed and services that provide warnings on the road ahead. The authors however also note that other, non-C-ITS, measures may be more effective, such as education and enforcement.

4.4.4 E-Call

An example of ITS application already in use in Europe and US but not yet in Asia that could benefit Asia is eCall (as it is called in Europe, also known as Automatic Crash Notification or Automatic Crash Response or Automatic Collision Notification in the US). This is a system that automatically calls local emergency number (e.g., 112) and sends GPS coordinates in the event of a crash. Such a system allows emergency assistance to come faster which hopefully increases chance to save life and reduces severity of injuries. These systems can help addressing regional road safety goal related to increasing responsiveness to post-crash emergencies (see Goal 5h in Annex 1). For this system to work, the vehicles need to have GPS fitted and ability to call and send data out, and ideally there should only be one emergency access telephone number per country/region.

4.4.5 Impact on Automated Transportation and Automated Vehicles.

In recent years Connected and Automated Transportation (CAT) and Automated Vehicles (AV) have gained significant attention in some parts of the world. Single systems assisting the driver in a specific situation (e.g. adaptive cruise controls) are commercially available, while fully automated vehicles, where traditional steering wheels or driver controls may be obsolete, are still in early phases requiring more research to reach maturity.

It is widely expected that CAT has a potential to largely contribute to increase the safety and efficiency of the transport system. Removing the human element from vehicle operation may have large benefits in lowering crash rates and severity.

There are furthermore high expectations on this being a highly innovative area, where new innovations would transform personal mobility, to open doors to people and communities which can't or prefer not to own individual cars, but also allowing new ways of utilizing space in cities or delivering public transport [101].

Challenges with a higher penetration of automated vehicles, as well as barriers to implementation need to be addressed. Additional issues include establishment of regulatory frameworks, issues of interoperability of connected systems, data management, data sharing, privacy, and cybersecurity. It is widely considered important to develop sustainable and profitable business models and business cases,

and any technology or system needs to be accepted by users and society. A net positive road safety effect is a pre-condition for the wider deployment.

4.4.6 Concluding remarks

Congestion is still among the main issues in many Asian cities. Based on the experience discussed previously, it seems likely that some forms of congestion charge at non-expressways and electronic toll system could benefit many Asian cities.

More and more person use mobile phones and can afford buying vehicles with built-in communication sensors and GPS. These developments give opportunities to use data collected from vehicles, road users, and infrastructure to create useful information for different applications of ITS, that make use of communication inside vehicles, V2V and V2I. Individual vehicles can be used as rolling data collectors and can share information about road conditions and traffic condition on the roads they are travelling. This can be used for road monitoring and maintenance (e.g., determining which roads to repair), and real time traffic flow modelling which can then be shared back to drivers to help routing. V2P ("vehicle to pedestrian") is an additional component in ITS. It takes advantage of vulnerable road users with mobile phones in a network with adequate coverage. Information provided by these different systems can be used for safety enhancing applications for vehicle occupants and vulnerable road users.

While ITS applications have high potential to improve road safety and could help provide safer and more sustainable transport, it is important to note that the use of ITS applications on its own is not a solution for the road safety problem. ITS implementation has to be accompanied by better road infrastructure, better driver license education, safer vehicles with increasing safety requirements, stricter enforcement on helmet use, seat-belt use, speed limits, etc.

Despite the numerous activities and discussions around CAT and AV the practical impact will not be noticeable until sufficient portions of the vehicle fleet and the infrastructure are equipped with the associated technologies and intelligent transport systems respectively. Even if the price of automation technologies decrease over time, the cost level may still be a barrier for a significant penetration for quite some time. In a thought exercise, using India as an example of low and middle-income countries, Mohan suggested that autonomous vehicles may not have big impacts directly in India, in terms of replacing private vehicles use in the near future [103]. While this indicates a limited impact on road safety for private vehicles, it may be more probable that different degrees of automation will be pursued more for public transport (e.g., shared taxi, shuttle/transit service in closed/designated environment) in Asia.

5 Summary of the key findings and recommendations

In this Chapter first the main findings from this study will be summarized followed by a number of recommendations. The Chapter concludes with a brief discussion on various road safety financing possibilities.

5.1 Summary of the key findings

The **total number of death** due to road accidents in the Asian EST region in 2013 was estimated to be almost 700.000, which is 55% of the global number of death. The majority of these death were found in China (38%) and India (30%). Compared to the year 2010 the number of death decreased in 2013 by 5,5%. The death rate per 100.000 population is the lowest (6,7) in the high-income countries in Asia and the highest (19,7) in South-East Asia, so almost 3 times higher. The death rate in South-East Asia is 13% above the world average rate and 26% less than the death rate in Africa. Vulnerable road users (VRU: pedestrians, cyclists and motor cyclists combined) are particular at risk in the Asian EST countries. Globally the number of VRU is about 50%, but in most Asian EST countries this is more than 60% and in five countries (Lao, Sri Lanka, Singapore, Thailand and Cambodia) it is even more than 80%, which is largely due to the high number of fatalities among motorized 2 and 3- wheelers in these countries.

The **United Nations (UN)** has been actively involved in addressing global road safety since its start after World War II. An overview of UN activities has been given in Chapter 2, including development of global traffic and vehicle regulations (UNECE), strengthen global activities in road traffic injury prevention (WHO and UNRSC), setting up an Asian Pacific road safety strategy (UNESCAP) and promoting sustainable regional development in Asia (UNCRD). Important UN milestones in the field of road safety are the establishment in 2011 of the UN Decade of Action for Road Safety (2011-2020) with a goal to stabilize and reduce the predicted levels of road traffic fatalities around the world and the adoption in 2015 of 17 **Sustainable Development Goals (SDGs)** with the important road safety related targets SDG 3.6: "*By 2020, halve the number of global deaths and injuries from road traffic accidents*" and SDG 11.2: "*by 2030, provide access to safe, affordable, accessible, and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women and children, persons with disabilities and older persons*". The importance of these SDG's was stressed by the 2nd Global high-level conference on road safety in Brasilia, resulting in the Brasilia Declaration and the UN Conference on Sustainable Urban Development and Housing - Habitat III. The Brasilia Declaration includes a proposed update of the actions in the Plan for the Decade of Actions for Road Safety concerning, among others, new risk factors like drugs and distraction by cell phones, ITS implementation, safety of VRU's and new funding opportunities for road safety. The New Urban Agenda adopted at Habitat III included several actions dealing with road safety, as an integrated component of a sustainable urban transport system, with the focus on NMT and vulnerable road users through measures like safe public spaces, sidewalks, cycling lanes, safe public transport etc.

The implementation of **quantified road safety targets and the use of performance indicators** to measure the progress against these targets are crucial in any effective road safety program. Chapter 2 provides an overview of various global and regional initiatives in this area. For Asia in particular the work done under coordination of UNESCAP is important for the Asian EST countries. This work which started in 2006 has resulted in 8 goals, 30 road safety targets and 40 performance indicators, adopted at the Third Session of the Ministerial Conference on Transport organized by UNESCAP in Moscow, 5-9 December 2016 [28].

In Chapter 3 the principles behind the valuation of the **economic impact of traffic accidents** and estimates for the **cost of road accidents in Asia** are presented. These costs consist of **direct costs** like medical and property damage costs and **indirect,** less tangible, **costs** due to loss of production and income of someone injured or killed in an accident as well as immaterial costs like suffering, pain, and loss of quality of life, further referred here to as Human costs. Three methods have been introduced to determine the costs of road accidents: the Human Capital (HC), Willingness-To-Pay (WTP) and iRap method. The WTP method has been specifically developed to deal in a more reliable way with the less tangible value a person puts on the reduction of fatality and injury risk and is the recommended method by economists nowadays to deal with such "human" costs and the related Value of Statistical Life (VSL). The chapter has highlighted the difficulties to estimate the VSL.

The iRAP method is a simpler "rule of the thumb" estimate taking the GDP in a country as the basis. Based on the iRAP method in an earlier study [6], the costs of road accidents in the Asian EST have been calculated for the year 2010 and expressed as total costs for a country and as a percentage of GDP. It is shown that road safety has a major impact on economies of Asian countries. The total resulting cost estimate for road accidents in the Asian EST countries in 2010 is 735 Billion US$ of which almost half in China. The average % GDP loss in the Asian EST region is 3.3% with the highest value (>4%) for the South Asia region. These GDP loss percentages were found to be higher than data in the WHO 2015 Global Status report [1], due to among others the use of the rule of thumb iRAP approach which may lead to higher estimates for the human costs, as well as the use of more accurate injury estimates than in other studies. These injury estimates are based on the IHME/World Bank data that became available in 2014 [3]. Note that on the other hand our estimates are also conservative since they exclude major cost components like the property damage costs, the costs of minor injuries, medical costs and administrative costs.

Chapter 3 concludes with an introduction in **cost-benefit and effectiveness analyses** and includes examples of a number of measures with a special emphasis on speeds and helmets in order to demonstrate that such analyses are a useful tool in choosing between different road safety measures and prioritization of governmental budgets. Significant efforts in policy development are needed to achieve the SDG's related to traffic safety. Due to the size of the effort it is vital that this policy is implemented in an efficient way, i.e. to meet the goals at lowest possible cost. There is a huge benefit for the single individual as well as society at large if the number of road traffic fatalities and injuries can be reduced.

In Chapter 4 it is shown that the SDG 3.6 target to halve by 2020 the number of global deaths and injuries from road traffic accidents implicates for the Asian EST countries a **saving of more than 340.000 lives annually**, a **reduction of 3 million hospital admissions** and a reduction of the number of fatalities per 100.000 population from 15,6 to 7,8 which is below the current level for high-income countries. When the SDG target 3.6 would be reached the **burden on the economy would be reduced with more than 350 billion US$ per year**, or equivalent to a growth in GDP of more than 1,5%. Such targets are extremely ambitious, but on the other hand examples from other parts of the world have shown that significant improvements are possible and therefore in Chapter 4 the importance of investments in road safety in Asia is discussed.

For this purpose first an overview of the status of a number of road safety measures in Asia is presented by a **dashboard of road safety measures** shown in Table 11. This dashboard is based on the road safety performance indicators developed by UNESCAP. Focus was on the indicators for which information was gathered in a consistent manner and this appeared to be the case in the WHO 2015 Global status report for 16 of the UNECAP indicators. Next a **policy frame work** was presented based on the Safe System Approach and the most relevant **road safety investments** were discussed with the focus on the most sensitive groups in transportation - children, old persons, girl and women, youth, poor, and

physically disabled persons in low and middle income countries. These groups largely rely for their transport and mobility needs on the use of non-motorized transport (NMT), in particular walking and cycling, and on the use of public transport. A number of the measures included in the earlier mentioned UNESCAP "Regional Road Safety Goals, Targets and Indicators for Asia and the Pacific 2016-2020", directly or indirectly concern these sensitive groups and provide an indication of which type of measures are relevant for these sensitive groups (see Table 13) and are briefly reviewed in Chapter 4. In this Chapter also examples of four road safety investments are discussed, namely investments in: safe roads, helmet wearing in Cambodia, public transport and work-related road accidents. It is important to stress here that the costs of many road safety investments lead to much larger savings in the future.

Chapter 4 concludes with a section on **investments in ITS**. Several examples of ITS implementations in Asia are presented and an indication of the cost-benefit of investments in ITS is given, unfortunately mainly based on European data, since limited data from Asia were available. Also potential new applications like **e-Call** and **connected automated transportation (CAT) and automated vehicles (AV)** have been introduced. The practical impact of CAT and AV will not be noticeable for quite some time even if the price of automation technologies will decrease and it can be questioned whether in high density urban areas in Asia with a strong mix with NMT, introduction of AV's replacing private cars ever will become practical, except for specific kinds of public transport as discussed by Mohan [103].

5.2 Recommendations

1. For the valuation of the economic impact of traffic accidents and consequently the effect of measures, **reliable estimates for the costs** of road accidents are needed. It is recommended to take into account all cost components in a country so both the direct costs (medical, property damage and administrative costs) and indirect costs (production loss and human costs). For the human costs the use of the WTP approach is the recommended method resulting in the Value of Statistical Life (VSL). If VSL data are not available in a country or cannot be determined it is recommended, as a first indication, to use the iRAP "rule of the thumb method" which estimated the benefit for each fatality and serious injury that can be saved due to a measure, based on a fixed multiplication factor on the country's GDP/capita. If in a country VSL estimates from existing studies in environmental, health and transport policy are available it is recommended to consider the use of a procedure developed by OECD to transfer the data for road safety analyses (see [40]).
2. Our estimates for the **% of GDP** loss due to road accidents results for most EST countries in higher estimates than the data available in the WHO 2015 global status report. The difference would even become larger if also the direct cost components (medical, property damage and administrative) would have been taken into account in our estimates. It is recommended that a **further analysis of these differences** is carried out, which may lead to recommendations for a global harmonisation of the methodology to be used for the valuation of the economic impact of traffic accidents.
3. For reliable impact assessment of measures and priority setting, **accurate reliable accident data** concerning the number of casualties and the causes of the accidents in a country are needed. It is recommended that if such data are not available yet that high priority is given to introducing them. Such accident data systems are also needed for monitoring the progress of the effect of measures.
4. In this paper a number of examples have been given of measures with a high benefit to cost ratio (see e.g. Table 10 and Table 14). Measures with high benefit to cost ratio's, include the 5 risk factors identified in the Plan for the Decade of Action (safe speed, drunk–driving, not wearing motorcycle helmets, not wearing seat-belts and not using child restraints in cars). Measures concerning these risk factors can often be introduced quite fast and relatively easy and do not require extensive cost-benefit analyses. It is recommended to **implement laws concerning such risk factors** in each country (if not done yet) and **introduce and maintain a strict enforcement policy** concerning such

measures. Also other measures in the field of infrastructure, safe vehicles and post-crash care show high cost to benefit ratios and therefore should be considered

5. Most of the people killed in accidents in low and middle income countries are pedestrians and cyclists mixing with motorized transport, while walking or cycling along the road and when crossing roads. An iRAP study presented in 4.3.1 showed that more than 90% of serious injuries and fatalities among pedestrians walking along the road, can be prevented by **highly cost-effective infrastructure measures**. So investments in this area are strongly recommended. If such measures cannot simply be implemented in existing infrastructures, where vulnerable road users mix with motorized transport, strict **speed measures** with speeds below 30 km/h should be introduced.
6. It is recommended that in the stage of **road network and public transport planning** road safety is taken into account from the beginning and therefore in any cost benefit analysis next to mobility and environmental aspects, the costs and benefit of road safety should be included in the analysis.
7. Since **safe public transport** is much safer per km travelled then other forms of private motorized and non-motorized transport, it is recommended that the effect of mode shifts from less safe to safer forms of transport are taken into account in cost benefit analyses of new public transport systems.
8. In this study a **dashboard of road safety performance indicators** has been developed based on the indicators developed by UNESCAP. For 16 out of the 40 proposed performance indicators by UNESCAP, data are available in the WHO 2015 global status report and these data have been included in the dashboard shown in Table 11. It is recommended that also for the other indicators data are gathered in a systematically in the Asian EST countries and that this dashboard is adopted to monitor the progress of road safety of the Asian EST countries in future EST forums.
9. The WHO has started on request of the UN in 2016 in collaboration with other parties a process to develop a set of detailed global performance targets and indicators for road safety (see 2.3). This process is expected to be finalized in May 2018 by a report submitted to a meeting of the Wold Health Assembly. It is recommended in **future updates of the UNESCAP targets and indicators,** to take the outcome of the WHO efforts in this field into account.
10. It is recommended to **perform detailed analyses of accidents in Asia**. Such an analysis may reveal that also other road safety measures are needed than what so far have been addressed in the Plan for the Decade of Action and the UNESCAP targets and indicators. An example is most likely the **safety of trucks** in accidents with other road users (like compatibility issues and limited truck driver vision due to blind spots), which was shown in Europe to represent a significant problem [104].
11. The majority of the **cost-benefit data** presented in this paper are based on studies in high-income countries and in particular based on data in Europe. It is recommended to take care with the use of such data in other regions and in particular **in low- and middle income countries,** since corrections may be needed to use them in quite different environments or new cost benefit studies may have to be carried out in the country.
12. **ITS applications** have high potential to improve road safety, but reliable cost benefit studies are limited up to know, in particular also in Asia. It is highly recommended to perform such studies, as well as considering a higher degree of these new technologies when planning physical and digital infrastructures. Note that ITS applications on its own are not a solution for the road safety problem. ITS implementation has to be accompanied by better road infrastructure, better drivers, better enforcement of traffic laws, safer vehicles fulfilling adequate safety standards etc.

5.3 Funding opportunities

Significant investments are needed to achieve the SDG's related to traffic safety. But the benefits are large: when the SDG target 3.6 would be reached the burden on the economy in the Asian EST region would be reduced with more than 350 billion US$ per year, or equivalent to a growth in GDP of more than 1,5%. Due to the size of the effort it is vital that the necessary investments are done in a prioritized

way and well balanced with other goals in the agenda for sustainable development. Governmental and private investors have an important responsibility in providing the investments but with the current levels of investments the SDG targets will never be met in particular in LMIC's without additional funding possibilities.

There are a few existing international funding possibilities like the World Bank Global Road Safety Facility (GRSF), FIA foundation and the Bloomberg Philanthropies Initiative for Global Road Safety. An overview of various possibilities and their goals is shown in Table 15, based on information in a recent UNECE document [105].

Table 15 Existing road safety funding possibilities [105]

Name	Goal
The World Bank Global Road Safety Facility (GRSF)	Increase funding and technical assistance for global, regional and country level initiatives designed to enable low- and middle-income countries to implement their own road safety programmes.
The FIA Foundation	Ensure safe, clean, fair and green mobility of all via road safety philanthropy, practical environmental research, interventions to improve air quality and tackle climate change, and strategic advocacy in road traffic injury prevention and motor vehicle fuel efficiency.
The Road Safety Fund of the FIA Foundation and WHO	Facilitates alliances between private sector donors and NGOs to support road injury prevention programmes in countries and communities
The Road Safety Grants Programme	Support country- and city-level NGO projects to develop and deliver high-impact, evidence-based interventions designed to strengthen road safety policies and their implementation.
Bloomberg Philanthropies Initiative for Global Road Safety	Strengthen national road safety legislation, and implement proven road safety interventions at the city level.

In LMIC's worldwide, the coming decade an additional $260 billion of programme financing will be required to achieve the SDG's 3.6 and 11.2 [106]. Based on the April 2016 General Assembly resolution 70/260 on improving global road safety, which requests the Secretary-General to consider the possibility of establishing a Road Safety Trust Fund, UNECE has been asked to take the lead to develop a proposal for such a Fund, in close cooperation with other UN organisations working on road safety, including the WHO [106]. The proposed Fund will be much larger than existing road safety Funds and will be required to work in partnerships with the multilateral development banks to finance additional country investments needed [106].

6 Way Forward

Road accidents leading to fatalities and injuries have a large social and economic impact on individuals and the society. In many low and middle income countries in Asia the % GDP loss due to road accidents exceeds 4%. In some Asian countries in the period 2010-2013 a decrease in road fatalities could be seen but in others an increase. A strong reduction in fatalities and serious injuries as asked for by SDG 3.6 will be a main challenge for all Asian countries and in particular in LMIC's due to the rapid motorisation that is taken place in these countries and due to the extreme large involvement of vulnerable road users (pedestrians, cyclists and motor cyclist combined) among the traffic victims. To reduce the road safety problems many measures are needed in all the 5 pillars in the Plan for the Decade of Action and an integrated approach is required involving all key stakeholders based on a strong vision supported up to the highest levels in a country.

The leading framework to guide the policy development is the Safe System Approach which for VRU's will lead to a strong emphasis on measures that improve the infrastructure (like separate lanes for non-motorized transport (NMT, i.e. pedestrians and cyclists) and measure that lead to improved public transport, where it is important that NMT networks are integrated with public transport, in order to optimize usage of both NMT and public transport networks. Therefore it is very important to take a systems approach (city level or higher) in road network and public transport planning and in any cost benefit analysis, road safety should be included in the analysis, in addition to other needs like mobility benefits and environmental impact. For the valuation of the economic impact of traffic accidents and consequently the effect of measures it is important to use reliable estimates for the costs of road accidents as was elaborated upon in recommendation 1 in section 5.2.

For motorcycle safety important measures include: adequate helmets which need to be always fastened, promotion of protective clothing, requirements for advanced braking systems on motorcycles and measures that improve the visibility of motorcycles like day-time running lights and may be also in some countries, where there is a very large participation of motorcycles, separate lanes for motorcycles. Like for motorcyclists also for bicyclist, bicycle helmets should be considered in particular if higher speed e-bikes become more popular in a country, as is the case already in China and many HIC's.

The paper has given many example of measures with high benefit to cost-ratio's and many of these measures are included in the "Renewed regional road safety goals, targets and indicators for Asia and the Pacific" [28] adopted by the Third Session of the Ministerial Conference on Transport in Moscow in Dec. 2016. It is strongly recommended that these goals, targets and indicators are adopted by Asian countries and that a formal process is implemented to monitor on a regular bases the progress on the performance indicators, where the dashboard of road safety that was introduced in this paper could be seen as a first step. The dashboard also gives a good first indication of which countries are lacking in the introduction of important road safety measures or fail to promote and enforce. Furthermore the dashboard can be used to measure the progress on achieving Goal 13 of the Bangkok 2020 Declaration dealing with the adoption of a zero-fatality policy and the Bali Vision concerning "Zero Accidents".

The required investments levels to meet the SDG targets will in many LMIC's in Asia exceed the national governmental and private funding possibilities and the future funding opportunities that may be offered by the intended UN Road Safety Trust Fund, discussed in 5.3 are urgently needed in LMIC to achieve these SDG targets.

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Annex 1 Renewed regional road safety goals, targets and indicators for Asia and the Pacific [28]

Goals and targets		*Indicators for monitoring achievements*	
Overall objective: 50 per cent reduction in fatalities and serious injuries on the roads of Asia and the Pacific over the period 2011 to 2020.			
(a)	Reduce the fatality rates by 50 per cent from 2011 to 2020.	(1)	Number of road fatalities (and fatality rates per 100,000 inhabitants).[a]
(b)	Reduce the rates of serious road injuries by 50 per cent from 2011 to 2020.	(2)	Number of serious road injuries (and injury rate per 100,000 inhabitants).
Goal 1: Making road safety a policy priority			
(a)	Create a road safety policy/strategy, designate a lead agency and implement a plan of action.	(3)	Information on existing national road safety policy, strategy, plan of action, and their implementation.[a]
		(4)	Name of designated lead agency on road safety.[a] Description of responsibilities of local, regional and national government organizations, including related coordination mechanism at the national level.
		(5)	National road safety reports or impact evaluation reports of government programmes.
(b)	Allocate sufficient financial and human resources to improving road safety.	(6)	Information on the amount of funding and number of qualified human resources allocated to road safety projects and programmes (public, private and donors) and research and development to create a safer road environment.
Goal 2: Making roads safer for vulnerable road users, including children, elderly people, pedestrians, non-motorized vehicle users, motorcyclists and persons with disabilities			
(a)	Reduce by one third the pedestrian death rate in road crashes.	(7)	Numbers of pedestrian deaths.[a]
(b)	Increase the number of safe crossings for pedestrians (e.g. with subway, overhead crossings or traffic signals).	(8)	Number of new safe crossings or improvements constructed or planned.

Goals and targets	*Indicators for monitoring achievements*
(c) Make the wearing of helmets the norm and ensure minimum helmet quality, in order to reduce the motorcyclist death rate by one third (or reduce it to below the average motorcyclist death rate of the ESCAP region).	(9) Number of motorcyclist deaths and motorcyclist deaths per 100,000 inhabitants.[a] (10) Existing laws or administrative rules for the mandatory use of helmets and specifying minimum helmet quality standards. Information on helmet use (percentage).[a]
(d) Ensure minimum child safety measures, in order to reduce the child death rate by one third.	(11) Number of child fatalities in road crashes. (12) Existing laws or administrative rules on measures for child safety in cars (child restraints) and on motorcycles (child helmets).[a] (13) Use of child seat restraints and child helmets (percentage).[a]
(e) Equip all school children with basic road safety knowledge.	(14) Existing or planned education programmes on road safety in school, starting class and its coverage.
(f) Ensure safe transportation access to elderly people and persons with disabilities.	(15) Information on safe transportation access to elderly people and persons with disabilities.
Goal 3: Making roads safer and reducing the severity of road crashes ("self-explaining" and "forgiving roads")	
(a) Integrate a road safety audit into all stages of road development starting at the design stage, conduct road safety inspection, carry out necessary improvement works, and improve hazardous locations.	(16) Number of, and information about, road safety audits carried out for road design, new road construction and major improvements.[a] (17) Number of improvement programmes carried out to make roads "forgiving" (e.g. addressing black spots, removing or cushioning roadside obstacles).
(b) Increase separate/secure road space for pedestrians and cyclists in urban and suburban areas (where space permits).	(18) Existing length of pedestrian and bicycle tracks in kilometres per 100,000 people or per 10,000 kilometres of roads (along highways and city roads). Programme to construct pedestrian and bicycle track.
Goal 4: Making vehicles safer and encouraging responsible vehicle advertising	
(a) Make regular inspection of road vehicles mandatory and ensure enforcement of inspection (starting in urban areas).	(19) Existing laws or administrative rules on vehicle inspection, frequency of inspection (annual), number of vehicle inspection facilities and organizations.
(b) Ensure safety requirements for new vehicles are in line with international standards.	(20) Existing laws and regulations specifying vehicle safety standards and implementation.

Goals and targets	*Indicators for monitoring achievements*
Goal 5: Improving national and regional road safety systems, management and enforcement	
(a) Accession/ratification and implementation of the United Nations instruments on road safety.	(21) Information on accession/ratification of United Nations instruments on road safety.[a]
(b) Implement a national (computerized) database, including a mobile reporting system where possible, that provides information on road crashes.	(22) Information on existing integrated road safety database and responsible organizations. (23) The existence of definitions of road fatality and serious injury being used for data collection, with an indication as to whether they are based on internationally accepted definitions.
(c) Aim to provide road safety at the stage of road network planning.	(24) Information about the incorporation of road safety at the stage of road network planning.
(d) Introduction of laws and regulations regarding mandatory use of helmets and seat belts, drinking and driving, use of mobile phones and speed limits.	(25) Information on laws or administrative rules on compliance regarding helmet use (including percentage use).[a] (26) Information on laws or administrative rules on compliance regarding seat-belt use and use of mobile phones (including percentage use).[a] (27) Information on laws or administrative rules on compliance regarding drinking and driving and speed limits.[a]
(e) Allow alcohol tests for prosecution (breathalyser and/or behavioural tests).	(28) Information on existing alcohol-level testing rules and types of tests and alcohol limits used and allowed for prosecution.[a]
(f) Make it the general practice to keep motorcycle headlights on at all times.	(29) Information on existing laws or administrative rules on keeping motorcycle headlights on while driving.
(g) Increase responsiveness to post-crash emergencies and improve the ability of health and other systems to provide appropriate emergency treatment and early rehabilitation for crash victims.	(30) Information on a single nationwide telephone number for use in case of emergencies including road crashes.[a] (31) Information on rehabilitation services.
(h) Apply new technologies in traffic management and intelligent transport systems, including navigation systems, to mitigate the risk of road traffic crashes and maximize response efficiency.	(32) Information on the use of intelligent transport systems in improving road safety.

Goals and targets		*Indicators for monitoring achievements*	
Goal 6:	**Improving cooperation and fostering partnerships**		
(a)	Encourage and recognize initiatives sponsored by the private sector.	(33)	Number of major partnerships in the area of road safety, funding (private sector and public-private initiatives).
(b)	Create new and deepen existing partnerships with non-governmental organizations.	(34)	Number, scope and funding of major partnerships with non-governmental organizations.
Goal 7:	**Developing the Asian Highway network as a model of road safety**		
(a)	Reduce the total number of fatalities and road crashes on the Asian Highway network.	(35)	Total number of fatalities and road crashes on the Asian Highway network in each country per year.[a]
(b)	Reduce the number of fatalities on all Asian Highway network segments to less than 100 per billion vehicle-kilometres.	(36)	Number of fatalities per billion vehicle-kilometres for each Asian Highway network segment per year.[a]
(c)	Increase resource allocation for measures related to road safety along the Asian Highway network.	(37)	Amount of resources allocated to safety-related works for Asian Highway network segments from Governments and donors.
(d)	Improve Asian Highway network segments to be forgiving to road users if a crash occurs; demonstrate best practice.	(38)	Information on road safety assessment and rating programme for the Asian Highway network.
Goal 8:	**Providing effective education on road safety awareness to the public, young people and drivers**		
(a)	Carry out targeted awareness campaigns and training programmes.	(39)	Information on the number of national road safety awareness campaigns and training programmes carried out.
(b)	Introduction of policies to reduce work-related road traffic crashes.	(40)	Information on policies to regulate and improve professional drivers' work conditions.

Source: Economic and Social Commission for Asia and the Pacific.

[a] Available fully or partially in the *Global Status Report on Road Safety 2015*, the Asian Highway Database or United Nations records.