Master of Public Health

Master international de Santé Publique

"Achieving sustainable environment and health through building sustainable cities"

MPH THESIS REPORT

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June 2013

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“Achieving sustainable environment and health through building sustainable cities”

I. Abstract

The shift to a dominantly urban world is dynamic, which needs to be effectively steered to enable the world to face current and future challenges, thus the need to focus on sustainable urbanisation. Across the globe, cities are centres of urbanisation and act as a locus of power; and are hence chosen as a focus for this research. Broadly the areas that come under a city’s jurisdiction and control are air quality, water quality, sanitation, building and construction, waste management and transport. Here the focus is on ‘active transport’ and ‘water, sanitation and hygiene’. As both these areas have the potential to make a massive health impact as they target major disease risk factors, i.e. unimproved water and sanitation, air pollution, and physical inactivity.

For each domain a comprehensive list of associated exposure area has been formulated, and the list is then analysed and critiqued to select a primary set and a secondary set of exposure areas. Having a direct correlation with health and environment has been used as one of the main selection criteria. For city transport, the following exposure areas were chosen: reducing air pollution emissions, reducing road injuries, and increasing physical activity. And for water, sanitation and hygiene, following exposure areas were chosen ‘Access to improved drinking water sources’ and ‘Improved sanitation facilities, and disposal of sewage’. For each sub area, analysis is done and respective indicators are presented with associated challenges and policy changes.

As a summary, this research advocates prioritising ‘efficient active transport’ and ‘water sanitation and hygiene’ as areas to focus for achieving sustainable development, based on the evidence of large population level health impact, cost effectiveness and being centred on providing benefits for masses.

Le passage à un monde principalement urbain est dynamique et doit être efficacement dirigé pour permettre au monde de faire face aux défis actuels et futurs, d'où la nécessité de mettre l'accent sur l'urbanisation durable. Partout dans le monde, les villes sont des centres d'urbanisation et fonctionnent comme un centre de pouvoir, et sont donc choisis comme thème pour cette recherche. Au sens large, les domaines qui relèvent de la juridiction et du contrôle d'une ville sont la qualité de l'air, de l'eau, l'assainissement, la construction, la gestion des déchets et des transports. Ici, l'accent est mis sur le «transport actif» et «eau, assainissement et hygiène». Ces deux domaines ont le potentiel d'avoir un impact énorme sur la santé car ils ciblent les principaux facteurs de risque de maladie, à savoir l'eau et l'assainissement non amélioré, la pollution de l'air, et l'inactivité physique.
Pour chaque domaine, une liste exhaustive de la zone d'exposition associée a été formulée, et la liste est ensuite analysée et critiquée pour sélectionner un ensemble primaire et secondaire d'un ensemble de zones d'exposition. Le fait d'avoir une corrélation directe avec la santé et l'environnement a été utilisé comme l'un des principaux critères de sélection. Pour le transport ville, les zones d'exposition suivantes ont été choisies : la réduction des émissions de polluants atmosphériques, la réduction des blessures de la route, et l'augmentation de l'activité physique. Pour l'eau, l'assainissement et l'hygiène, les zones d'exposition suivantes ont été choisies «L'accès à des sources améliorées d'eau potable» et «l'amélioration des installations d'assainissement et l'élimination des eaux usées. Pour chaque sous-région, l'analyse est faite et les indicateurs respectifs sont présentés aux défis associés et des changements de politique.

En résumé, cette étude préconise l'utilisation en priorité des critères «transports efficaces actifs» et «assainissement de l'eau et de l'hygiène» comme étant les plus pertinents pour parvenir à un développement durable, au vu de l'impact sanitaire, de la rentabilité et des effets bénéfiques pour la population.

II. Acknowledgements

I would like to acknowledge and extend my heartfelt gratitude to the following persons who have made the completion of this research possible:

- ***Prof. Antoine Flahault*** (Professor at Paris Descartes, Sorbonne Paris Cité), my Academic advisor on this project, for his timely feedback, vital encouragement and ongoing support.
- ***Prof. Sir Andrew Haines*** (Professor at London School of Hygiene and Tropical Medicine), my Professional advisor on this project, for his inputs, feedback and ongoing support.
- ***Dr. Carlos Dora*** (Co-ordinator, Public Health and the Environment Department, World Health Organization), for his useful inputs and guidance in shaping the section on 'Active Transport'.
- ***Prof. Sandy Cairncross*** **(**Professor of Environmental Health at London School of Hygiene and Tropical Medicine) for his useful inputs in developing the section on 'Water, Sanitation and Hygiene'.
- All MPH EHESP faculty members and staff for providing guidance, assistance and timely support.

It was a great learning experience and an honour for me to work with you all.

III. Introduction

III.1 Need to focus on steering urbanisation in developing the post 2015 development agenda

The world is moving rapidly towards urbanisation. An estimate by UN Habitat forecasts that by 2050 more than two-thirds of the global population will be living in cities. [1] The shift to a dominantly urban world is dynamic, which needs to be effectively steered to enable the world to face current and future challenges. Thus is the need to focus on sustainable urbanisation, and thus the need to focus on sustainable cities.

Across the globe, cities are centres of urbanisation. Cities act as a locus of power in a region, providing jobs and being centres for economic growth. Being the centre of growth, cities face many challenges that include the increasing urban sprawl, increasing metropolitanisation, emergence of urban corridors and regions – all of which generate new demands, rising inequality, implications of immigration etc.

Thus, inclusion of the urbanisation factor with a focus on cities is fundamental and critical in determining the post 2015 global development agenda. Also, The MDG experience calls for the need to anchor the new agenda at the local level, particularly within the framework of city development. [2]

Cities could also be the locus for change, as they have the potential for dealing with regional and global challenges pragmatically and efficiently. Cities are the places where new ideas crystallise, technological and artistic innovation happen, and creative solutions to problems emerge. Cities, in the past, have shown to act as locus for social and political change and a centre where new forms of participatory decision-making can be experimented. [3]

III.2 Impact of city centred urbanisation on environment

Along with benefits of urbanisation, come challenges such as urban air pollution, greenhouse gas emissions and challenges associated with providing basic amenities such as such as access to clean drinking water. Problems can be classified in 2 domains, firstly, problems associated with poverty, and secondly, those associated with economic growth or affluence. In some cities, especially in the developing world, the two domains coexist simultaneously.

In the developing world, the poor sections of urbanised fast growing cities face unsuitable living conditions. Local governments are unable to provide for the basic needs of their citizens. At least 220 million urban dwellers lack access to improved source of drinking water; more than 420 million do not have access to the simplest latrines [4]. Between one and two thirds of the solid waste generated is not collected. It piles up on streets and in drains, contributing to flooding and the spread of disease.

The rapid economic growth brings huge burden on resources and consumption along with excessive emissions, and in turn exerts strong environmental pressure. More than 1.1 billion people live in urban areas worldwide are exposed to particulate or sulphur dioxide levels in excess of WHO guidelines [5]. In cities across the world, domestic and industrial effluents are released to waterways with minimal or no treatment, threatening both human health and aquatic life. The urban poor still represents a huge proportion of population shut off from the benefits of economic growth, which is exposed both to the hazards resulting from economic growth, such as industrial emissions, and to the hazards that accompany poverty.

In the wealthiest cities of the developed world, environmental problems are related not so much to rapid growth as to extravagant resource consumption. An urban dweller in New York consumes approximately three times more water and generates eight times more garbage than does a resident of Mumbai [7], [8]. The massive energy demand of wealthy cities contributes a major share of greenhouse gas emissions.

Overall, cities contribute to about 70% of the total green house emissions and thus present the world's population with the best chance of reducing our ecological footprint. Cities are also most vulnerable to climate change, as 90% of all urban areas are coastal [9], thus putting them first at risk of rising sea levels. Financial impact of climate change will thus also be first borne by these major cities, making them even more vulnerable. Because of their concentrated form and efficiencies of scale, cities offer major opportunities to reduce energy demand and minimize pressures on surrounding lands and natural resources.

III.3 Association between health and environmental changes and degradation

Nearly one quarter of the global disease burden is attributable to the modifiable environment. Of the 102 major diseases reported in the World Health Report 2004, 85 are partly caused by exposures to environmental risk factors. [10]

The environmental disease burden is not distributed evenly across the world, and those living in middle-income countries disproportionately experience this burden. For e.g., in the case of infectious diseases, total number of healthy life years lost per capita was 15-times higher in developing countries than in developed countries. In case of non-communicable diseases, for e.g. for cardiovascular diseases the per capita numbers of healthy life years lost were up to 7-times higher in cities from developing countries [10].

Air pollution is a major environmental risk to health, and by reducing air pollution levels the global burden of disease from respiratory infections, heart disease, and lung cancer could be significantly reduced. The lower the levels of air pollution in a city, the better respiratory (both long- and short-term), and cardiovascular health of the population will be. Indoor household air pollution from solid fuels is estimated to cause approximately 3.55 million premature deaths, and ambient particulate matter pollution is estimated to cause 3.22 million deaths worldwide per year [17]. Exposure to air pollutants is largely beyond the control of individuals and requires action by public authorities and thus the importance of looking at it at the city level.

The environmental disease burden is heavier among children. Globally, the per capita number of healthy life years lost to environmental risk factors was about 5-fold greater in children under five years of age than in the total population [10]. Add to that, the fact that these statistics don't take in account the longer term effects of environmental exposure that occur at a young age and that take time to manifest as diseases.

Environment also encompasses local city setting, in terms of housing and living conditions that includes water sanitation and hygiene, availability of green spaces etc. Lack of sanitation is a serious health risk and an affront to human dignity. It affects billions of people around the world, particularly the poor and disadvantaged. If the trend continues as currently projected, by 2015 there will be 2.7 billion people without access to basic sanitation [12].

Population health or disease burden is an effect of environmental, social and behavioural factors. However, interventions or modifications based on environmental changes have several added advantage such as:

- Improving population health or preventing disease before it arises eliminates associated health-care treatment costs, and no burden is borne by the population;
- Environment based interventions are generally more sustainable as they end up achieving a longer-term impact on health, as compared to medical treatment;
- Environmental modification is often the most equitable option, as they generate benefits across broad groups or populations.

Now understanding the immense environmental burden and associated population level health impact caused by rapid urbanisation, it is imperative to take into account the urbanisation factor with a focus on cities for determining the post 2015 global development agenda. Given the opportunity cities offer, it is important to work towards building sustainable cities which are more resilient to climate change and are a healthier place to live.

IV. Project Objective

The focus of research is to define what could cities do to become more resilient to climate change and become a healthier place to live. To select exposure areas that are directly associated with environmental and health impact and come under a city's jurisdiction, and then with respect to exposure areas define indicators that could be used in achieving sustainable development.

Broadly the areas that come under a city's jurisdiction and influence are air quality, water quality, sanitation, building and construction, waste management and transport. Here we look to focus on transport and water sanitation (which comes under housing improvements) as areas where cities could action.

I. **Active transport:** Access to public transport ensures physical activity and in turn better health. Moreover, mass population using public transport results in massive reduction in air pollution. Thus in turn having both, an environmental impact and a health benefit. Also, access to efficient transport system enables residents to move outside of their own community, which has been shown to positively correlate with a reduced fear of social isolation and positive mental health [13].

II. **Housing improvements:** Improved housing designs and provision of water and sanitation facilities offer a major untapped potential to achieve sustainable micro environment for population and in turn a massive impact on health, especially in developing countries. Adverse impact on health could occur through a range of mechanisms, both direct and indirect, including as a result of extreme weather, indoor air pollution, injuries or burns, the ingress of disease vectors and lack of clean water and sanitation [14]. Urban cities in the developing world face a different challenge, i.e. to ensure access to basic infrastructure services such as electricity, water and sanitation, housing, or household waste collection. Households with lower income are more likely to occupy low-quality housing, which is more difficult and more expensive to heat, illustrating the spatial segregation of cities. Extra deaths between December and March are attributed to cold weather, with children, older people and people with long-term illnesses being the most vulnerable.

Environmental noise problems is another associated risk factor with poor housing, and can also lead to sleep disturbance, cardiovascular disease and impaired mental health. This is more severe in areas of deprivation and in the areas of high-density housing and other accommodation commonly occupied by people with lower income. However, in this piece of research we are not going to focus on noise pollution associated with poor housing. Here, our primary focus is on achieving improved water and sanitation facilities as a priority, as it is closely linked with environmental and health benefits.

The current Millennium Development Goal (MDG) target for sustainable access to safe drinking-water and sanitation is part of MDG 7 – "ensure environmental sustainability". And this same target is also crucial in making progress for the health and development-related MDGs Goals i.e. eradicate hunger (MDG 1); reduce child mortality (MDG 4); improve maternal health (MDG 5) and combat HIV, malaria, and other diseases (MDG 6) [15].

II a. **Water sanitation and hygiene:** 1 billion people lack access to improved source of drinking water [16], and 337 thousand annual deaths are attributable to unsafe water, sanitation and hygiene [17]. The burden is not distributed evenly across the world, and those living in middle-income countries disproportionately experience this burden. Where, a significant amount of disease could be prevented through better access to safe water supply, adequate sanitation facilities and better hygiene practices. Improper drainage and

sewage and inadequate sanitation facilities leads to breading of mosquitoes, and in turn to all vector diseases.

II b. Household energy and household air pollution: 3 billion still rely on solid fuels (wood, dung, crop wastes, charcoal and coal) burned in open fires or traditional stoves that are highly inefficient and emit high levels of air pollution into and around the home [18].

In developing countries, a huge public health burden is associated with indoor air pollution from inefficient burning of biomass fuels. Replacing biomass with a low-emissions household cooking stove is one proposed solution that can make a massive impact in reducing the health burden associated with indoor air pollution.

Even in developed countries, improvements in the efficiency of household energy use could, if implemented correctly, have appreciable benefits for population health, mainly arising from improved indoor air quality and control of winter indoor temperatures.

Note: Due to constraints of time available for research, only 'Active transport' and 'Water sanitation and hygiene' are covered in this report.

Other areas where cities have a degree of influence are areas such as:

- **Health services:** Making cities more resilient for disaster management in context of climate change, for e.g. required health services in face of floods or heat waves;

- **Safe access to green spaces:** Evidence indicates benefits of green spaces for both physical and mental health and well-being. These include decreases in general health problems, blood pressure, cholesterol and stress levels and improved perceived general health and resilience [16]. However, the benefits of increases in physical activity and improved mental health only arise if the green spaces are of high quality, accessible and safe.

- **Access to healthy eating options:** This seems to be an area with very minor degree of influence; however there are cases where cities have managed to influence healthy eating behaviour. Promoting initiatives, voluntary healthy eating drives are possibilities cities could experiment with to inculcate change. The recent e.g. of such initiative was seen in New York, where the city mayor pushed for a ban against large soda cans.

As mentioned above, in scope of this study is what comes under the jurisdiction or influence of cities do, i.e. areas where cities could act and move towards becoming more resilient and a healthier place to live. Further, among all possible areas briefly described we have chosen to focus on developing active transport and achieving sustainable solutions to water, sanitation and hygiene.

V. Methodology

Based on research, for each above mentioned specific areas (Active transport, water sanitation and hygiene) the paper outlined associated exposure, environmental and health impact, and available data sources to monitor. For each associated exposure, a comprehensive list of possible specific indicators to monitor progress towards developing a resilient city was consolidated. The list was then analysed and critiqued, through discussions with project advisors, to select a primary set of indicators and a secondary set of indicators. Advocating for environment and health, one of the basic criteria for the selection of indicators is for them to have a direct correlation with health and environment.

For getting an expert view, useful inputs and guidance were taken through interview/meetings.

- For 'Active Transport': Dr. Carlos Dora (Co-ordinator, Public Health and the Environment Department, World Health Organization) provided useful inputs and guidance based on his expertise and prior experience of developing the European program on Transport Environment and Health at WHO European Centre for Environment and Health.

- For 'Water, Sanitation and Hygiene': Prof. Sandy Cairncross (Professor of Environmental Health at London School of Hygiene and Tropical Medicine) provided useful inputs based on his experience in developing countries implementing water, sanitation and public health programs.

While focusing on what cities could do, the objective is to look into how we can integrate environment and health issues in the decision making process and policy implementation. To do so, defining indicators to monitor, measure and track progress is the first step. Indicators are critical in helping better understand and answer the following questions:

- Better understanding the current situation – where are we now?
- Assessing the situation – how are we doing?
- Diagnosis of the situation – why are we here?
- What do we need to prioritise
- Identifying key issues and making a plan/strategy for how can we improve?
- Defining policy - Understanding what is important?
- Communicating the message of change – What are we trying to achieve?
- Delineating responsibilities – who should be accountable?
- Monitoring progress – Is the new approach yielding results?
- Understanding results – what have we achieved?

Following is a list of criteria that will be considered while selecting indicators to measure transportation performance (adapted from a report by Canadian Victoria Transport Policy Institute (VTPI) [7]:

- Comprehensiveness – indicators should reflect various economic, social and environmental impacts

- Data quality – data collection practices should reflect high standards to ensure that information is accurate and consistent
- Comparability – data collection should be standardized so the results are suitable for comparison between various jurisdictions, times and groups. Indicators should be clearly defined.
- Easiness to understand – indicators must be useful to decision makers and understandable to the general public.
- Accessibility and Transparency – indicators (and the data they are based on) and analysis details should be available to all stakeholders.
- Cost effectiveness – indicators should be cost effective to collect. The decision making worth of the indicators must outweigh the cost of collecting them.
- Net Effects - indicators should differentiate between net (total) impacts and shifts of impacts to different locations and times.
- Performance targets – indicators should be suitable for establishing usable performance targets.

Apart from the above indicator criteria, following three indicators were also included:

- Degree of jurisdiction control – indicators around parameters where the city jurisdiction has its influence to bring change.
- Previously used to influence policy - indicators that have been used before to influence policy are the ones where politicians also have vested interest to make an impact.
- Drives community participation – indicators that could get community involvement are effective in bringing a sustainable impact.

Which indicators are selected can significantly influence analysis results. Choice of indicator could make a particular policy or programme rank higher or lower in terms of its associated impact. Also there is often a trade-off between convenience and comprehensiveness when selecting indicators. A smaller set of indicators using easily available data is more convenient to use but may overlook important impacts. A larger set can be more comprehensive, but may have unreasonable data collection costs.

Using the above criteria, analysis is done for each domain that results in an exposure that has an impact on environment and health. Looking at what is the associated environmental and health impact of each listed exposure, and then what possible indicators could be used to monitor and assess progress. The proposed indicators are then assessed with respect to the selection criteria list mentioned above, using a 3 point scale (with 1 being weak influence/relevance, 2 being fair influence/relevance and 3 being strong influence/relevance). The aim of the research is to identify the set of indicators. In addition, a list of possible policy recommendation will be added for each domain area covered.

Note: The criteria analysis tables have been included in the appendices section.

VI. Impact of city transport in achieving sustainable environment and health

As demand and pressure associated with urbanisation takes over cities, the demand for efficient transport system for efficient mobility becomes important. As cities grow in size, with more and more number of people affluent to use a personal automobile for daily commute, the burden of daily traffic circulation becomes unsustainable. As a result there is more congestion; more air pollution; and people take longer to reach their destination.

There are many cities, more so in the developing world but also in the developed world, where local public transport is not very well developed or does not have complete connectivity. As a result, more people opt for personal automobile resulting in a more and more congested daily traffic movement, so much so that people spend hours reaching a nearby destination. Heavy automobile traffic brings with it heavy air pollution, having an acute impact on environment and health.

City transport is an area that could be influenced by city jurisdiction, and is an actor that could impact the three basic pillars of sustainability, i.e. help in achieving economic, social and environmental sustainability. The table#1 below, adapted from a list developed by Victoria Transport Policy Institute.

Economic	Social	Environmental
Economic productivity	Equity / Fairness	Climate change prevention and mitigation
Local economic development	Human safety, security and health	Air, noise and water pollution prevention
Resource efficiency	Community development	Non-Renewable Resource Conservation
Affordability	Cultural heritage preservation	Open space preservation
Efficient mobility	Mobility for disadvantaged	Biodiversity protection
Operational efficiency	Aesthetics	

Table#1: Transportation impact on sustainability

Table #1 above shows how sustainable transport impacts the basic 3 domains of sustainability. However, as mentioned in the methodology above, the scope of this research focuses on identifying areas which have an impact on both environment and health.

VI.1 Description

Sustainable development calls for a balance in achieving economic, social and environmental objectives in long term with sustainability. “Sustainability planning is to development what preventive medicine is to health: it anticipates and manages problems rather than waiting for crises to develop” [20]. Sustainability approach needs to understand that transport affects people in multiple ways and needs to have an integrated strategy for coordinated planning among different sectors, groups and stakeholders to successfully implement change.

To have an understanding, following are some definitions used in the literature for sustainable transport:

“Sustainability is not about threat analysis; sustainability is about systems analysis. Specifically, it is about how environmental, economic, and social systems interact to their mutual advantage or disadvantage at various space-based scales of operation.” [21]

“The goal of sustainable transportation is to ensure that environment, social and economic considerations are factored into decisions affecting transportation activity.” [22]

And following are definitions used specifically for sustainability transport indicators:

Sustainable transport indicators (STIs) are regularly updated performance measures that help transport planners and managers to take into account the full range of economic, social and environmental impacts of their decisions [23].

A forecastable, quantifiable variable, usually with target value representing an objective, which symbolises environmental or other impacts of transport infrastructure plans (including ordinal scales: e.g. low, medium, high) [24].

City transport plays a considerable role in the economy, however, transport is also considered to be the sector with the fastest growth in environmental pollution. Apart from energy generation and industrial processing, transport is a major contributor to air pollution. Especially in mega cities, where the density of population is high could lead to a huge burden of transport associated exposures on environment and health. Thus is the imperative need to carefully plan and influence city transport to achieve sustainable growth and development. It is also important to recognise that transport decisions affect people in many ways, so a variety of objectives and impacts should be considered in the planning process.

There is an urgent need to implement adequate policy instruments which would help to mitigate and control the negative impacts of transport activities, and indicators have proven to act as a valuable policy tools for measurement and evaluation of transport sustainability performance. The selection criterion for choosing indicators has been described in the methodology section. Which indicators are selected can significantly influence analysis results. Choice of indicator could make a particular policy or program rank higher or lower. Also there is often a trade-off between convenience and comprehensiveness when selecting indicators. A smaller set of indicators using easily available data is more convenient to use but may overlook important impacts. A larger set can be more comprehensive, but may have unreasonable data collection costs.

Here in this research, emphasis has been put on investing in public transportation. Investing in public transport has multiple benefits such as: a) Helping to reduce consumption of oil, b) Lessening our impact on the environment, c) Stimulating economic growth and development by creating “green jobs”, d) reducing congestion, e) increasing the amount of physical activity people engage in on a regular basis.

Identifying comprehensive list of exposure areas

Using the criteria list mentioned in the methodology section, table#A.1 (in the appendices) is developed based on analysing each domain area that is an exposure or has an impact on environment and health. Looking at what is the associated environmental and health impact of each listed exposure, and then what possible indicators could be used to monitor and assess progress. The proposed indicators are then assessed with respect to the selection criteria list mentioned above, using a 3 point scale (with 1 being weak influence/relevance, 2 being fair influence/relevance and 3 being strong influence/relevance).

Table#A.1 (in the appendices) also talks about the respective critique for some of the factors. In the next step, the exposure factors were grouped into primary and secondary factors and respective indicators. The secondary exposure areas are the ones where the impact on health exists but is more indirect. Also, exposure factors and indicators that either have a very weak association with health or only have an indirect impact are dropped, for e.g. biodiversity protection which only has an environment impact, and also has a slightly weaker association with city transport.

Analysing the comprehensive list

For the area under *air pollution*, the indicator on incidence to respiratory diseases is dropped as it is difficult to attribute the incidence associated with only the pollution generated by city transport. Also incidence of diseases could also be due to indoor pollution, for e.g. indoor air pollution due to burning coal for cooking. The other two exposure areas that are dropped are emissions of green house gases and CFCs/halocarbons. Green house gases have an effect via environment change leading to health impacts in long run, but there is weak direct impact. Similarly emissions that deplete ozone (CFCs/halocarbons), have a weak association with emissions from cars or transport as very low amounts of gases leak out. Also, depletion of ozone has an indirect impact on health.

Exposure to *noise pollution* is moved in the category of secondary set of exposure areas and indicators as there is weak association with health, i.e. there is a weak supporting evidence of the mental health impact caused by noise pollution.

For the same reason, *green space preservation* is moved to secondary set of indicators. Green spaces have a weak correlation with city transport, and there is weak available evidence of a mental health impact or physical health impact.

For green spaces to be accessible they need to satisfy the primary condition of being safe and well maintained to be chosen by people for having a walk or a run. So even though carving out new green spaces for parks and recreational activities in already developed cities might be difficult to achieve. However, there is a possibility to increase usage of existing green spaces by making them safer to access and by keeping them well maintained.

Having an efficient *public transit system* has shown to have a positive health impact [27, 28]. Due to an indirect association this factor has only been included in the secondary list of exposure factors. However, implementing an efficient public transit system needs a strong government motivation and a huge financial investment. Furthermore, it also needs a cultural and behavioural change on the part of public, which could

again be influenced by introducing supporting policies such as diversify options and limit access to existing roads, road tolls and increased taxes.

VI.2 Set of chosen exposure areas with proposed indicators

Following table#2 summarises the chosen exposure areas and respective indicators grouped into two sets, primary and secondary with respect to one having direct and a strong association with health.

		Exposure	Impact		Indicators	Nature/ Data availability
			Environmental	Health		
Primary set	Air pollution due to emissions	Exposure to polluted air, Gases realeased by burning non renewable fuels	Polluted environment, further leading to climate change. Consumption of non renewable resources	Direct toxicity of air pollutants	Per capita emissions of 'conventional' air pollutants (CO, VOC, NOx, particulates, etc.)	Quantitative, Less is better, 3
	Traffic injuries / fatlities	Traffic related injuries	Lesser use of cycles or two wheelers and more use of cars, leading to more pollution	All minor or major injuries to fatalities	Per capita crash disabilities and fatalities	Quantitative, Less is better, 3
	Physical activity	Indulging in physical activity to travel or activity to access transport	Walking, cycling or more use of public transport leads to greener environment	More physical activity acts as a protective factor for mant diseases	Rating on pedestrian friendly/ bike friendly streets % of population that regularly walks and cycles (more than 15 mins)	Qualitative, More is better, 1
Secondary set	Green space preservation	Land devoted to transport activity	Lack of green spaces leads to poor air quality	Green spaces are used for walking, and also have a +ve effect on mental health	Per capita land devoted to transportation facilities	Quantitative, Less is better, 3
	Noise pollution	Exposure to Noise pollution	Noise pollution	Adverse impact on mental health	Portion of population exposed to high levels of traffic noise	Quantitative, Less is better, 2
	Public transit system	Operational efficiency	More the extent of public transit used, lower the harmful impact on environment	More the extent of public transit used, more is the indulgence in physical activity to access and hence more the health benefits	»Miles of fixed-route bus/train service »Number of minutes between buses/trains on scheduled routes	Quantitative, Less is better, 3
		Affordability			Portion of household expenditures devoted to transport, particularly by lower-income households.	Quantitative, Less is better, 2
		Quality perceived			»Perceived as choice of commute »Perceived as safe to travel	Quanlitative, More is better, 1

Table #2: List of chosen primary and secondary transport associated exposure areas

VI.3 Discussion: On selected exposure areas

Reducing air pollution due to emissions

A number of factors can be identified as influencing the amount of emissions attributable to the transport sector, and an effective strategy will need to take all these factors into account. They include: (a) the amount that vehicles are used in a given country or metropolitan area; (b) the age of the vehicle fleet and the technology used within it; (c) the extent to which vehicles are properly maintained; (d) the availability of appropriate fuels and the extent to which they are used properly.

Corresponding to attributing reasons, there are various strategies to reduce **air pollution**, i.e. (a) Technical improvements with vehicles, i.e. improvements with respect to efficiency of fuel combustion, maintenance of vehicles, etc (b) using cleaner and better fuels, (c) systemic improvements, i.e. reducing congestion (though there are studies that demonstrate that with reducing congestion is also associated with induced

traffic), (d) behavioural approaches to reduce vehicular travel i.e. modal shift, use of public transport, use of non motorized modes, biking etc. The desired effect of all policies is to bring down emissions.

For measuring emissions, choosing an indicator involves making a series of decisions on the following issues: (1) The scale at which the emissions will be measured (neighbourhood, city, or region?); (2)The method for measuring emissions (top-down, e.g. based on regional fuel sales volumes, or bottom-up, e.g., estimating total vehicle kilo meters travelled [VKT] in a city or region based on surveys or traffic counts); (3) The data collection method (using existing data, travel surveys, odometers, etc.); and (4) The timeframe for monitoring emissions. [31]

Based on city setting (i.e. standards of current available measurements) the exact method for monitoring and measuring data may vary. However to cover countries across the globe, the method that is most recommended is the one to assign VKT according to where vehicles are fuelled. The method is probably the easiest to measure and has least cost associated with it. Also, the vast majority of developing countries only collect data on sales of fuels. Another method of collecting data could be through use of remote sensing technology, that is carried out to collect a sample and emissions could then be extrapolated. Though, this is a technique more apt for a developed world setting.

Road injuries, which are one of the most serious adverse effects of the rising traffic in urban cities. About 1.24 million people die each year as a result of road traffic crashes, with road traffic injuries being the leading cause of death among young people, aged 15–29 years. 91% of the world's fatalities on the roads occur in low-income and middle-income countries, even though these countries have approximately half of the world's vehicles. [29] Also, notable is the fact, that almost half of those who die in road traffic crashes are pedestrians, cyclists, or users of motorized two-wheelers, and this proportion is higher in poorer economies [29]. More specifically, according to a estimate by 2030 health losses from road traffic deaths and injuries for men are projected to rank 2nd behind those from HIV/AIDS, and from 2015 to 2030 they will be the single biggest cause of healthy life years lost by boys and girls, aged 5 – 14. [30]

Reducing road injuries has been included in the primary set of exposure areas, as it impacts all three pillars of sustainability and has a direct association with health. Traffic injuries impact young people more and in turn have a heavy economic impact with loss in productive time (which could be in years). Policies aimed at reducing traffic injuries need a multisectoral approach, and are policies that can be influenced by city jurisdiction. The four broad pillars of policy making in road safety are establishing measures, educating people, establishing stringent law enforcement, and evaluating and monitoring policy changes. What exact policy or measure is chosen depends on local factors and local setting, however, the overall objective could be summarised by using the indicator of reducing the total number of traffic injuries.

Physical activity, which is an essential component of any strategy that aims to seriously address the problems of sedentary living and obesity among children and adults. Active living contributes to individual physical and mental health but also to social cohesion and community well-being. Being physically active is not just limited to practicing sports, in fact they exists everywhere – where people live and work, in neighbourhoods etc. The way we build our cities, design the urban environment and provide access to the natural environment can be a great encouragement or a great barrier to physical activity and active living.

Transport plays a key role in determining our daily physical activity, as almost everyone needs to move everyday to get to work, to meet friends or just to get groceries. Behavioural approaches, local cultural factors and accessibility determine how we chose to travel. Is we too dependent on use of a personal vehicle or one chooses to walk and use public transit? Thus, transport is the most practical and sustainable way to increase physical activity on a daily basis; and increased active transport will achieve co-benefits such as improved air quality, reduced traffic congestion, and reduced CO_2 emissions.

Increasing active transport requires the development and implementation of policies influencing land use and access to footpaths, bikeways and public transport, in combination with effective promotional programs to encourage and support walking, cycling and use of public transport (e.g. trains, trams and buses) for travel purposes. This combination of strategies can shift mode choice away from personal motorised vehicles and increase physical activity.

Hence, the objective of the community should be to make people walk or cycle more, and the proposed indicators are intended to measure the same. First is, rating of streets on pedestrian friendliness or bike friendliness, that takes into account how are cities designed and if they are compatible to walking and cycling as a preferred mode. Second is the actual measure that is the percentage of population that walks and cycles regularly. Both would need conducting a survey, and an increase in rating or percentage is the desired goal. What do cities need to do exactly, will depend and vary from city to city, but a relative inc. is what cities should aim for. [32]

Table#A.3 (in the appendices) describes the rating analysis of chosen exposure areas and indicators with respect to indicator selection criteria. The proposed indicators are assessed with respect to the selection criteria list mentioned above, using a 3 point scale. The given rating in the table is based on my own judgement call and need to be validated. However, the idea is to have a list of indicators where an individual indicator might be weak on few selection criteria's but is strong on others and overall provides a good mix with some weight age given to each selection criteria.

VI.4 Associated policy recommendations

Reducing emissions: There are many well documented policies to reduce emissions, such as strategy for modal shift and promotion of high quality public transport systems, tax measures and road charging schemes, mandatory planning to set up targets for a shift towards environmentally friendly modes of transport (public transport, cycling, walking), Investments in transport with priority in high energy efficiency and lower emissions, monitoring and benchmarking targets etc. Studies have shown that better roads, better efficient vehicles are indeed way forward, but there are questions with respect to sustainability, as these may lead to an effective increase in number of vehicles on roads. Hence, modal shift, and development of active transport is tipped as the right way forward.

Traffic injuries: There are several documented policies to reduce traffic injuries such as managing exposure to risk through transport and land-use policies, shaping the road network for road traffic injury prevention, improving visibility of road users, promoting crash-protective vehicle design, setting and securing compliance with road safety rules etc. However, for the developing world where the burden is highest, strong law enforcement and education are primary needs which need to be prioritised.

Physical activity: Some of the recommended policy changes include creating integrated neighbourhoods that facilitate walking and cycling, providing easy access to seashores, rivers, lakes and forests on the periphery of the city, conserving and developing green spaces. Developing public transport has proven to be very useful in many cities all around the globe to increase physical activity.

Following table #3 lists policies associated with respect to selected exposure areas and indicators. The list has been selected through literature research, and represents some recommendations. The exact policy change will depend on city setting and situation.

	Exposure	Indicators	Objective	Policy changes through sustainable transport
Primary set	Air pollution due to emissions	Per capita emissions of 'conventional' air pollutants (CO, VOC, NOx, particulates, etc.)	»Reduce transport associated emissions »Reduce climate change emissions associated with transport	»Emission standards, Emission taxes »Strategies to change travel behavior: Move to public transport, cycling »Quantify cuts in CO_2 emissions »Alternative fuels: Investments in transport with low GHG emissions
	Traffic injuries / fatalities	Per capita crash disabilities and fatalities	»Reduce traffic injuries	»Ensure strong enforcement of traffic laws »Establishing measures: Safety regulations, such as separate lane driving for bikes » Educating people about safe driving practices
	Physical activity	Rating of streets on pedestrian friendliness or bike friendliness	»Improve walking and cycling conditions, traffic calming,	» Programs to encourage and support walking, cycling and use of public transport » Investment in infrastructure for safer walking and cycling » Complete networks of footpaths, bikeways, and public transit support
		% of population that regularly walks and cycles (more than 15 mins)	»Make people indulge in physical activity	
Secondary set	Green space preservation	Per capita land devoted to transportation facilities	Conserve open spaces	»Allocate land area for parks/open spaces »Ensure maintenance of parks/open spaces
	Noise pollution	Portion of population exposed to high levels of traffic noise	Protect quiet areas	» Invest in noise barriers and reduce noise emissions at source
	Public transit system	»Miles of fixed-route bus/train service »Number of minutes between buses/trains on scheduled routes	Make public transport efficient and well connected	»Strategy for modal shift and promotion of high quality public transport systems »tax measures and road charging schemes
		Portion of household expenditures devoted to transport, particularly by lower-income households.	Make public transport accessible in terms of affordability	Introduce discounts for lower income groups
		»Perceived as choice of commute »Perceived as safe to travel	Make public transport a preffered mode for travel	Invest in quality of public transit

Table#3: Associated policies with respect to exposure areas

VII. Impact of water sanitation and hygiene in cities for achieving sustainable environment and health

Introduction

Ensuring access to safe, resilient and sustainable water and sanitation will accelerate sustainable development on multiple dimensions such as health, development, and the environment.

Sustainable access to safe drinking water and sanitation is closely linked with environmental and health benefits. The current Millennium Development Goal (MDG) target for sustainable access to safe drinking-water and sanitation is part of MDG 7 – "ensure environmental sustainability". And this same target is also crucial in making progress for the health and development-related MDGs Goals i.e. eradicate hunger (MDG 1); reduce child mortality (MDG 4); improve maternal health (MDG 5) and combat HIV, malaria, and other diseases (MDG 6). [15]

Following table#4 presents a list that has been consolidated to outline some of the important factors as per the three sustainability pillars that are impacted by access to improved source of drinking water, waste disposal and sanitation. The table below showcases how the impact of improved source of drinking water, access to improved sanitation facilities and better water management has positive impact encompassing three basic pillars of sustainability.

Economic	Social	Environmental
Economic productivity	Right to water and sanitation	Disposal of industrial waste and hazardous waste
Local economic development with sanitation services such as toilets, operation and maintenance services	Equity in accessibility, non discrimination	Water body preservation due to pollution, for conserving aquatic ecosystem in balance
Toilets and safe water increase school attendance (esp. for girls)	Unhygienic surrounding impacts sense of dignity	Waste water treatment
Affordability	Equity and safety, particularly for women	Drainage, sewage and waste disposal
Time spent on ensuring access to water	Health impact: Against malnutrition and water borne diseases such as malaria, dengue fever etc.	Safe guarding against water related disasters
Water productivity through agriculture		Scarcity of resources (drinking water)

Table#4: Sustainability pillars with respect to water, sanitation and hygiene

This domain is more a concern for the low income populations in developing nations. Low income populations are often the first to be affected by water shortages and sanitary crises: due in a large part to lack of funding, public networks have not been laid quickly enough to reach outlying settlements, which are often difficult to access or are located far from the city centre.

VII.1 Description and discussion on associated sub areas

Access to improved source of drinking water:

"The human right to water entitles everyone to sufficient, safe, acceptable, physically accessible and affordable water for personal and domestic uses" – General Comment No. 15 (2002): The Right to Water.

An adequate and dependable source of water is needed to sustain human life, future economic development, and the integrity of ecosystems. About 884 million people lack access to safe water supplies (although the number of people without access to water in their homes is considerably higher) and 2.6 billion are without access to basic sanitation. [33]

Thanks to MDGs, the target for improving the proportion of population with improved drinking water has been achieved, as over 2 billion people gained access to improved water sources from 1990 to 2010 and the proportion of population still using unimproved sources is reduced from 24% to 11% [33]. Though a significant progress has been achieved, but a great deal of work still needs to be done. Huge disparities still exist in access to an improved source of drinking water across the globe. While coverage of improved water supply sources is 90 per cent or more in Latin America and the Caribbean, Northern Africa and large parts of Asia, it is only 61 per cent in sub-Saharan Africa. [33]

Access to safe drinking water: There are two major challenges with measuring access to improved source of drinking water. First, is about monitoring progress with correct measurement. As sources which are not adequately maintained and are therefore may not actually providing 'safe' drinking water are unaccounted, as a result, leading to over-estimation of people using safe water supplies. However, advancements are being made in terms of how data is collected, which is by moving from collecting data from providers to collecting data from users through surveys.

Second, the increase in number of people having access to an improved source of drinking water is offset by the rise in population. Hence, the suggested indicator is to measure the increase in proportion of people having access to improved source of water.

Another important factor to consider is the role of local supplier for drinking water. In the absence of official departments, local water businesses spring up to palliate insufficiencies in public supply. The concern with local supplier is usually no monitoring systems in place. As a result service is highly varied, not only in terms of price, but also in regard to water quality and availability. "Generally speaking, the more intermediary suppliers there are in the supply chain, the more unfavourable the quality, availability and price of water will be for the end consumer" [34]. Hence, it is important to include these suppliers in planning to increase coverage, but introduce relevant price and quality monitoring systems.

Collection, treatment and disposal of sewage (human excreta and other effluents)

Mega cities and urban lifestyle brings with it the challenge of managing tonnes of waste generated by cities everyday from day to day lifestyle, from households, from industries etc. Collection, treatment and disposal of waste are critical for maintaining a sustainable lifestyle. Sewage collection and treatment is an essential part of the "hidden infrastructure" a city has to manage. Sewage treatment is the process of removing contaminants from wastewater and household sewage, both runoff effluents, domestic, commercial and institutional. It includes physical, chemical, and biological processes to remove physical, chemical and

biological contaminants. Its objective is to produce an environmentally safe fluid waste stream (or treated effluent) and a solid waste (or treated sludge) suitable for disposal or reuse (usually as farm fertilizer).

In developing countries, there is a significant proportion of housing settlements where sewage flows directly into the water bodies contaminating the environment. In many developing countries the bulk of domestic and industrial wastewater is discharged without any treatment or after primary treatment only. In Latin America about 15 percent of collected wastewater passes through treatment plants (with varying levels of actual treatment). [38]

A major challenge with controlling sewage disposal and waste water treatment is that currently, there is no internationally agreed target for wastewater collection and treatment, and water reuse; and no system to effectively monitor how much wastewater countries and the global community is treating. [42] Hence, urban cities could very well be the starting point for setting up targets to treat a proportion of waste water.

Access to Improved Sanitation

An improved sanitation facility refers to either having a connection to a public sewer or a septic system, or having a pour-flush latrine, a simple pit latrine or a ventilated improved pit latrine. Whereas, an unimproved sanitation facility refers to a public/shared latrine, an open pit latrine or a bucket latrine. [33]

Progress in sanitation and improved hygiene has greatly improved health, but many people still have no adequate means of disposing of their waste. This is a growing nuisance for heavily populated areas, carrying the risk of infectious disease, particularly to vulnerable groups such as the very young, the elderly and people suffering from diseases that lower their resistance. Poorly controlled waste also means daily exposure to an unpleasant environment. The build up of faecal contamination in rivers and other waters is not just a human risk: other species are affected, threatening the ecological balance of the environment.

The discharge of untreated wastewater and excreta into the environment affects human health by several routes, i.e. by polluting drinking water, by entering into the food chain, for example via fruits, vegetables or fish and shellfish; by bathing, recreational and other contact with contaminated waters; by providing breeding sites for flies and insects that spread diseases.
Human excreta lead to transmission of many infectious diseases including cholera, typhoid, infectious hepatitis, polio, cryptosporidiosis, and ascariasis. WHO (2004) estimates that about 1.8 million people die annually from diarrhoeal diseases where 90% are children under five, mostly in developing countries [33]. Chronic diarrhoea can also hinder child development by impeding the absorption of essential nutrients that are critical to the development of the mind, body, and immune system. It can also impede the absorption of life-saving vaccines.

A significant progress has been made in increasing the proportion of people who use improved sanitation facilities. Even though it is very likely that we will fall short of the MDG target of reaching 75% coverage by 2015, however MDGs need to be acknowledged for achieving a coverage rate of 63%, which is expected to go up to 67% by 2015 [33].

Any investment in better sanitation, starting from construction of pit latrines has direct impact on improving public health and quality of life. The impact of better sanitation has a marked impact in children and women. Better sanitation reduces child diarrhea and improves overall child health. For women and girls in particular, improved sanitation offers greater dignity, privacy, and personal safety.

VII.2 Set of chosen exposure areas with proposed indicators

Table# A.2 (in the appendices) is developed to lists each domain area that is an exposure or has an impact on environment and health. Looking at what is the associated environmental and health impact of each listed exposure, and then what possible indicators could be used to monitor and assess progress.

Using the comprehensive list (Table#2), following Table#5 is developed that summarises the chosen exposure areas and respective indicators grouped into two sets, primary and secondary sets. The selection criteria to choose primary and secondary set of indicators is based on how strong is the association with health (Refer table #A.2).

		Exposure	Impact		Indicators	Critique	Nature/ Data availability
			Environmental	Health			
Primary set	Access to improved drinking water sources	Poor communities within urban cities not having access to clean drinking water	Urban city activities polluting natural resources of water	Leading to diseases such as diarrhoea, or diarrhoea leading to malnutrition, intestinal infections etc	» Increase in the proportion of population that has access to improved source of drinking water	Weak environmental impact; more a concern for rural	Quantitative, More is better, 2
					» Cost of improved source of drinking water to poor	Doesnot account for maintaining an improved source	Quantitative, Less is better, 2
	Improved sanitation facilities, and disposal of sewage (human excreta n other effluents)	Open defecation; Poor sanitation or no sanitation system leading to water pollution and unhygienic surroundings	Feces, when not properly contained pollute the water sources, Housing improvement required to guard against weather and climate changes	Poor sanitation and unhygienic surrounding leads to breeding of mosquitoes and vector borne diseases Water pollution caused by uncontrolled feces, could lead to illness and death	» Proportion of sewage collected and treated before disposal » Proportion of households connected to public sewer system		Quantitative, More is better, 3
					» Number of households not having access to improved sanitation facilities	Less of a concern for urban cities, more a concern for rural areas	Quantitative, More is better, 3
Secondary set	Collection and management of industrial waste including Hazardous waste effluents	Releasing industrial waste directly in water bodies; unmanaged waste disposal	Polluting water bodies with untreated industrial waste which non decomposable	Contact with contaminated water directly or through food chain. Acute health effect: Skin/eye irritation, burning Chronic: Reproductive health, genetic modifications to cancer	» Proportion of industrial waste collected and treated	Unaccounted illegal industrial waste dumping	Quantitative, More is better, 3
					» Regulations for dumping industrial waste		Qualitative, More is better, 2
					» Annual amount of hazardous waste produced per sector (industry, mining, agriculture)	Standards vary from country to country	Quantitative, More is better, 3
	Controlling water related health risks	Water contamination	NA	Water related diseases spread instantly, cities need to have strong measures to guard contamination of water (especially drinking water)	» Proportion of water treated (by chlorination or other methods)	Overlaps with access to improved drinking water	Quantitative, Less is better, 3
					»Prevalence of water borne diseases	Does not monitor root causes	Quantitative, More is better, 3
		Efficiency of city drainage to drain excess water during heavy rainfall/snowfall		Stagnant water leads to breeding of mosquitoes, and facilitates spread of diseases	» Frequency of city streets getting flooded »Sales of bed nets/mosquito coils		Quantitative, Less is better, 2

Table #5: List of chosen primary and secondary water, sanitation and hygiene associated exposure areas

Among the secondary set exposure areas, the ones which have an association with health but the relationship are less direct or are not immediate, are management of industrial waste, controlling water related health risks, health services that have safe water supply.

Industrial waste including hazardous waste disposal:

Industrial waste is another important environment polluting aspect associated with urban cities. Heavy metals, toxic organic and inorganic substances also can pose serious threats to human health and the environment - particularly when industrial wastes are added to the waste stream. Nitrates from waste water can build up to high concentrations in water sources underground. Nutrients may also cause eutrophication - undesirable excess in nutrients - in water sources. This can result in overgrowth of algae

and harmful cyanobacteria. The toxins produced by some toxic cyanobacteria cause a range of health effects, from skin irritation to liver damage [36].

Industrial waste and some effluents in household waste are hazardous in nature for the environment. Hazardous waste is defined as waste that has potential even in low concentrations, to have a significant adverse effect on the public health or the environment. Hazardous waste can be of following types:

- Corrosive - A corrosive material can wear away (corrode) or destroy a substance. For example, most acids are corrosives that can eat through metal, burn skin on contact, and give off vapours that burn the eyes.
- Ignitable - An ignitable material can burst into flames easily. It poses a fire hazard; can irritate the skin, eyes, and lungs; and may give off harmful vapours. Gasoline, paint, and furniture polish are ignitable.
- Reactive - A reactive material can explode or create poisonous gas when combined with other chemicals. For example, chlorine bleach and ammonia are reactive and create a poisonous gas when they come into contact with each other.
- Toxic - Toxic materials/substances can poison people and other life, and can cause illness and even death if swallowed or absorbed through the skin. Pesticides, weed killers, and many household cleaners are toxic.

Health impact of industrial waste dumping: Humans, plants, and animals can be exposed to hazardous substances through inhalation, ingestion, or dermal exposure. Exposures can be either acute in nature (a single time exposure) or chronic (occurs over a much longer period of time, usually with repeated exposures in smaller amounts).

This proposed indicator is to monitor the annual amount of hazardous waste produced per sector (industry, mining, agriculture). It is useful to monitor trends in hazardous waste production, the effectiveness of policy and programme implementation, such as waste minimisation, cleaner production and recycling, and for allowing medium to long-term planning of hazardous waste landfill sites and treatment facilities.

Controlling water related health risks:

Controlling water related health risks refers to systems in place to improve water sources in the city, efficiency of city drainage to drain excess water during heavy rainfall/snowfall etc. City municipalities have sufficient influence to put in place systems to improve water sources by methods such as chlorination, and also to keep a close eye on spread of any water related disease outbreak and be ready to take immediate protective action. Water related diseases spread instantly, thus cities must have strong measures to guard contamination of water (especially drinking water).

The health issues related to drainage water management can be grouped in three categories [43]:

I. water related vector-borne diseases;
II. faecal/orally transmitted diseases; and
III. chronic health issues related to exposure to residues of agrochemicals.

Proper and efficient surface and subsurface drainage of excess water in cities, in a timely manner, plays an important role in controlling water related diseases. Malaria, schistosomiasis (bilharziasis) and lymphatic filariasis are important water related vector-borne diseases. Despite control programs, health services and available treatments, these diseases today represent a growing health problem.

In an interview conducted as part of project research with Prof. Sandy Cairncross, Professor of Environmental Health at London School of Hygiene and Tropical Medicine, he explained how there exists a triangle between solid waste management, rain water drainage and mosquito breeding. Poor solid waste management leads to grounds for breeding of mosquitoes, which in turn leads to spread of vector diseases. Poor solid waste management is also found associated with poor rain water drainage system [44]. Similarly poor rain water drainage could lead to creating breeding grounds for mosquitoes and also lead to sanitation problems.

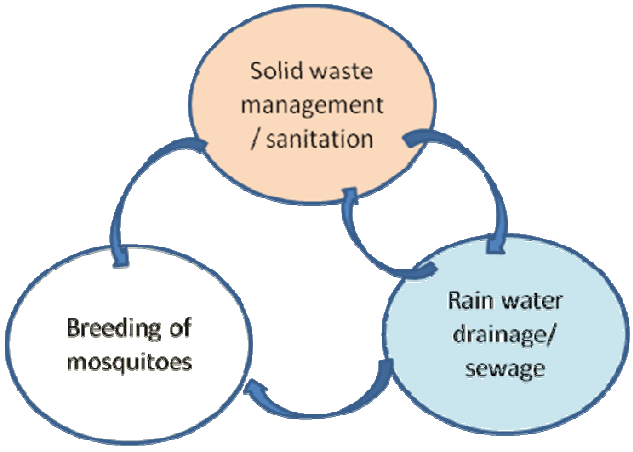

Fig 1: Interconnected forces with respect to water drainage, sanitation and hygiene

Careful control and appropriate reuse of drainage water can help protect the environment and optimize the use of water resources. Hence, water sanitation and hygiene is an exposure area that impacts both health and environment. This area not only has an economic costs/loss associated i.e. with spread of vector borne diseases, but could also have an impact on traffic movement and mobility in an urban city, and could lead to higher traffic congestion, higher emissions and air pollution.

VII.3 Associated policy recommendations

Following table #4 lists policies associated with respect to selected exposure areas and indicators. The list has been developed through literature research, and represents some recommendations. The exact policy change will depend on city setting and situation.

Water and sanitation services have to compete with public services, and the allocated budgets haven't been sufficient in developing countries. SDGs could prove to be a force in bringing water and sanitation services at the forefront to make sure they get required allocation of resources. Cities need to plan and set targets to increase coverage and ensure maintenance programs for existing installations. As mentioned earlier in the report, role of local supplier need to be well recognized. They should be duly incentivized, monitored and regulated to ensure quality and affordable access. Also, the service delivery could be improved through help of partnerships with civil society and the private sector.

For waste management, solving the sanitation challenge in the developing world will also require radically new innovations that are deployable on a large scale. Innovation is especially needed in urban areas, where billions of people are only capturing and storing their waste, with no sustainable way to handle it once their on-site storage—such as a septic tank or latrine pit—fills up. Improvements in toilet design, pit emptying, and sludge treatment, as well as new ways to reuse waste, can help governments and their partners meet the enormous challenge of providing quality public sanitation services—particularly in densely populated urban neighborhoods. [37]

	Exposure	Indicators	Objective	Policy recommendations
Access to improved drinking water sources	Poor communities within urban cities not having access to clean drinking water	» Increase in the proportion of population that has access to improved source of drinking water	» Increase coverage of population having access to improved source of drinking water	» Facilitate increased access to safe water by funding provision activities » Plan and develop supply network, » Ensure maintenance programs for existing installations » Support, monitor and regulate local supplier for drinking water
		» Cost of improved source of drinking water to poor (time and money)	» Make improved source of water more easily accessible	» Improving service delivery though partnerships with civil society and the private sector
Improved sanitation facilities, and disposal of sewage (human excreta n other effluents)	Open defecation; Poor sanitation or no sanitation system leading to water pollution and unhygienic surroundings	» Proportion of sewage collected and treated before disposal	» Build systems and capability to collect and treat household sewage » Increase coverage of population having access to improved source of sanitation	» Identifying and recognising areas/people where there is need for sanitation » Developing a plan with defined goals and targets, and allocate budgets » Building public toilets and sewage systems and informing people of the benefits of good hygiene practices
		» Proportion of households connected to public sewer system		
		» Number of households not having access to improved sanitation facilities		
Collection and management of industrial waste including Hazardous waste effluents	Releasing industrial waste directly in water bodies; unmanaged waste disposal	» Proportion of industrial waste collected and treated	» Build systems and capability to collect and treat industrial waste » Reduce production of harmful waste produced per sector	» Setting up and ensuring effective regulatory mechanisms for industries to follow set guidelines » Enforcing relevant legal frameworks, » Influencing reduction in production by imposing tax on producing industrial waste
		» Regulations for dumping industrial waste		
		» Annual amount of hazardous waste produced per sector (industry, mining, agriculture)		
Controlling water related health risks	Water contamination	» Proportion of water treated (by chlorination or other methods)	» Build local systems and capability to improve drinking water sources » Build capability to fight against water borne vector diseases » Improve city drainage systems	» Build local capability for corrective mechanisms, and allocate budgets » Identifying local areas which are frequent grounds for breeding of mosquitoes and taking corrective actions » Educating people about good hygiene practices to avoid breeding of mosquitoes
		»Prevalence of water borne diseases		
	Efficiency of city drainage to drain excess water during heavy rainfall/snowfall	» Frequency of city streets getting flooded		
		»Sales of bed nets/mosquito coils		

Table #6. Associated policies with respect to exposure areas

Overall, a strong high-level political commitment is required to be put behind all initiatives and efforts to accelerate and sustain improvements in access to adequate and safe drinking-water, sanitation and hygiene services. Achieving goals and targets would need steady focus and commitment on water and sanitation priorities, backed by adequate allocation of resources, and regular and transparent monitoring of progress. States, regions need to identify stakeholders who will be accountable and define their respective roles and responsibilities for achieving set goals and targets. The idea of proposing indicators is to follow a general framework to achieve goals and targets as suited to respective regions.

The importance of investing in safe drinking water, sanitation and its association with health care was strongly advocated by the Kofi Annan, ex-UN Secretary General. In his own words,

> "*We shall not finally defeat AIDS, tuberculosis, malaria, or any of the other infectious diseases that plague the developing world until we have also won the battle for safe drinking water, sanitation and basic health care.*"

VIII. Discussion

Understanding the immense environmental burden and associated population level health impact caused by rapid urbanisation, it is imperative to take into account the urbanisation factor with a focus on cities for determining the post 2015 global development agenda. Given the opportunity cities offer, it is important to work towards building sustainable cities which are more resilient to climate change and are a healthier place to live.

While focusing on what could cities do, and keeping in mind what comes under their jurisdiction, following areas were identified: Active Transport, Water sanitation and hygiene, Household energy and household air pollution, providing education, health services, safe access to green spaces, and access to healthy eating options. Due to constraints of time available for research, only 'Active transport' and 'Water sanitation and hygiene' are covered in this report.

For city transport a comprehensive list of associated exposure area was formulated, and the list was then analysed and critiqued to select a primary and a secondary set of indicators. Reducing air emissions, reducing road injuries, and increasing physical activity were chosen to be the sub areas to focus, given their direct association with both health and environment.

- Reducing emissions could be done by following broadly two strategies, one to reduce the number of vehicles on street and second to invest in better technology/alternate fuels etc. Research shows investing in better technology helps but ends up to more cars on streets, hence the sustainable way forward is to have policies to reduce number of vehicles plying. Emphasis needs to be given for investing in strategies to change travel behaviour, i.e. making people move to public transport, cycling etc. A move to use of public transport is not only a sustainable solution, but is also a healthy active living solution, as people end up doing more physical activity on a regular basis.

- Traffic injuries impact young people more and thus have a heavy economic impact with loss in productive time (which could be in years). The proposed indicator is 'to reduce per capita crash disabilities and fatalities', which may sound straight forward but achieving success needs a multisectroal approach and commitment. The four broad pillars of policy making identified for road safety are establishing measures, educating people, establishing stringent law enforcement, and evaluating and monitoring policy changes.

- Physical activity is being advocated as an essential component of any strategy that aims to seriously address the problems of sedentary living and obesity among children and adults. The proposed indicators are: a) rating on pedestrian friendly/ bike friendly streets, b) increase in percentage of population that regularly walks and cycles (more than 15 mins). The advocacy idea is to make streets friendlier for walking and biking, and encouraging people to do more physical activity. Research has shown, well connected city transport system can go a long way in not only reducing air pollution but making people walk a lot more, and hence should be the way forward for making cities sustainable.

For water, sanitation and hygiene, again a comprehensive list of associated exposure area was formulated, and the list was then analysed and critiqued to select a primary and a secondary set of indicators. 'Access to improved drinking water sources' and 'Improved sanitation facilities, and disposal of sewage' were chosen to be the main sub areas to focus, given their direct association with both health and environment.

Water and sanitation services have to compete with public services, and the allocated budgets haven't been sufficient in developing countries. SDGs could prove to be a force in bringing water and sanitation services at the forefront to make sure they get required allocation of resources.

- For providing improved source of drinking water, specific areas/ population need to be identified and respective plans and targets should be created to extend coverage. The indicators proposed are: a) Increase in the proportion of population that has access to improved source of drinking water; b) Cost of improved source of drinking water to poor. The first indicator measures proportion, thus accounts for the factor of increase in population and takes into account quality by categorizing as improved sources only. However, there is a need to install measures to ensure that sources which have been categorized as 'improved' do not deteriorate and are well maintained. The second indicator accounts for accessibility in terms of cost.
  In developing countries, the role of local suppliers needs to be included in planning to increase coverage, and at the same time measures need to be introduced o monitor price and quality.

- Any investment in better sanitation, starting from construction of pit latrines has direct impact on improving public health and quality of life. Creating appropriate sanitation infrastructure and public services that work for everyone, including poor people, and that keep waste out of the environment is a major challenge. Hence, solving the sanitation challenge in the developing world will require radically new innovations that are deployable on a large scale. Indicators proposed here are: a) Proportion of households connected to public sewer system, b) and households having access to improved sanitation facility.

Overall, a strong high-level political commitment is required to be put behind all initiatives and efforts to accelerate and sustain improvements in access to adequate and safe drinking-water, sanitation and hygiene services. Achieving goals and targets would need steady focus and commitment on water and sanitation priorities, backed by adequate allocation of resources, and regular and transparent monitoring of progress. The idea of proposing indicators is to follow a general framework to achieve goals and targets as suited to respective regions.

In the end, reviewing the list of risk factor clusters, clustered as following by Lim et al. [17]: Unimproved water and sanitation, Air pollution, Other environmental risks, Child and maternal under nutrition, Tobacco smoking, Alcohol and drug use, Physiological risk factors (high cholesterol, BMI, BP etc), Dietary risk factors and physical inactivity, Occupational risk factors and Sexual abuse and violence [17].

Table #7, on following page presents an analysis of impact of each city associated area with respect to risk factor clusters. This is a qualitative analysis of degree of impact of each area with respect to relevant risk factor clusters. This has been done using Harvey ball analysis (using a scale of 1(white moon) to 5(full black moon)).

Active transport has a strong impact on reducing air pollution (already emphasised in the paper earlier). Moreover, it also has some degree of impact on exposure to smoking, as most countries have regulations against smoking in public transport. Hence, when people use public transport compared to using their own car, they are forced to not to smoke for that duration of travel. Interestingly, public transport could also have an impact on reducing sexual abuse and violence, when implemented with supporting policies. An e.g. of this is implementation of Delhi Metro in New Delhi, where there has been a major issue with eve teasing and sexual abuse. In Delhi Metro, separate coaches for women supported by a women police constable, have been very effective, and have managed to make travel safer for women and have helped in increasing their mobility.

Risk factor clusters	Active transport	Housing improvements		Accessible open spaces and fresh foods	Health services
		Water sanitation and hygiene	Household energy and indoor air pollution		
Unimproved water and sanitation		●			
Air pollution	◕		◕	◑	
Other environ. Risks (radon/lead exposure)			◑		
Child and maternal under nutrition		◑			
Tobacco smoking	◔		◔		
Alcohol and drug use					
Physiological risk factors					●
Dietary risk factors and physical inactivity				◕	
Occupational risk factors			◔		
Sexual abuse and violence	◔	◔	◔		

Table #7. Impact of each city associated area on risk factor clusters, analysed using Harvey ball analysis

For water sanitation and hygiene, apart from its obvious benefits in countering the 'unimproved water and sanitation' risk factor, it also has a major impact on child and maternal under nutrition. As with improved source of drinking water and improved sanitation and hygiene, there is reduction in incidence of diseases such as diarrhoea, malaria and pneumonia.

To conclude, the areas in scope of this research, 'active transport' and 'water sanitation and hygiene' have the potential to make a major impact on four out of ten risk factors, i.e. Unimproved water and sanitation, Air pollution, Physiological risk factors and Dietary risk factors and physical inactivity, thus demonstrating a massive associated health impact.

Moreover, both these areas i.e. 'active transport' and 'water sanitation and hygiene', not only have the evidence of large population level health impact, but are also cost effective and call for efficient use of public resources. Both the areas are centred on providing benefits for masses and engaging people in the conversation of sustainable change. Thus, makes a strong case for prioritising these areas and having them at the centre of planning and goal setting while redefining sustainable development goals.

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X. Appendices

	Exposure	Impact		Indicators	Critique	Nature/ Data availability
		Environmental	Health			
Air pollution due to emissions	Exposure to polluted air	Polluted environment, further leading to climate change	Direct toxicity of air pollutants	Per capita emissions of 'conventional' air pollutants (CO, VOC, NOx, particulates, etc.)	Pollution travels in atmosphere, diff. to monitor air pollution	Quantitative, Less is better, 3
				Incidence of Respiratory diseases (cardiac, pulmonary, chronic bronchitis, lung cancer)	Difficult to attribute incidence of respiratory diseases	Quantitative, Less is better, 3
	Emission of CFCs and related halocarbons	Ozone depletion	Harmful effects due to exposure to UV rays	Per capita consumption of Ozone depleting substances	Indirect impact on health	Quantitative, Less is better, 2
	Emission of green house gases	Green house effects leading to climate change	High conc of Green house gases in environment has adverse health effect	Per capita emissions of Green house gases (CO_2, CH_4, N_20, etc.)	Indirect and weak correlation with health impact	Quantitative, Less is better, 3
Non renewable resource use	Consumption of non renewable resources	Non renewable resources scarcity or extinction	Harmful gases released by usage of non renewable resources	Per capita fossil fuel consumption	Impact on health overlaps with air pollution as an exposure	Quantitative, Less is better, 3
	Gases realeased by burning non renewable fuels	Outdoor air pollution		Non-renewable resource consumption in the production and use of vehicles and transport facilities		Quantitative, Less is better, 3
Noise pollution	Exposure to Noise pollution	Noise pollution	Adverse impact on mental health	Portion of population exposed to high levels of traffic noise	Weak supporting evidence of mental health impact	Quantitative, Less is better, 2
Safety	Traffic related injuries		All minor or major injuries to fatalities	Per capita crash disabilities and fatalities	Weak association with environment	Quantitative, Less is better, 3
	Street safety and security	More people choosing to use personal vehicle, in turn causing air pollution and congestion	Sense of insecurity to walk alone to use public transport, leads to lesser physical activity	Perception of security to walk/bike on streets (on a scale of 10)	Secure streets is not the only reason for people to choose public transport or walk/use a cycle	Qualitative, More is better, 1
				Per capita number of reported incidents		Quantitative, Less is better, 3
Physical activity	Indulging in physical activity to travel or activity to access transport	Walking, cycling or more use of public transport leads to greener environment	More physical activity acts as a protective factor for mant diseases	Rating on pedestrian friendly/ bike friendly streets	Difficult to collect data and then monitor	Qualitative, More is better, 1
				% of population that regularly walks and cycles (more than 15 mins)		Quantitative, More is better, 1
Green open space preservation	Accessibility and safeness of green spaces	Maintenance of green spaces	Green spaces make people walk, and also have a positive effect on mental health	Accessibility/Safeness of green spaces for recreational activity/walking etc	Difficult to attribute / measure impact of green spaces on health	Qualitative, More is better, 1
	Land devoted to transport activity	Lack of green spaces leads to poor air quality		Per capita land devoted to transportation facilities		Quantitative, Less is better, 3
Biodiversity protection	Exposure to sewage, solid waste and air pollution generated by city transport activities	Diminishing natural protected areas	Weak and indirect impact on health	»Proportion of protected natural areas; »Monitoring a threatened species (Proportion of species approaching target population size)	Weak and indirect impact on health	Quantitative, More is better, 3
Public transit system	Operational efficiency	More the extent of public transit used, lower the harmful impact on environment	More the extent of public transit used, more is the indulgence in physical activity to access and hence more the health benefits	»Miles of fixed-route bus/train service »Number of minutes between buses/trains on scheduled routes	Needs a strong govt motivation and financial investment to provide efficient public transport. Also, needs a cultural and behavioral change.	Quantitative, Less is better, 3
	Affordability			Portion of household expenditures devoted to transport, particularly by lower-income households.		Quantitative, Less is better, 2
	Quality perceived			»Perceived as choice of commute »Perceived as safe to travel		Quanlitative, More is better, 1

Table #A.1: Transport associated exposure with an environmental and health impact, and corresponding indicators with description of their nature and associated critique

	Exposure	Impact		Indicators	Critique	Nature/ Data availability
		Environmental	Health			
Access to improved drinking water sources	Poor communities within urban cities not having access to clean drinking water	Urban city activities polluting natural resources of water	Leading to diseases such as diarrhoea, or diarrhoea leading to malnutrition, intestinal infections etc	» Increase in the proportion of population that has access to improved source of water	Weak environmental impact; more a concern for rural	Quantitative, More is better, 2
				» Cost of improved source of drinking water to poor	Does not account for maintaining an improved source	Quantitative, Less is better, 2
Improved sanitation facilities, and disposal of sewage (human excreta n other effluents)	Open defecation; Poor sanitation or no sanitation system leading to water pollution and unhygienic surroundings	Feces, when not properly contained pollute the water sources, Housing improvement required to guard against weather and climate changes	Poor sanitation and unhygienic surrounding leads to breeding of mosquitoes and vector borne diseases Water pollution caused by uncontrolled feces, could lead to illness and death	» Proportion of sewage collected and treated before disposal » Proportion of households connected to public sewer system		Quantitative, More is better, 3
				» Number of households not having access to improved sanitation facilities	Less of a concern for urban cities, more a concern for rural areas	Quantitative, More is better, 3
Collection and management of industrial waste including Hazardous waste effluents	Releasing industrial waste directly in water bodies; unmanaged waste disposal	Polluting water bodies with untreated industrial waste which non decomposable	Contact with contaminated water directly or through food chain. Acute health effect: Skin/eye irritation, burning Chronic: Reproductive health, genetic modifications to cancer	» Proportion of industrial waste collected and treated	Unaccounted illegal industrial waste dumping	Quantitative, More is better, 3
				» Regulations for dumping industrial waste		Qualitative, More is better, 2
				» Annual amount of hazardous waste produced per sector (industry, mining, agriculture)	Standards vary from country to country	Quantitative, More is better, 3
Disposal and treatment of solid waste (trash)	Disposal of solid waste generated by urban cities	Air pollution and unpleasant odours, Contamination of soil, ground n surface waters; Loss of productive land due to the presence of nonbiodegradable items	Health hazards from accumulation of polluted water, which provide breeding grounds for mosquitoes and attract flies, vermin	» Segregation of waste » Treatment of waste	Standards vary from country to country	Qualitative, More is better, 3
Water resource management	Measures taken by cities for water resource management	Water as a resource needs to conserved and waste water needs to be retreated	Emphasis on water resource management improves standards of water consumed	» Percentage of financial resources dedicated » Cities having a policy/framework	Weak direct and immediate health impact	Quantitative, More is better, 3
Controlling water related health risks	Water contamination	NA	Water related diseases spread instantly, cities need to have strong measures to guard contamination of water (especially drinking water)	» Proportion of water treated (by chlorination or other methods)	Overlaps with access to improved drinking water	Quantitative, Less is better, 3
				»Prevalence of water borne diseases	Does not monitor root causes	Quantitative, More is better, 3
	Efficiency of city drainage to drain excess water during heavy rainfall/snowfall		Stagnant water leads to breeding of mosquitoes, and facilitates spread of diseases	» Frequency of city streets getting flooded »Sales of bed nets/mosquito coils		Quantitative, Less is better, 2
Impact on education (learning ability)	Access to clean drinking water and proper sanitation facilities have a major impact on access of education for children (especially important for girl child)	NA	Children's learning is affected by related conditions, such as dehydration, diarrhoea and intestinal worm infections, contribute to absenteeism, impair cognitive ability and	»Percentage of schools not having access to clean drinking water and sanitation facility	More of an issue for rural areas	Quantitative, Less is better, 3
Health services that have safe water supply /adequate sanitation	Lack of safe drinking-water, adequate sanitation and hygiene in health centres, clinics and hospitals	NA	Patients are highly susceptible to infections and count on a safe and clean environment.	»Percentage of health facilities not having access to clean drinking water and sanitation facilities	The issue mainly exists for rural areas	Quantitative, Less is better, 3

Table #A.2: Water, sanitation and hygiene associated exposure areas with an environmental and health impact, and corresponding indicators with description of their nature and associated critique

	Exposure	Indicators	Comprehen-siveness	Data Quality	Comparability	Easiness to understand	Accessibility and transparency	Cost effectiveness	Differentiate net effects	Performance targets	Degree of jurisdiction control	Previously used to influence policy	Drives community participation
Primary set	Air pollution due to emissions	Per capita emissions of 'conventional' air pollutants (CO, VOC, NOx, particulates, etc.)	3	3	2	2	2	3	2	3	2	3	2
	Traffic injuries /	Per capita crash disabilities and fatalities	3	3	3	3	3	3	2	3	3	1	2
	Physical activity	Rating of streets on pedestrian friendliness or bike friendliness	2	1	1	2	2	1	3	3	3	2	3
		% of population that regularly walks and cycles (more than 15 mins)	2	1	2	2	2	1	2	3	2	2	3
Secondary set	Green space preservation	Per capita land devoted to transportation facilities	2	2	2	1	2	3	3	3	2	1	1
	Noise pollution	Portion of population exposed to high levels of traffic noise	2	2	1	1	2	2	1	2	2	1	2
	Public transit system	»Miles of fixed-route bus/train service »Number of minutes between buses/trains on scheduled routes	3	3	3	2	2	3	3	3	3	3	2
		Portion of household expenditures devoted to transport, particularly by lower-income households.	3	2	3	3	2	2	3	3	3	3	3
		»Perceived as choice of commute »Perceived as safe to travel	3	2	3	3	2	3	2	3	2	3	2

Table#A.3 Rating city transport related indicators with respect to chosen criteria

	Exposure	Indicators	Comprehen-siveness	Data Quality	Comparability	Easiness to understand	Accessibility and transparency	Cost effectiveness	Differentiate net effects	Performance targets	Degree of jurisdiction control	Previously used to influence policy	Drives community participation
Access to improved drinking water sources	Poor communities within urban cities not having access to clean drinking water	» Increase in the proportion of population that has access to improved source of drinking water	2	2	2	2	2	1	2	3	3	3	1
		» Cost of improved source of drinking water to poor	3	3	2	2	2	3	2	3	2	3	2
Improved sanitation facilities, and disposal of sewage (human excreta n other effluents)	Open defecation; Poor sanitation or no sanitation system leading to water pollution and unhygienic surroundings	» Proportion of sewage collected and treated before disposal	3	3	3	3	2	3	3	3	2	1	2
		» Proportion of households connected to public sewer system	3	3	2	2	2	3	3	3	2	1	1
		» Number of households not having access to improved sanitation facilities	3	2	2	2	2	2	2	3	3	1	1
Collection and management of industrial waste including Hazardous waste effluents	Releasing industrial waste directly in water bodies; unmanaged waste disposal	» Proportion of industrial waste collected and treated	2	2	2	2	2	3	2	2	2	1	2
		» Regulations for dumping industrial waste	2	2	2	2	2	3	3	3	3	2	1
		» Annual amount of hazardous waste produced per sector (industry, mining, agriculture)	2	3	2	2	1	3	2	2	2	1	1
Controlling water related health risks	Water contamination	» Proportion of water treated (by chlorination or other methods)	2	3	2	2	2	3	2	3	3	1	1
		»Prevalence of water borne diseases	2	3	2	2	2	3	1	2	2	2	2
	Efficiency of city drainage to drain excess water during heavy rainfall/snowfall	» Frequency of city streets getting flooded	1	2	1	1	1	2	1	2	3	2	1
		»Sales of bed nets/mosquito coils	2	2	2	2	2	3	2	2	1	1	2

Table#A.3 Rating water sanitation and hygiene related indicators with respect to chosen criteria

Note: The given ratings in the tables above, are based on my own judgement call and need to be validated. However, the idea is to have a list of indicators where an individual indicator might be weak on few selection criteria's but is strong on others and overall provides a good mix with some weight age given to each selection criteria.