# Technical Description of the New Measures for Ecosystem Services and Human Habitat

# DRAFT TEXT –Revision 1

### As described below, one measure still to be selected for the Ecosystem Services component so the detailed summary results are preliminary

Ian Noble - 27 August 2012

## Adding Ecosystem Services to the Core Life Support Sectors

The GAIN Index was initially launched in 2011 with a strong structure to help guide the selection of measures (i.e. the variables that make up the Index). For the vulnerability component of the Index the structure was in the form of a matrix with one axis a set of core life support “sectors” covering Food, Water, Health and an Infrastructure sector (made up of Coastal, Transport and Energy) and the other axis a set of components of vulnerability; Exposure, Sensitivity and Capacity (Fig. 1). In releasing the 2011 version we recognized that many would argue for the inclusion of a sector representing Ecosystem Services among the core life support sectors and the need to include additional urban oriented sectors in the Infrastructure section. This document describes the measures to complete the plan for the vulnerability component of the original GAIN Index.

## Rationale for the Ecosystem Services sector

Ecosystem services are the multitude of processes that humans rely upon to support their lives and livelihoods. These processes provide food and clean water, regulate the climate, support nutrient cycling and provide cultural experiences. In developing the GAIN vulnerability measures we have sought to choose sets of measures that are tangible, simple but directly relevant to the concept to be captured. It is obviously difficult to capture ecosystem services in six simple measures so the use of integrative, synthetic measures was also considered.

### The Measures

### *Exposure*

To be consistent with the other core sectors, we sought a measure of exposure that reflects the size of the likely impacts of climate change over the next few decades. This has proved difficult. An obvious measure is the effect of climate change on the distribution of the ecosystems and biomes[[1]](#footnote-1) that provide the services on which we depend. There are estimates of the proportion of the land surface on which the type of biome might be expected to change under projected climate change. However, most of these estimates are based on what is now old projections and models and most do not account for these changes on a country by country scale as this is rarely relevant to the question at hand. We are still seeking a measure that appropriately captures this element. ***Advice on this will be most welcome.***

Another measure of exposure is how much we depend upon ecosystem services to provide the basis of our economies. Here we have used the work on natural capital, derived largely from the World Bank, that seeks to estimate human dependency on “natural capital”, which is the stock ecosystem goods that can deliver ecosystem services in the future. This work seeks to capture and value the full range of natural capital including both ecosystem services and natural resources such as minerals and fossil fuels. In our measure we choose to focus only on the value of those services derived from ecosystems and expressed as a proportion of the GDP (see ENC – Dependency on Natural Capital below for a complete description).

### *Sensitivity*

To capture the component of sensitivity we again use a synthetic measure. In this case we use the “Ecological Footprint”, which has been gaining increasing acceptance as a proxy for the total impact of human livelihoods on the Earth and its sustaining systems. The ecological footprint seeks to measure the number of hectares of land and ocean needed to support the livelihood of each individual within a city, country or region. It also compares this with the support that the territory of each country can provide per hectare. Some countries have a net deficit; i.e. the population needs more hectares than can be provided locally and thus draw upon resources in other countries and/or deplete resources at greater than a sustainable rate. Some have a net surplus. We use this measure of deficit or surplus as an indicator of how sensitive a country might be to climate change. Countries with a surplus are either able to manage their demand to match their supply or have sufficient land area and associated resources to meet their demand. In either case they are in a better position to meet the challenges of adapting to climate change than a country that is in deficit. Note that this measure is simply seeking to capture the sensitivity of a country and not the ethical situation. The Netherlands, despite high standards of sustainability etc is in net deficit and makes a net drawdown upon resources from elsewhere, whereas Australia because of its low population, large area and abundant resources is in surplus. [See ENC – EEF – Ecological Footprint Surplus/Deficit]

As a second and more qualitative measure of sensitivity we have used an estimate of the health of the country’s ecosystems via the proxy of the proportion or number of threatened species within that country. Threatened species indicate either severe pressure on those ecosystems or the inability to manage those ecosystems effectively, or a combination of both. In either case, the ecosystems are likely to be more sensitive to additional threats associated with climate change. [See ETS – Threatened Species]

### *Capacity*

As a measure of capacity to adapt we have chosen the ability of a country to provide conservation protection to its biomes and its ability and its willingness to engage in international cooperative efforts using multilateral environmental agreements as the proxy. Protection of biomes (and their component ecosystems) is an indication of a capacity of the national institutions to make decisions to undertake conservative management of significant components of the landscape to provide resources and buffers for the future. This is a capacity that is likely to translate into effective reactions to the challenges of climate change. [See EPB Protected Biomes]

Similarly the capacity to work effectively in multilateral efforts to protect the environment is an indicator of a capacity to plan and cooperate in adapting to the effects of climate change. Our proxy does not capture the effectiveness of such engagement in multilateral processes, but work is underway to improve on this. [See EIC – Engagement in Multilateral Environmental Agreements].

## Rationale for the Urban Sector / Human Habitat

The urban sector is of particular importance in effective adaptation to a changing climate as it is also the focus of many other social and economic changes. Internally generated rapid economic and population growth in cities is a challenge in its own right, but it is often exacerbated by substantial migration from rural areas driven as much by the poverty of rural regions as by the attractiveness and opportunities of the cities. In selecting the measures and in seeking feedback from our technical advisors, we decided to modify our approach to recognize the ‘Human Habitat’ as a 5th life support sector.

The measures selected do place more direct emphasis on urban habitats than rural. However, many rural challenges are already covered in the other life support sectors and increasingly the challenge of the future will be creating sustainable cities in a changing world. Cities are usually the financial, administrative and intellectual hubs of society so disruption to their smooth running has significant flow on effects to the rest of the country.

### The Measures

### *Exposure*

There are many measures of the exposure of human habitats to climate and related hazards. Some are already included indirectly in other components of the GAIN Index; e.g. the proportion of the population exposed to seal level threats in the coastal sector. Here we have chosen two measures of exposure. The first seeks to capture the concentration of the population and the associated finance, skills etc in the largest city of the country [See UUC – Urban Concentration]. The second measure looks at the risks from a series of natural hazards (not just climate related, but including earthquakes etc) to the 633 urban areas across the world with greater than 750,000 inhabitants and which house 1.5 billion people [See URP – Urban Risk Profiles].

### *Sensitivity*

Again there are many measures of the quality of urban life, which in turn might indicate the sensitivity of urban areas to the additional impacts of a changing climate. Some, such as comparative levels of poverty in urban versus rural areas would be suitable but are inconsistently recorded with many countries missing data. We have used the UN Millennium Development Goal indicator of the percentage of the urban population living in slums, which is available for most developing countries and can be set to a default value for developed countries. As a second estimate of sensitivity we have chosen to use the difference between the rate of population increase in urban versus rural areas [See UEX - Excess Urban Population Growth]. Rapid urban growth is indicative of challenges in both rural and urban areas. It often reflects poor conditions in rural areas that drive people to the cities in search of better livelihoods. This in turn leads to increased strain on the provision of urban services, which may detract from their continued improvement and maintenance.

### *Capacity*

The two measures of capacity reflect issues of importance to the smooth operation of settlements in general, although probably more important in cities in particular. The first is the effect of electric power outages on business operations [See UEA - Value lost due to electrical outages]. Even though the measure is based on the loss of sales from outages, it is probably a good proxy for the impact on many other aspects of people’s lives. The second measure is based on expert assessment of the quality of core infrastructure (ports, railroads, roads, information technology) that is fundamental to support trade and transport [See UQI - Quality of trade and transport-related infrastructure]. In both measures it is assumed that the capacity to provide effective services and infrastructure under current circumstances is indicative of the capacity to do so under the changing conditions of the future.

## Scoring

Each of the measures described above has been obtained from appropriate reliable sources for as many countries as possible (always >75% of the target of all UN members[[2]](#footnote-2)). The distribution of values of the measure was examined including the mean, median and 5%, 10%, 90% and 95% percentiles and upper and lower bounds selected. These bounds are at “natural” values (such as 0 or 100%) or within the range of the 5% and 10% or 90% and 95% percentiles. The countries scores were then normalized to a range of 0 to 1 between the bounds selected. Occasionally the bounds were varied to provide an average score across all countries within the range of about 0.3 to 0.5 and a standard deviation of about 0.2.

The original values, bounds and scores derived for each measure are shown in the attached spreadsheet.

Each measure was assessed for how independent its score was from the other measures as we sought to select measures that were as independent of each other as possible – i.e they provided different insights into the overall assessment of vulnerability. They were also assessed against existing measures contributing to the Vulnerability Score and against common metrics such as GDP per capita and the Human Dimension Index.

Overall, poor countries are more vulnerable in relation to their Ecosystem Services than wealthy but as Fig 2 shows there is a wide dispersal of scores across all incomes. The separate measures for the Ecosystem Services component are relatively independent with the highest correlation being between the Engagement in Multilateral Environmental Conventions and the (Ecosystem) Natural Capital Dependency scores (R2=0.21). Thus each measure appears to be contributing different information to the overall Ecosystem Services score.

The measures contributing to the Ecosystem Services and Urban Sectors show low correlations with the measures already included in the 2011 Vulnerability Score (most R2<0.1). They are often slightly more correlated with the 2011 Readiness measures. The Dependency on Natural Capital and Urban Slums measures show the highest correlations (average about R2 of 0.2 and 0.3 respectively). The highest correlations are logical – e.g. Urban Slums with Energy Access and Health Diseases (R2 about 0.7). This indicated that overall the new measures are introducing new information into the GAIN Vulnerability Score.

## Effect of the New Measures on Vulnerability Scores and Rankings

The net effect of the new measures on average vulnerability is small (Fig. 3) with the average vulnerability score rising from 0.330 to 0.348, and an average absolute change of 0.030. The largest changes are increases of 0.05 or more among middle vulnerability countries such as Lebanon, Vietnam and Moldova, and among small island states with Palau showing the greatest with an increase of 0.103. The largest falls occur amongst some of the most vulnerable countries (Central African Republic, Dominica, Senegal) and among wealthy countries (Luxemburg, Belgium, Canada) with falls of 0.04 to 0.07.

These changes have an effect on the rankings with some countries becoming more vulnerable by 30 or more positions (e.g. Lebanon, Kyrgyzstan, Moldova, Uzbekistan, Vietnam) and others reducing their vulnerability ranks by more than 25 positions with Russia showing the greatest improvement in vulnerability rank (38 positions). But the overall absolute change in rank is 12 positions with a third changing by 5 positions or fewer. Only 2 of the original 20 least vulnerable countries fell out of that list (Fig 4)[[3]](#footnote-3) while in the 20 most vulnerable countries 4 countries – 3 African; Burkina Faso, Mauritania, & Zambia plus Micronesia - rise out of that zone to be replaced by Haiti, Madagascar, Solomon Islands and Yemen.

## Summary

The value of adding the new measures is that they add a much richer set of information underlying the iconic GAIN and Vulnerability scores. The Ecosystem Services and Human Habitat measures complete the commonly recognized of human life support ‘sectors’ - food, water, health and now ecosystem services and human habitat. They add to the richness of the index and provide greater opportunity to dig deeper into risks and opportunities for investment. That these measures did not hugely affect the overall vulnerability scores and rankings demonstrates the inherent robustness of the GAIN index and its value as an icon in attracting attention and raising awareness about the importance of vulnerability to climate events and readiness to adapt to changing climatic circumstances.

## Summary of the New Measures

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | **Exposure** | **Sensitivity** | **Capacity** |
| **Ecosystem Services** | Quantity | Exx  tbd | EEF - Ecological Footprint Surplus/Deficit | EPB - Protected Biomes |
|  | Quality | ENC - Dependency on Natural Capital | ETS - Threatened Species | EIC - Engagement in International Environmental Conventions |
| **Human Habitat** | Quantity | UUC - Urban Concentration (% urban population in largest city) | UUS - % Urban Population Living in Slums | UEA - Value lost due to electrical outages (% of sales) |
|  | Quality | URP – Urban Risk Profiles (Risks to populations living in cities >0.75M) | UEX - Excess Urban Population Growth (compared to rural) | UQI - Quality of trade and transport-related infrastructure |

### Ecosystem Services

**Measure:** tbd

**Description**: Seeking a measure of the threat from climate change to ecosystems/biomes.

**Rationale**: This will match the other core sectors (Food, Water, Health) each of which has a measure that deals with the exposure to future climates (e.g. Projected temperature increase, projected agricultural yields).

**Source**:

**Coverage**:

**Time Series**:

**Issues**: Many projections of biome shifts are quite dated (i.e. old GCM modeling, limited selection of GCMs and most based on a single ecological model). There are several more up-to-date projections, but none express results on a per country basis as it is not a mainstream variable likely to be used in analyses.

**Measure:** ***EEF - Ecological Footprint Surplus/Deficit***

**Description**: The ecological footprint measures the number of hectares of land and water, both within and outside the country, to supply the average demand on the ecosystems services by the lifestyles of the population of each country. This is compared with the estimated capacity of a country’s ecosystems to regenerate and maintain ecosystem services for either internal use or export. This measure uses the surplus or deficit of capacity to supply over the demand within each country.

**Rationale**: A country with a surplus has the capacity to produce more from within its boundaries and thus is likely to have more options to adapt to a changing climate.

**Source**: Results from National Footprint Accounts 2011 edition, [www.footprintnetwork.org](http://www.footprintnetwork.org) extracted on 12 July 2012.

**Coverage**: 151 countries

**Time Series**: Technically available since 1961, but will require some effort to extract them.

**Issues**: (i) The ecological footprint has been in use since 1992 and the subject of considerable scientific testing and debate. The methods of calculation are becoming more standardized and it is gradually being taken into account in policy making and national reporting. Here we use the data provided by the Global Footprint Network led by one of the originators of the idea, Mark Wakernagel.

(ii) We also exclude the carbon footprint component of the Ecological Footprint since this does not directly affect sensitivity relating to adaptation. The urban component is also effectively excluded as it appears in both the demand and supply side of the equation.

(ii) There is a similarity in concepts between the Ecological Footprint and the Natural Accounting approach used in ENC. We have checked the correlations between the two measures and the data that goes into constructing them. While there is a strong correlation between some of the components (e.g. Grazing land capital and footprint) as they are based on the same or similar data (Ha of grassland per capita), there is little correlation between the two measures used (r2 is -0.024 and Fig 5) as ultimately the data are used to calculate quite different measures – a measure of capital in one case and a measure of supply in the other.

**Measure:** ***EPB – Protected Biomes***

**Description**: Taken directly from the Yale Environmental Performance Index (EPI) which defines it as follows … “The weighted percentage of biomes under protected status, where the weight is determined by the size of biomes within a country. Countries are not rewarded for protecting beyond 17% of any given biome (i.e., scores are capped at 17% per biome) so that higher levels of protection of some biomes cannot be used to offset lower levels of protection of other biomes.”

**Rationale**:. Countries with good protection of their core ecosystem types are likely to have the capacity to implement a wider range of actions to continue to protect and manage ecosystem services under a changing climate.

**Source**: Emerson, J.W., A. Hsu, M.A. Levy, A. de Sherbinin, V. Mara, D.C. Esty, and M. Jaiteh. 2012. 2012 Environmental Performance Index and Pilot Trend Environmental Performance Index. New Haven: Yale Center for Environmental Law and Policy

http://epi.yale.edu/downloads

**Coverage**: 192 countries

**Time Series**: Annual since 1990

**Issues**: (i) The measure does not take into account the quality of the management of the protected area. The Yale team also acknowledges this and they are working towards gathering improved data.

**Measure:** ***ENC - Dependency on Natural Capital expressed as a % of the GDP.***

**Description**: Based on Natural Capital accounting project of the World Bank. This measure seeks to account for the use of natural capital in national accounting by including information on the change in natural capital such as mineral resources, forest stocks etc. In this measure only those elements related to ecosystem services are counted. These are crop, pasture, forest (timber), forest (non-timber) and protected areas. Sub-surface capital such as oil, gas and mineral reserves are not included in this measure for GAIN.

**Rationale**: This measure captures a country’s reliance on ecosystem services, which are themselves exposed to disruption by climate change.

**Source**: See “The Changing Wealth of Nations : Measuring Sustainable Development in the New Millennium.” World Bank 2011, ISBN 978-0-8213-8554-8 (electronic). <http://data.worldbank.org/sites/default/files/total_and_per_capita_wealth_of_nations.xls>

**Coverage**: 148 countries.

**Time Series**: Three estimates; 1995, 2000, 2005

**Issues**: (i) This is a comprehensive treatment with strong academic input and institutional support but it is not widely used elsewhere probably due to its complexity. The most recent estimate appeared this year but reflects data of 2005. Although work on similar measures continues and is accelerating under the “green accounting” umbrella, it is not certain that another comparable update will occur.

(ii) With only 148 countries, this is one of the vulnerability measures with the weakest coverage.

(iii) This measure includes GDP in its calculation as the natural capital is expressed as the net present value of the particular capital as a percentage of the GDP – something we have tried to avoid given it can impose a double jeopardy on poor countries. However, its correlation with ln(GDP per capita) is R2=0.54 with a wide scatter among the poorer countries (Fig. 6) showing that it provides additional information.

**Measure:** ***ETS -*** ***Threatened Species.***

**Description**: Composite measure made up of (1) the percentage of mammal species recorded as threatened; (2) the percentage of plant species threatened; and (3) the number of bird species threatened. These three groups (mammals, plants and birds) represent a good, but incomplete, coverage of the state of ecosystems. Birds have to be treated differently from mammals and plants because the number of bird species within a country is difficult to determine as many are migratory over long distances and the source of the threat of extinction may arise from causes far distant from the country.

**Rationale**: Threats of extinction arise from many pressures currently unrelated to climate change. Further climate change is likely to exacerbate these pressures in many cases and thus this measure is an indication of the sensitivity of a country’s ecosystems services to change in the future.

**Source**: IUCN Red Book and related data.

**Coverage**: 187 countries.

**Time Series**: Single estimate only.

**Issues**: (i) There is some overlap with a country’s capacity to manage its natural resources.

(ii) The measure does not include species that have passed from threatened to extinct. There are data that could be used but they would have to be rescaled to be incorporated. Extinction data also raised issues of equity; for example regions recently settled by technological societies such as North America and Australia will score disproportionately high while extinctions for areas with longer settlement of this type (e.g. Europe and China) many extinction would go unrecorded.

**Measure:** ***EIC -*** ***Engagement in International Environmental Conventions***

**Description**: A measure based on the country’s participation in international forums, which is taken as an indicator its capacity to engage in multilateral negotiations and to reach agreement on appropriate actions internally.

**Rationale**: Although not a direct measure of capacity, the failure to take part in such forums is usually associated with either lack of technical capacity to deal with the issues and/or lack of political ability to reach decisions over appropriate engagement.

**Source**: From <http://sedac.ciesin.columbia.edu/entri/index.jsp>

**Coverage**: 198 countries

**Time Series**: Annual since 1995 based on the continually increasing number of conventions etc and the time lags in countries signing and ratifying the agreements.

**Issues**: (i) The outcome for this measure is strongly dependent on the process of selecting the agreements to be included (Table 1). We sought to include "environmental treaties" in their broadest sense while avoiding any to do with military/warfare; gross marine pollution, safety at sea and other shipping controls. We also excluded treaties directly setting up International organizations such as the World Bank etc. We also excluded agreements with less than 20 signatories.

(ii) Some agreements have a limited regional scope (e.g. dealing with Atlantic tuna). We could have excluded them, but this would have limited the list (16 out of 54 have clear regional scope of application), but many are signed by countries beyond the region (e.g those with fishing fleets in the Atlantic). Many (17 out of 54) also deal with the agreements on oceans and this may disadvantage land-locked countries, however, land-locked countries are sometimes signatories to such conventions (e.g. those relating to whaling). It could similarly be argued that some agreements are not relevant to many countries on other grounds (e.g. those to do with desertification). Thus we chose to retain a wide set of agreements rather than begin a culling process that would have reduced the list to only 10 to 20 or so.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

### Urban

**Measure:** ***UUC - Urban Concentration***

**Description**: Percentage of the population living in the largest city.

**Rationale**: A high concentration of people in one city creates challenges in adapting to climate change. The concentration suggests stressed services, few choices for displaced rural poor and vulnerability to major losses in a single extreme climate event.

**Source**: World Bank, World Development Indicators, EN.URB.LCTY.UR.ZS

**Coverage**: 183 countries

**Time Series**: Annual since 1995

**Issues**: (i) An alternative measure is the proportion of the population living in cities with a population of 0.75 million or more (this is the threshold used by UNESA). But this approach would exclude the 71 countries with no city reaching the UNESA threshold.

**Measure:** ***URP - Urban Risk Profile***

**Description**: A natural disaster risk index for populations living in large cities (i.e. >0.75M people).

**Rationale**: The large cities of a country are the centres of attraction for rural to urban migration and the economic drivers in most countries. Severe human suffering and social and economic disruption can occur if these cities are struck by natural disasters. This measure seeks to capture that risk based on a data set from the UNESA statistical data. See the Annex for a detailed description of its derivation.

**Source**: UN Dept Economic & Social Affairs; <http://esa.un.org/unup/CD-ROM/Urban-Agglomerations.htm>

**Coverage**: 192 countries; 121 countries have cities meeting the size criterion and the remaining countries are given a default risk of zero.

**Time Series**: Single estimate of the risk profile itself, although the population weightings could be updated as populations change, but the effect would be very small over the next 5 to 10 years.

**Issues**: (i) See the Annex for issues associated with its derivation.

(ii) The data used in this measure indirectly brings in information from the databases of recent frequency and impacts of disasters. We have tried to exclude these data as much as possible from the GAIN Index as we wanted to maintain them as a largely independent source of corroborative data for assessing the validity of the Index.

(ii) What value be given to should countries without a city of 0.75 million people? Here the default is zero, since we are trying to measure the threat to large conurbations and all that depend on them.

**Measure:** ***UUS - Urban Population Living in Slums***

**Description**: A slum household is defined as a group of individuals living under the same roof lacking one or more1 of the following conditions: Access to improved water; Access to improved sanitation; Sufficient-living area; Durability of housing (Tenure is included as a 5th element, but insufficient data is available).

**Rationale**: Slums impose a great challenge to successful adaptation especially in cities.

**Source**: UN Millennium Development Goals Data - 7.10 Proportion of urban population living in slums. <http://mdgs.un.org/unsd/mdg/Metadata.aspx?IndicatorId=0&SeriesId=710>

**Coverage**: 87 countries in the original set but expanded to159 after assumption that wealthier countries have a default score of 0

**Time Series**: 1990, 1995, 2000, 2005, 2007, 2009; best for 2005

**Issues**: (i) This is an indirect estimate and includes some measures that overlap with those used elsewhere in the Index. However correlation analysis shows that correlations are low. It is related to GDP/cap but still conveys useful information especially at intermediate levels of GDP/cap (Fig 7).

(ii) The assumption that wealthy countries (not estimated as part of the MDG) have no people in slums is probably technically correct by the UN MDG definition, but an underestimate in practice.

**Measure:** ***UEX - Excess Urban Population Growth***

**Description**: Excess rate of population growth in urban centres compared with the population growth rate in the whole country.

Formulae:

Expected urban popn growth = Urban popn \* Country Popn growth

Excess urban popn growth = (Urban Popn \* Urban Popn growth – Expected urban popn growth) /   
 Expected urban popn growth

**Rationale**: If the urban population is growing considerably faster than the country as a whole, this is likely to be putting additional strain on urban services and making it difficult for city managers to also consider and plan for the effects of climate change.

**Source**: World Bank, World Development Indicators; SP.URB.TOTL; SP.URB.GROW; SP.POP.GROW

**Coverage**: 186 countries

**Time Series**: Since 1995

**Issues**: None???

**Measure:** ***UEA - Value lost due to electrical outages***

**Description**: Percentage of sale lost due to electrical outages.

**Rationale**: This is a measure of the capacity to provide a stable supply of electricity, which is fundamental to production, life support and comfort. It is likely to be indicative of the capacity to provide other essential services. Analysis of other possible measures relating to the provision of services (e.g. road provision, travel times, the efficiency various business transactions etc) show them to be correlated with electrical outages but not as comprehensively reported in many cases, or used elsewhere in the Readiness Axis.

**Source**: World Bank, World Development Indicators; IC.FRM.OUTG.ZS

**Coverage**: 150 countries

**Time Series**: Scattered 2002 to 2010 with most reporting countries having 2 or 3 values

**Issues**:

**Measure:** ***UQI - Quality of trade and transport-related infrastructure***

***Description:*** Logistics professionals' perception of country's quality of trade and transport related infrastructure (e.g. ports, railroads, roads, information technology), on a rating ranging from 1 (very low) to 5 (very high). Scores are averaged across all respondents.

**Rationale**: The quality of this infrastructure is indicative of capacity to effectively supply and manage essential infrastructure by the public and private sectors. It is assumed here that same capacity is indicative of a capacity to sustain that infrastructure in the face of future changes, including climate change.

**Source**: World Bank, World Development Indicators; LP.LPI.INFRA.XQ

**Coverage**: 159 countries

**Time Series**: 2006 & 2009 for most countries

**Issues**: (i) This measure is close to some of those used directly or indirectly in the Readiness axis, which is indicative of the overlap between ‘capacity’ and ‘readiness’ as we have discussed before.

## Figures

Figure 1. New Summary of the matrix of measures (in blue)

|  |  |  |  |
| --- | --- | --- | --- |
| **Sector** | **Exposure** | **Sensitivity** | **Capacity** |
| **Water** | 🞆 🞊 | 🞆 🞊 | 🞆 🞊 |
| **Food** | 🞆 🞊 | 🞆 🞊 | 🞆 🞊 |
| **Health** | 🞆 🞊 | 🞆 🞊 | 🞆 🞊 |
| **Human Habitat** | 🞆 🞊 | 🞆 🞊 | 🞆 🞊 |
| **Ecosystem Services** | 🞆 🞊 | 🞆 🞊 | 🞆 🞊 |
| **Infrastructure** |  |  |  |
| Coastal | 🞆 | 🞆 |  |
| Energy | 🞆 | 🞆 |  |
| Transport | 🞆 | 🞆 |  |

New Listing of all the measures used in the Vulnerability Score of the GAIN Index

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sector** | | **Exposure** | **Sensitivity** | **Capacity**  **(Low capacity contributes to vulnerability)** |
| **Life Support Sectors** | | | | |
| **Water** | **Quantity** | **High** Projected change in precipitation | **High** Internal and external freshwater water extracted for all uses | **Low** Population with access to improved water supply |
| **Quality** | **High** Projected change in temperature | **High** Mortality among under 5 yr-olds due to water-borne diseases | **Low** Population with access to improved sanitation |
| **Food** | **Quantity** | **High** Projected change in agricultural (cereal) yield | **High** Proportion of the population living in rural areas | **Low** Agricultural capacity |
| **Quality** | **High** Coefficient of variation in cereal crop yields | **High** Food import dependency | **High** Children under 5 suffering from malnutrition |
| **Health** | **Quantity** | **High** Estimated impact of future climate change on deaths from disease | **Low** Health workers per capita | **Low** Longevity |
| **Quality** | **High** Mortality due to communicable (infectious) diseases | **High** Proportion of health expenditure derived from internal resources | **High** Maternal mortality |
| **Human Habitat** | **Quantity** | **High** Concentration of urban population | **High** proportion of population in urban slums | **High** Losses to electrical outages |
| **Quality** | **High** Urban risk profile | **High** excess of urban over rural population growth rates | **Low** Quality of transport & trade related infrastructure |
| **Ecosystem  Services** | **Quantity** | tbd | **Low** Ecological footprint surplus | **Low** Protection of biomes |
|  | **Quality** | **High** Dependency on natural capital derived from ecosystems | **High** Threatened species | **Low** Engagement in multilateral environmental agreements |
| **Infrastructure Sectors** | | | | |
| **Coast** | **Quantity** | **High** Proportion of land less than 10m above sea-level | **High** Proportion of population living less than 10m above sea-level | *Measured on the Readiness Axis* |
| **Energy** | **Quantity** | **Low** Population with access to reliable electricity | **High** Energy at risk |
| **Transport** | **Quantity** | **High** Frequency of floods per unit area | **Low** Percentage of roads paved |

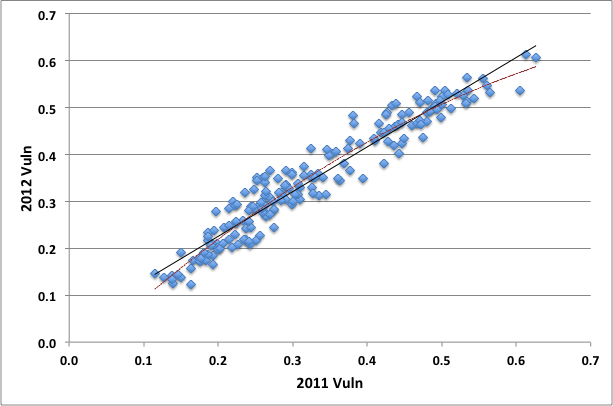
Figure 2. The relationship between the Total Ecosystem Services Vulnerability component to GDP per capita (here Ln(GDP/cap)). Although there is a negative relationship (poor countries are more vulnerable on this score, R2=0.34), there is a wide dispersal across all income levels.



*Figure 3. Country rankings with respect to the new measures and the effect of the new measures on vulnerability rankings1. The background colours in the rightmost column of ranking data show reduced or no change in vulnerability rank (green), increased vulnerability (pink) and new to the list (yellow).*

To be redone

1 Note that this list of the “Original” differs slightly from that shown on the web as the web used different rules for missing data for inclusion in the list. However, it does not change the basic conclusions.

*Figure 4. The new measures increase the average vulnerability score marginally from 0.330 to 0.348 with middle vulnerability countries tending to increase slightly in vulnerability and those with high or low vulnerability being more likely to fall.*

*Figure 5. No correlation between the measures based on Natural Capital Dependency and the Net Ecological Footprint scores.*



*Figure 6. Relationship between Dependency on (Ecosystem) Natural Capital and GDP per capita. There is a negative relationship (R2=0.54) but there is a wide scatter among the poorer countries, while wealthier countries (above about $5000 to $8000 per year) tend to be less dependent on the ecosystem component of natural capital. Many of the wealthier countries are mineral and oil rich states and are thus dependent on natural capital in its full definition.*



*Figure 7. Proportion of the population living in slums is related to wealth, but there is nevertheless a wide scatter among countries of intermediate wealth per capita.*



Table 1. List of international agreements used in EPB – Engagement in Environmental Treaties

|  |
| --- |
| **List of international agreements used in *EPB – Engagement in Environmental Treaties*** |
| 1. African Convention on the Conservation of Nature and Natural Resources |
| 1. Agreement for the Establishment of a General Fisheries Commission for the Mediterranean |
| 1. Agreement for the Establishment of the Asia-Pacific Fishery Commission |
| 1. Agreement for the Implementation of the Provisions of the United Nations Convention on   the Law of the Sea relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks |
| 1. Agreement on the Conservation of African-Eurasian Migratory Waterbirds |
| 1. Amendment of the Plant Protection Agreement for the Asia and Pacific Region |
| 1. Amendment to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (Art.XI) |
| 1. Amendment to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (Art.XXI) |
| 1. Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer |
| 1. Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer |
| 1. Amendments to Articles 6 and 7 of the Convention on Wetlands of International Importance especially as Waterfowl Habitat |
| 1. Convention concerning the Protection of the World Cultural and Natural Heritage |
| 1. Convention for the Establishment of the European and Mediterranean Plant Protection Organisation |
| 1. Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region |
| 1. Convention for the Protection of the Mediterranean Sea against Pollution |
| 1. Convention for the Protection of the Ozone Layer |
| 1. Convention for the Regulation of Whaling |
| 1. Convention on Biological Diversity |
| 1. Convention on Environmental Impact Assessment in a Transboundary Context |
| 1. Convention on Fishing and Conservation of the Living Resources of the High Seas |
| 1. Convention on International Trade in Endangered Species of Wild Fauna and Flora |
| 1. Convention on Long-Range Transboundary Air Pollution |
| 1. Convention on Wetlands of International Importance especially as Waterfowl Habitat |
| 1. Convention on the Conservation of Antarctic Marine Living Resources |
| 1. Convention on the Conservation of European Wildlife and Natural Habitats |
| 1. Convention on the Conservation of Migratory Species of Wild Animals |
| 1. Convention on the Continental Shelf |
| 1. Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal |
| 1. Convention on the High Seas |
| 1. Convention on the International Maritime Organization |
| 1. Convention on the Protection and Use of Transboundary Watercourses and International Lakes |
| 1. Convention on the Territorial Sea and the Contiguous Zone |
| 1. International Convention for the Conservation of Atlantic Tunas |
| 1. International Convention for the Protection of New Varieties of Plants as amended on 23.10.1978 |
| 1. International Convention for the Regulation of Whaling |
| 1. International Convention to Combat Desertification in those Countries Experiencing Serious Drought and or Desertification |
| 1. International Plant Protection Convention |
| 1. International Plant Protection Convention (1979 Revised Text ) |
| 1. International Tropical Timber Agreement |
| 1. International Tropical Timber Agreement |
| 1. Plant Protection Agreement for the Asia and Pacific Region |
| 1. Protocol Relating to Modification of the International Convention for the Conservation of Atlantic Tunas |
| 1. Protocol concerning Mediterranean Specially Protected Areas |
| 1. Protocol for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources |
| 1. Protocol on Substances that Deplete the Ozone Layer |
| 1. Protocol to amend the Convention on Wetlands of International Importance especially as Waterfowl Habitat |
| 1. Protocol to the Antarctic Treaty on Environmental Protection |
| 1. Protocol to the Convention on Long-Range Transboundary Air Pollution concerning the Control of   Emissions of Nitrogen Oxides or their Transboundary Fluxes |
| 1. Protocol to the Convention on Long-Range Transboundary Air Pollution on further Reduction of Sulphur Emissions |
| 1. Protocol to the Convention on Long-range Transboundary Air Pollution on Long-Term Financing of   Co-operative Programme for Monitoring and Evaluation of the Long Range Transmission of Air Pollutants in Europe ( EMEP ) |
| 1. Protocol to the International Convention for the Regulation of Whaling |
| 1. The Antarctic Treaty |
| 1. United Nations Convention on the Law of the Sea |
| 1. United Nations Framework Convention on Climate Change |

## Annex 1 – Derivation of the *Urban Risk Profile*

The UNESA provide data for the 633 cities with populations of at least 0.75 million people (c. 2010 data)[[4]](#footnote-4). These data include the risk posed to these cities by natural events: cyclones, droughts, floods, earthquakes, landslides and volcanoes. These can form the basis to calculate an overall risk index for each city.

Even though the GAIN Index focuses on climate change, in our analysis here the non-climate related risks; earthquakes, volcanoes and landslides (which may have a climate component) are included. The rationale is that we are seeking to measure the impact of any major disruption by natural causes on the functioning of the city. A case could be made for including a wider range of natural causes (e.g. endemics; heat-waves, etc) and human induced disturbances such as industrial accidents, but data are not available for them. As will be discussed below, it is unlikely that their inclusion would have made a great difference to the final scores.

The UNESA data set also includes whether a city is coastal and whether it lies within an arid area. These latter variables may be used to give an indication of whether the city is subject to chronic risks, such as coastal storms and erosion or water restrictions, that don’t reach disaster levels but that may reduce the operating effectiveness of the populations within the affected cities.

Calculations:

The risks from the six core disaster types are given in the UNESA data by ranges; no risk (here scored 0); deciles 1 to 4 (scored 2.5); deciles 5 to 7 (scored 6) and deciles 8 to 10 (scored 9)[[5]](#footnote-5). The coastal data is simply coastal (here scored 10) or not (scored 0), and the dryland data includes 5 categories which I have rated; not arid (scored 0); dry sub-humid (2.5); semi arid (5); arid (7.5) and hyper-arid (10). Thus, after scoring each variable has a range of approximately 0 to 10. From these variables we need to calculate a combined risk score.

After a number of trials with the data an *arbitrary judgment* was made to allocate 80% of the risk score to the six core disaster types and 10% to each of the chronic risks (coastal and aridity). This seemed to give an appropriate balance to the sub-disaster, chronic risks and the impacts of disasters.

However, the 80% of the risk score needs to be weighted in some way to account for the different likelihoods that the different core disaster types might occur (e.g. floods are much more common than volcanic disasters) and how they might affect the cities. An earthquake and a drought might affect roughly the same number of people but the earthquake does much more damage to infrastructure. We used the CRED disaster database on the number of people affected and economic losses in these disasters over the period 1978 to 2010 to weight the different disaster types [See the Table below]. These historical data are the best representation we have of the current, and new future, frequencies and impacts of natural events. For example, floods are responsible for 54% of the people affected (column E in the Table) but only 25.5% of the losses (column B). The CRED data do not separate impacts in urban and rural areas and nor does any other equivalently comprehensive data set. Also, the loss data are estimated for only 30% of disasters and it is clear that the losses in developing countries are under-estimated or often not estimated at all.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | A | B | C | D | E | F | G |
| Disasters from 1978 to 2010 | Estimated Losses (US$ Billion) | As % | Scaled Loss Weights | People Affected (millions) | As % | Scaled Affected Weights | Average Scaled Weights |
| Flood | 460 | 25.5% | 2.04 | 3,105 | 54.0% | 4.32 | 3.18 |
| Storm | 765 | 42.4% | 3.40 | 778 | 13.5% | 1.08 | 2.24 |
| Drought | 91 | 5.1% | 0.40 | 1,709 | 29.7% | 2.38 | 1.39 |
| Earthquake | 475 | 26.4% | 2.11 | 148 | 2.6% | 0.21 | 1.16 |
| Landslides | 8 | 0.4% | 0.04 | 10 | 0.2% | 0.01 | 0.02 |
| Volcano | 3 | 0.2% | 0.01 | 4 | 0.1% | 0.01 | 0.01 |
| **Total** | **1,803** | **100.0%** | **8.00** | 5,754 | 100.0% | 8.00 | 8.00 |

The contribution by each of the disaster types was rescaled to total 8 for each of the losses and people affected (columns C & F in the Table) and the average contribution calculated (column G). The two chronic stresses were given a weight of 1. These weights were used to calculate a weighted sum of risks for each city. Thus the highest risk score approaches 100, while a city with no risks would score 0.

The outcome was an average risk score across all cities of 31 with half of the score being contributed by flood risk, a sixth by drought risk and a little less by both of cyclone (storm) and coastal position. Earthquakes contributed <4% and landslides and volcanoes were negligible. The 30 highest risk cities based on this methodology are shown below.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Rank** | **City** |  | **Risk** |  | **Rank** | | **City** |  | **Risk** |
| 1 | Manila | Philippines | 72.9 |  | 9 | Zhongshan | | China | 63.0 |
| 1 | Davao | Philippines | 72.9 |  | 9 | Zhuhai | | China | 63.0 |
| 3 | Cebu | Philippines | 70.8 |  | 9 | Bucheon | | Rep. Korea | 63.0 |
| 4 | Da Nang | Viet Nam | 68.1 |  | 9 | Goyang | | Rep. Korea | 63.0 |
| 5 | Chittagong | Bangladesh | 67.6 |  | 9 | Ulsan | | Rep. Korea | 63.0 |
| 6 | Tokyo | Japan | 66.1 |  | 9 | Acapulco | | Mexico | 63.0 |
| 7 | Kolkata | India | 65.2 |  | 9 | New Orleans | | USA | 63.0 |
| 8 | Busan | Rep. Korea | 63.2 |  | 23 | Ahvaz | | Iran | 61.7 |
| 9 | Hong Kong | China | 63.0 |  | 24 | Valparaíso | | Chile | 61.3 |
| 9 | Jinjiang | China | 63.0 |  | 25 | Reynosa | | Mexico | 60.6 |
| 9 | Lufeng | China | 63.0 |  | 25 | McAllen | | USA | 60.6 |
| 9 | Quanzhou | China | 63.0 |  | 27 | Kaohsiung | | China | 60.1 |
| 9 | Shantou | China | 63.0 |  | 28 | Tainan | | China | 59.8 |
| 9 | Shenzhen | China | 63.0 |  | 29 | Taipei | | China | 59.7 |
| 9 | Xiamen | China | 63.0 |  | 29 | Matola | | Mozambique | 59.7 |

But the potential impact of natural disasters must also depend on the population of the city. When population is taken into account (risk score \* population) we see that Tokyo is by far the city with the greatest risk of damages (social and economic) from natural disasters with as score twice as high as the next rated cities – Shanghai and New York.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Rank |  | Population weighted risk |  | Rank |  | Population weighted risk |
| 1 | Tokyo | 2460 |  | 16 | Mumbai | 521 |
| 2 | Shanghai | 1202 |  | 17 | Seoul | 516 |
| 3 | New York-Newark | 1071 |  | 18 | Jakarta | 488 |
| 4 | Delhi | 956 |  | 19 | Rio de Janeiro | 464 |
| 5 | Kolkata | 939 |  | 20 | Lima | 457 |
| 6 | Manila | 865 |  | 21 | Hong Kong | 449 |
| 7 | Dhaka | 740 |  | 22 | Guangdong | 433 |
| 8 | Shenzhen | 670 |  | 23 | Lagos | 422 |
| 9 | Mexico City | 664 |  | 24 | Chennai | 418 |
| 10 | Osaka-Kobe | 649 |  | 25 | Foshan | 386 |
| 11 | Guangzhou | 645 |  | 26 | Bogotá | 385 |
| 12 | Los Angeles | 612 |  | 27 | London | 381 |
| 13 | Karachi | 608 |  | 28 | Lahore | 372 |
| 14 | São Paulo | 574 |  | 29 | Chittagong | 354 |
| 15 | Buenos Aires | 572 |  | 30 | Istanbul | 353 |

These scores now need to be converted to a national score. This is done by calculating the sum of the populated weighted scores for each of the large cities within a country and dividing this by the number of people living in those large cities to reflect the potential damage at an individual level. Thus, we have essentially a per capita risk for the populations living in the largest centres of habitation and production.

The countries most at risk are shown below.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 1 | Somalia | 70.1 |  | 16 | Laos | 54.6 |
| 2 | Ecuador | 68.5 |  | 17 | Indonesia | 53.4 |
| 3 | Chile | 65.6 |  | 18 | Jordan | 52.2 |
| 4 | Afghanistan | 65.6 |  | 19 | Colombia | 52.1 |
| 5 | Mozambique | 64.7 |  | 20 | Haiti | 51.3 |
| 6 | Nicaragua | 64.7 |  | 21 | Japan | 50.1 |
| 7 | Philippines | 64.5 |  | 22 | Madagascar | 50.0 |
| 8 | Guatemala | 64.1 |  | 23 | Algeria | 49.9 |
| 9 | Bangladesh | 62.2 |  | 24 | Peru | 49.6 |
| 10 | Viet Nam | 60.5 |  | 25 | New Zealand | 48.7 |
| 11 | Lebanon | 58.5 |  | 26 | Singapore | 48.7 |
| 12 | Dominican Rep. | 56.5 |  | 27 | Argentina | 48.3 |
| 13 | Rep. Korea | 55.4 |  | 28 | Honduras | 48.0 |
| 14 | Pakistan | 55.3 |  | 29 | India | 47.2 |
| 15 | Nepal | 54.8 |  | 30 | Iran | 47.0 |

The lowest scoring countries (scores 20 or lower) are a mix of European and East European countries with inherently low disaster risk profiles, but it also includes some similar developing countries such as Mongolia, Togo and Zambia.

One issue that remains is how to deal with the 70 UN countries that do not have any cities of 750,000 population. Some have widely dispersed, largely rural populations and here an appropriate score is low and approaching zero as they have no large population centres at risk. The risks to these countries are picked up through other measures in the full Index. However, Iceland, for example, has a population of only 320,000 of which 200,000 live in the Reykjavik area is not captured in the above analysis. The risk to Reykjavik is likely to be as important (or greater) than the risks to some countries scoring high on the country risk index above. Similarly Jamaica does not appear in the scored countries (even though some sources quote the population of Kingston as exceeding 750,000) while Cuba, which is in the same cyclone risk area, is scored as 30.8.

At this stage all countries without a city of >750,000 people are scored as zero. The overall effect on the total vulnerability score of allocating a zero score is less than 2% for most cases. An alternative approach would be to mark these countries as having missing data. This would result in a slightly smaller “error” but could also lead to a few countries being excluded from the GAIN Index due to too many missing values. The third option would be to allocate estimated values to the 70 countries (e.g. 25 to all small island states in cyclone zones), but this is not being pursued at this stage.

1. Biomes are a higher order structure than ecosystems. They are made up of a collection of ecosystems and “ecoregions” representative of a particular broad climate and soil type. There are several schemes describing the Earth’s biomes, but most recognize 10 to 20 biomes for terrestrial ecosystems. [↑](#footnote-ref-1)
2. List of 192 countries; South Sudan cannot be included [↑](#footnote-ref-2)
3. San Marino also fell out as it reports insufficient data to be included in the 2012 Index [↑](#footnote-ref-3)
4. UNESA World Urbanization Prospects: The 2011 Revision: Highlights. ESA/P/WP/224 March 2012 [↑](#footnote-ref-4)
5. Natural Disaster Hotspots: A Global Risk Analysis (Dilley et al., 2005) jointly produced by the Center for Hazards and Risk Research (CHRR), the Center for International Earth Science Information Network (CIESIN), the International Research Institute for Climate Prediction (IRI), and the Lamont-Doherty Earth Observatory (LDEO) at Columbia University, and the Hazard Management Unit (HMU), Development Economics Research Group (DECRG) at the World Bank, (http://www.ldeo.columbia.edu/chrr/research/hotspots/). The database includes information collected for cyclones (for the period between 1980 and 2000), droughts (between 1980 and 2000), earthquakes (between 1976 and 2002), floods (between 1985 and 2003), landslides, and volcano eruptions (between 79 and 2000). Data are published with a spatial resolution ranging from a 30 by 30 arc second grid to a 2.5 by 2.5 arc degree grid for cyclones, earthquakes, landslides, volcanoes, droughts and floods. Data for floods are less reliable or missing in the early-mid 1990s. For each single hazard, all grid cells with occurrence data were divided into deciles, 10 classes consisting of approximately equal numbers of grid cells. The higher the value of the grid cell, the higher the decile ranking and the greater the frequency of the hazard relative to other cells (Dilley et al., 2005: 23-34). [↑](#footnote-ref-5)