# Summary of Measures in the Vulnerability component of GAINTM.

The vulnerability component of GAIN follows a consistent structure based on the best of published thinking on the topic, the IPCC Review process, and guidance received from the Council of Scientists and the Advisory Board.

The basic structure focuses on an initial set of ‘sectors’ made up of Water, Food, and Health that cover core issues relating to people’s well-being. It also has an infrastructure section that initially includes the three sectors Coastal, Transport and Energy, which directly affect the livelihoods of many people. Within each of the sectors vulnerability is represented by three components describing Exposure of the sector the climate related hazards and in particular climate change; Sensitivity of that sector to the impacts of that hazard and the Capacity of national populations to cope/adapt with these potential impacts. The Vulnerability axis of GAINTM seeks to represent vulnerability and adaptive capacity that is largely in the domain of action by communities, Civil Society Organizations and/or national governments. Adaptive capacities that may realistically be influenced by or affect the private sector are reflected in the Readiness Axis.

Based on feedback at the May 2011 Meetings, the following criteria were used in selecting the measures for inclusion in the GAINTM:

1. Meet user needs and ensure they are transparent and conceptually clear.
2. Consistent with current knowledge and best practice.
3. Composed of a small set of variables with the selection based on a logical structure; e.g. selected sectors each treated by Exposure – Sensitivity – Capacity as described above.
4. Based on data that are accessible, quality checked, and comprehensive in national coverage.
5. The Sensitivity and Capacity measures should be actionable; i.e. they can be influenced by actions and leading to measurable changes within a few years.
6. The Sensitivity and Capacity measures should have time series of data available wherever possible so that national progress over the past decade or so can be tracked.
7. Potentially scalable from national to regional and local.
8. They should avoid directly incorporate broad socio-economic measures, such as GDP/capita, HDI etc., but instead focus on variables that are directly representative of the sector and the components of vulnerability.
9. Selection of measures should be guided by existing relevant indices and the GAINTM outcome compared with those indices.

The draft GAINTM 1.0 model implements this guidance as follows.

* For each of the sectors (water, food, health) two streams of measures are incorporated; one describing essentially quantitative measures (amount of water, how much is used, how many have access) and the other, where possible, quality measures (exposure to poor quality water, impacts of poor water on people, access to quality management measures).
* The selection of measures will always be a subjective exercise, but some greater objectivity is introduced by following the above guidelines and the systematic structure. Numerous variables (c. 20 different measures for water alone) have been considered and tested against the guidelines in making the selection.
* Often potential variables were highly correlated. In this case they were examined for the information that appeared to be associated with the ‘outlier’ observations to see if the variables had different sensitivities. They were also compared with other measures to be included in a sector, or other sectors, to see if they appeared to be providing additional information. Often the choice was swayed by the availability and quality of the global data.

The Table below briefly describes the selection for the draft version of GAINTM 1.0. They are subject to revision based on further analysis and advice from the Council of Scientists, the Advisory Board and wider public consultation. Annex 1 provides a more detailed technical description of each of the measures and the data sources used. The highly structured inclusion rules (sectors, by components of vulnerability etc.) provide a means for a debate on the inclusion of better measures, of new sectors etc.

## Creating the Index

Systematic methods for converting the raw data from the various measures into an index are needed. There are many different methods for rescaling raw data into similar ranges of values, including normalizing to a common mean and standard deviation; setting base low and high values for the raw data (e.g. from the observed minimum to the observed maximum; or from 0 to 100% compliance etc.) and scaling the data either linearly or after a transform to a prescribed range (e.g. 0 to 1; 0 to 100; -1 to +1). Some indices convert the raw data to ranked values and work with them.

In the GAINTM Vulnerability Index, we were guided by the principles of transparency and simplicity. Thus, we used the following procedures.

* The measure itself was selected so that the raw data itself was a meaningful representation of the information we were seeking. If some form of transformation was needed (e.g. expressing in appropriate units, log transformation to better represent the real sensitivity of the measure etc.) it was considered at this stage.
* Baseline minimum and maximum values for the raw data were selected. These were based on common sense criteria and usually encompassed all or most of the observed range of values, but in some cases countries exceeded the bounds and their scores ‘saturated’. For example, for access to improved water the range was set from 0% to 100%; for water related child mortality it was set from 0% to 40% which was just above the highest observed; for mortality from communicable diseases it was set from 0 % to 60% even though some countries have higher rates. All measures were then scaled to the range 0 to 1.
* The measures were combined by simple arithmetic average for each of the sectors considered without further weighting.
* The sectors were combined to give the final Vulnerability Index by simple arithmetic average again.
* Other methods for calculating the final index are possible and could be justified, but this is a simple and transparent process and it appears to provide an adequate result. Annex 3 provides a discussion of the sensitivity of the Vulnerability Index to these assumptions including the use of geometric means, ranked values and the random exclusion of measures.

Table 1. Summary of the measures used in the Vulnerability Index

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Sector |  | Exposure | Sensitivity | Capacity |
| Water | Quant | **Projected change in precipitation (%).** Gross measure of threat to water resource – change in run-off would be better but not available currently in a globally comprehensive and authoritative data set. | **% Internal and external freshwater water extracted for all uses.** An indication of how much of the nationally controllable resource is already being used. | **% Population with access to improved water supply.** High % indicates capacity to deliver water to the population and hence lower vulnerability. |
|  | Qual | **Projected change in temperature**. Water quality issues rise in warmer conditions as disease growth & spread increases; less water for sanitation etc. {Also brings projected temperature change onto the Vulnerability axis} | **Mortality among under 5 yr-olds due to water borne diseases**. Measure of current extent of impacts due to poor water quality (and to a lesser extent quantity). | **% Population with access to improved sanitation**. As above. |
| Food | Quant | **Projected change in agricultural (cereal) yield** (based on Wheeler 2011). Cereal yield is often treated as the most effective indicator of the effects of climate on food supply. This measure is a compilation of several estimates of the effect of projected climate change on cereal yield. | **% of population living in rural areas**. These people have livelihoods most vulnerable to climate impacts and usually poorer services. | **“Modernization” of agriculture.** A combined measure of fertilizer use per ha of arable land, percentage or arable land irrigated and the mechanization (number of tractors per ha) of agriculture. Not all of these measures are relevant to (or reported by) all countries so the average of the two best (least vulnerable) measures is used. |
|  | Qual | **Coefficient of Variation in cereal crop yields.** This is a measure of the ratio of the standard deviation to the mean national cereal yield over the past 20 years (corrected for technological yield increases) and reflects the exposure of national crop yields to the climate and other national effects. | **Cereal Import Dependency.** The ratio of imported to total consumption of cereals, which is an indicator of the sensitivity of food supply to international production trends and price shocks. | **% Under 5 year-olds with “wasting”.** This measures low weight to height ratios and is considered the best measure of persistent malnutrition. High malnutrition among young children is a strong indicator of low capacity to deliver food. |
| Health | Quant | **Estimated impact of current CC on DALYs**. These are based on work by WHO and published in Ebi 2008. They project changes in mortality from three major diseases due to climate change. | **Doctor & Nurses per capita**. A measure on-the-ground delivery of health services. | **Longevity**. Greater longevity implies better capacity for general health support either through medical services or through community practices. |
|  | Qual | **% of total mortality due to communicable (infectious) diseases.** An indication of the current exposure of the population to factors likely to worsen under climate change. | **% of health expenditure derived from external resources.** An indicator of the sensitivity of the local health systems to any form of shock. | **Maternal Mortality.** Lifetime risk of female mortalitydue to maternity related factors. High mortality indicates poor capacity to deliver health care to a particularly vulnerable group. |
| Infrastructure sectors | | | For the 3 infrastructure sectors only one set of exposure and sensitivity measures are included. Capacity in relation to infrastructure threats is not included as they often overlap with measures considered for the Readiness Axis. | |
| Coastal | Quant | **% Land less than 5 m above sea-level.** This is the zone that is subject to threats from sea level rise and storms. | **% Population in the zone less than 5 m above sea-level.** Sensitivity of both people and to a large extent infrastructure. |  |
| Energy | Quant | **% population with access to reliable energy**. People without access to electricity will remain vulnerable to impacts on the energy sector, either through impacts on traditional energy sources or through delays in achieving eventual access. | **% energy derived from either imports or hydro-power**. As both could be vulnerable to disruption under climate change. {I am still working on this to incorporate a component to represent imported fuel used to generate electricity. Also, should the exposure & sensitivity measures be swapped? There is only a single estimate for energy access and a time series for the source of energy.} |  |
| Transport | Quant | **Number of floods reported in the CRED data-base** over the period1992 to 2007 divided by total land area. Floods represent the major threat to transport infrastructure in many part of the world. | **% of roads that are paved**. Paved roads are usually much less sensitive to climate impacts than unpaved. |  |
|  |  |  |  |  |

# Results for the Vulnerability Axis.

## Data Availability

{The results from our efforts to incorporate the change in the measures in the recent past are not yet ready, but will be available this week – July 11th. We have time series data over the period 1995 to about 2008 for most non-exposure measures. Box 2 gives an idea of the types of analyses we are doing. }

The availability of globally comprehensive and quality checked data at national level data is one of the main criteria for selecting measures for inclusion in the GAINTM. A number of measures, including some often used or cited as good indicators, such as measures of irrigation use, were rejected because of poor or inconsistent coverage. Data were taken from the World Development Index (May 2011 version) were available as they represent a set of quality checked, maintained, full sourced and publicly available information.

**Table 2. The 20 least and the 20 most vulnerable countries and a sample from the middle ranked countries based on the 185 countries with sufficient data.**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Vulnerability | | | | | |  |
| Least | | Middle | | Most | | Not Scored |
| Denmark | 0.102 | Tunisia | 0.290 | Lesotho | 0.496 | Andorra |
| Norway | 0.125 | Indonesia | 0.293 | Marshall Is | 0.497 | Congo (DRC) |
| France | 0.139 | Montenegro | 0.293 | Kiribati | 0.500 | Liechtenstein |
| Germany | 0.140 | Saudi Arabia | 0.293 | Rwanda | 0.505 | Monaco |
| UK | 0.142 | Albania | 0.295 | Tanzania | 0.505 | Nauru |
| Finland | 0.144 | Vietnam | 0.295 | Malawi | 0.507 | Romania |
| Switzerland | 0.144 | Libya | 0.297 | Afghanistan | 0.507 | Timor-Leste |
| Czech Rep | 0.145 | Bahrain | 0.299 | Burkina Faso | 0.511 | Tuvalu |
| New Zealand | 0.147 | Grenada | 0.301 | Mauritania | 0.512 |  |
| San Marino | 0.153 | Fiji | 0.303 | Liberia | 0.512 |  |
| Poland | 0.158 | Suriname | 0.304 | Sierra Leone | 0.523 |  |
| Sweden | 0.158 | Sri Lanka | 0.304 | Mali | 0.528 |  |
| Ireland | 0.159 | Bahamas | 0.306 | Chad | 0.533 |  |
| Austria | 0.165 | Seychelles | 0.307 | Ethiopia | 0.534 |  |
| Luxembourg | 0.168 | Philippines | 0.310 | Angola | 0.535 |  |
| USA | 0.176 | Cape Verde | 0.311 | Zambia | 0.546 |  |
| Uruguay | 0.182 | Nicaragua | 0.312 | Niger | 0.558 |  |
| Slovenia | 0.187 | Costa Rica | 0.313 | Mozambique | 0.560 |  |
| Italy | 0.189 | Dominican Rep | 0.313 | Cent Afr Rep | 0.575 |  |
| Croatia | 0.189 | Sao Tome Princ. | 0.313 | Burundi | 0.582 |  |

The target set of countries for inclusion is the 192 members of the UN (as of 30 June 2011). This means that territories etc. are omitted, but often data coverage for them is spotty. Eventually full data sets were available for 171 countries and if the coverage criteria is relaxed to allow for up to 3 missing measures the number increased to 185. Among the countries with missing data are several developed countries that do not report data consistently. These include Andorra, Liechtenstein, Monaco, Romania and San Marino. Sometimes data for the new Baltic States had to be estimated from earlier national statistics. Data for Least Developed Countries and Small Island States were often missing. Estimates were made where they could be logically justified, for example by assessing Small Island States as being fully exposed to coastal risks. In some cases estimates were made that were moderately more pessimistic that the likely value. This provides an incentive to the country to provide a more accurate estimate. These estimates are documented in the full databases.

Table 3. **Sample of rankings based on the 185 countries meeting the “relaxed” criteria for completeness**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Vulnerability | | | | | |
| Most exposed | | Most sensitive | | Least capacity | |
| Zambia | 0.564 | Burundi | 0.587 | Somalia | 0.858 |
| Central Afr. Rep | 0.553 | Afghanistan | 0.555 | Chad | 0.855 |
| Afghanistan | 0.502 | Somalia | 0.546 | Niger | 0.848 |
| Mozambique | 0.494 | Marshall Islands | 0.539 | Sierra Leone | 0.826 |
| Mali | 0.494 | Malawi | 0.536 | Afghanistan | 0.825 |
| Bangladesh | 0.490 | Mozambique | 0.535 | Mali | 0.796 |
| Botswana | 0.488 | Yemen | 0.519 | Nigeria | 0.784 |
| Gambia | 0.477 | Kiribati | 0.504 | Ethiopia | 0.783 |
| Lesotho | 0.468 | Ethiopia | 0.502 | Burkina Faso | 0.773 |
| Angola | 0.465 | Papua New Guin. | 0.502 | Madagascar | 0.751 |
| Burundi | 0.465 | Niger | 0.496 | Central Afr. Rep | 0.751 |
| Dominica | 0.464 | Micronesia, F.S. | 0.494 | Burundi | 0.749 |
| Mauritania | 0.462 | Samoa | 0.494 | Angola | 0.722 |
| Togo | 0.460 | Senegal | 0.493 | Sudan | 0.719 |
| Zimbabwe | 0.456 | Zambia | 0.489 | Guinea-Bissau | 0.719 |
| Rwanda | 0.455 | Lesotho | 0.488 | Liberia | 0.711 |
| Malawi | 0.448 | Rwanda | 0.487 | Guinea | 0.707 |
| Namibia | 0.447 | Central Afr. Rep | 0.481 | Mozambique | 0.696 |
| Myanmar | 0.441 | Angola | 0.480 | Mauritania | 0.689 |
| Tuvalu | 0.435 | Bhutan | 0.477 | Tanzania | 0.686 |

## What the Vulnerability Axis tells us

The full ranking is provided in Annex 2 and a summary in the Table 2. The least vulnerable are a group of developed and largely European countries, while the most vulnerable are a mix of least developed African and Small Island States. Table 3 shows the states that scored highest as the most exposed, sensitive or lowest capacity. Again African and Small Island States predominate. Four countries rank in the most vulnerable for all three components: Afghanistan, Burundi, Central African Republic and Mozambique. Somalia appears high on both sensitivity (3rd) and low capacity (1st), but is not ranked in the top 20 most vulnerable states because it is assessed as having only moderate exposure.

### Relationship with other Vulnerability Indices

We compared the GAINTM Vulnerability Index with other published indices (see also Box 1 for comparisons with sectoral indices such as the Water Poverty Index).

While there is strong agreement among the indices in that they find a group of least developed or conflict affected states as the most vulnerable, they vary significantly in the detailed rankings. Some of this variation arises because of different goals for the indices and thus the selection of measures; for example, some are more oriented towards environmental quality, some are tuned for financial allocations etc. Some of the variation arises from different approaches to the construction of the index (e.g. Brooks & Adger 2003); and some arises because the indices in the comparison have been developed over more than a decade and the available data and the condition of the countries have changed over that period.

Five indices and the GAINTM Vulnerability Index were compared by looking for overlap between countries in the top 20 for each index (Table 4). A total of 65 countries appear in the 120 slots in the comparison (6 indices by 20 top ranks); 17 appear in 3 or 4 indices and none in more than 4. The GAINTM Vulnerability Index includes 14 of the 17 among its top 20, which shows that it is not an outlier among the indices.

A closer comparison shows further differences. The Wheeler index has been developed at about the same time as that as GAINTM and with similar although not identical goals; Wheeler suggests his index as a tool for the allocation of public money for adaptation while the GAINTM seeks to provide guidance to both the private and public sectors on where to place investments. The two indices have 11 countries in common among their top 20 but Fig. 2 shows that the correlation in scores between the indices is only r2=25%.

**Table 4. A comparison of the 20 most vulnerable countries in recently published indices. Countries in blue appear 4 times in the table and those in red 3 times.**

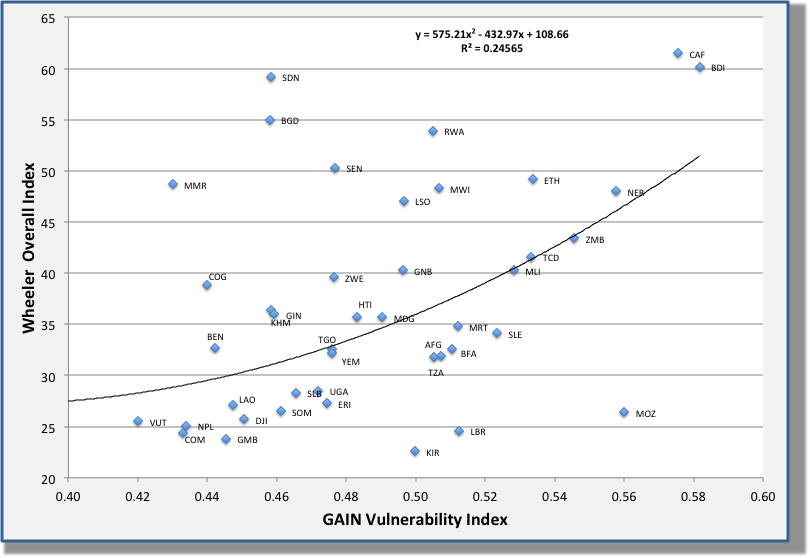
|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Moss et al 2001** | **WEF 2002** | **Brooks & Adger 2003** | **DARA 2010** | **Wheeler 2011** | **GAIN1.0 Vulnerability Index** |
| Bangladesh | Angola | Antigua & Bar. | Afghanistan | Bangladesh | Afghanistan |
| Cambodia | Burundi | Australia | Angola | Burundi | Angola |
| China | Cambodia | Bangladesh | Burkina Faso | Cambodia | Burkina Faso |
| Egypt | Central Afr Rep. | Belize | Burundi | Central Afr Rep | Burundi |
| India | Chad | Cambodia | Congo DR | Chad | Central Afr Rep |
| Iran | Ethiopia | China | Djibouti | Congo | Chad |
| Libya | Guinea | Djibouti | Equ. Guinea | Ethiopia | Ethiopia |
| Mexico | Guinea-Bissau | Fiji | Guinea-Bissau | Guinea | Guinea-Bissau |
| Nigeria | Haiti | Guyana | Haiti | Guinea-Bissau | Kiribati |
| Poland | Liberia | Iran | Liberia | Lesotho | Lesotho |
| Rep Korea | Madagascar | Kenya | Madagascar | Malawi | Liberia |
| Saudi Arabia | Malawi | Kiribati | Mali | Mali | Malawi |
| Senegal | Mali | Laos | Mozambique | Myanmar | Mali |
| South Africa | Mozambique | Malawi | Myanmar | Niger | Mauritania |
| Sudan | Niger | Moldova | Niger | Rwanda | Mozambique |
| Thailand | Rwanda | Mongolia | Rwanda | Senegal | Niger |
| Tunisia | Sierra Leone | Philippines | Senegal | Sudan | Rwanda |
| Ukraine | Somalia | Swaziland | Sierra Leone | Vietnam | Sierra Leone |
| Uzbekistan | Zaire | Tajikistan | Somalia | Zambia | Tanzania |
| Yemen | Zambia | Zimbabwe | Vanuatu | Zimbabwe | Zambia |
| 3 | 15 | 3 | 10 | 13 | 14 |

The above numbers are a count of the number of frequently appearing countries (3 or 4 times).

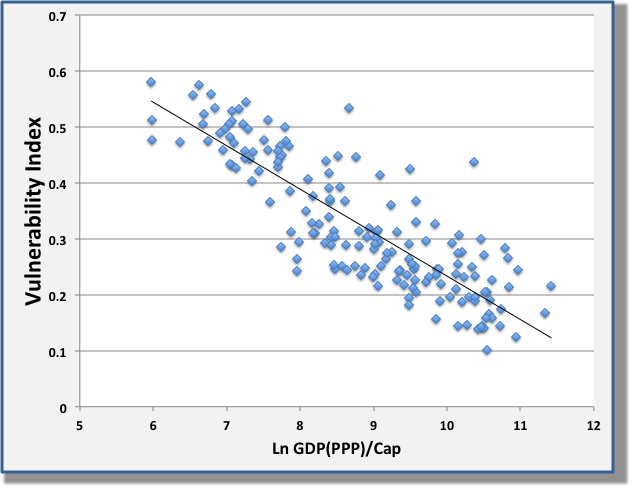
### Correlation with National Income per capita

Many developing countries and both public and NGO development agencies have expressed concerns about vulnerability indices as they so often incorporate and simply exaggerate the effect of low resources and in particular the effect of low incomes. In developing the Vulnerability Index direct and indirect inclusion of GDP per capita was avoided. However, many of the variables are correlated with GDP per capita and as a consequence so is the Index itself (Table 5, Fig. 2). This is particularly true of the Capacity component and for the Health sector, as might be expected.

**Figure 1. A comparison of the most vulnerable countries in the Wheeler (2011) and GAINTM 1.0 Vulnerability indices. Even though there is overlap in the countries ranking as the most vulnerable, there is still substantial differences in the scores.**



**Figure 2. Relationship between the GAINTM Vulnerability Index and national income**



The scatter about the best-fit line, which can be considered as a predictor of Vulnerability based on national income, contains some information about national circumstances. Countries falling well above the best-fit line tend to be resource rich counties where the distribution of the benefits of the wealth is not evenly distributed. But countries with high (or low) exposure, which is only weakly correlated with income, will also tend to fall away from the best-fit line.

**Table 5. Pearson r2 correlation (with sign) of the components of the Vulnerability Index with Ln(GDP(PPP) per capita)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Summary** |  |  |  |
| Total | -0.72 |  |  |
| Water | -0.37 |  |  |
| Food | -0.47 |  |  |
| Health | -0.71 |  |  |
| Infrastr | -0.36 |  |  |
| Exposure | -0.47 |  |  |
| Sensitivity | -0.50 |  |  |
| Capacity | -0.72 |  |  |
| **Water** |  | **Food** |  |
|  |  |  |  |
| Delt PPt as % | NS | ACDI | -0.15 |
| % f/water withdrawals | NS | % Rural Popn | -0.47 |
| Improved water | -0.52 | Two measure Av | -0.34 |
| Delta Temp | 0.08 | CV annual Yield | NS |
| Water Deaths <5yr | -0.48 | Import Depend | 0.06 |
| Improved sanitation | -0.64 | %Wasting | -0.52 |
|  |  |  |  |
| **Health** |  | **Infrastructure** |  |
|  |  |  |  |
| CC induced Dalys | NS | Area % <5m asl | NS |
| 2\*Doc+Nurse/Midwife | -0.52 | Pop % <5m asl | NS |
| Longevity | -0.64 | % pop with electricity | -0.56 |
| % mort comm diseases | -0.60 | Energy at risk | NS |
| Ext Resources Health | -0.42 | Floods frequency | NS |
| Maternal Mortality | -0.52 | % Paved roads | -0.38 |
|  |  |  |  |

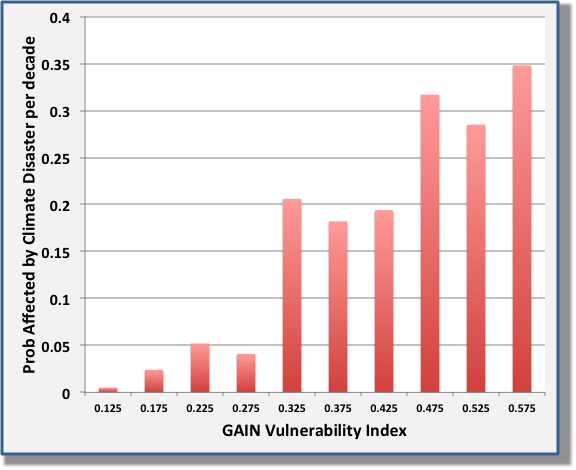
## Testing the Validity of the Vulnerability Index

There is no direct way to test indices that seek to provide information about future conditions, and especially where those conditions are expected to change from recent and current conditions. Nevertheless it might be expected that an effective index of future vulnerability largely based on measures taken recently should be related to current vulnerability. That leaves the question of how to measure current vulnerability.

One test is that numerous studies have concluded that vulnerability is associated with low national incomes per capita. As shown above, even though we were careful to minimize the direct or indirect inclusion of GDP per capita information from the GAINTM index, we found a high correlation between the two.

Another test is to ask if the GAINTM Index is correlated with recent impacts of climate change on people. Here we use the CRED database on disasters to calculate the number of people affected by climate related disasters over the 30-year period 1980 to 2010. The correlation was highly significant but with only an r2=22%. However, as Fig. 3 shows that the probability that an individual has been affected by a climate related disaster increases from less than 1% per decade in countries with low values of the Vulnerability Index to 35% at the highest values.

**Figure 3. The relationship between the GAINTM Vulnerability Index and the probability of being affected by a climate related disaster over the past 30 years.**

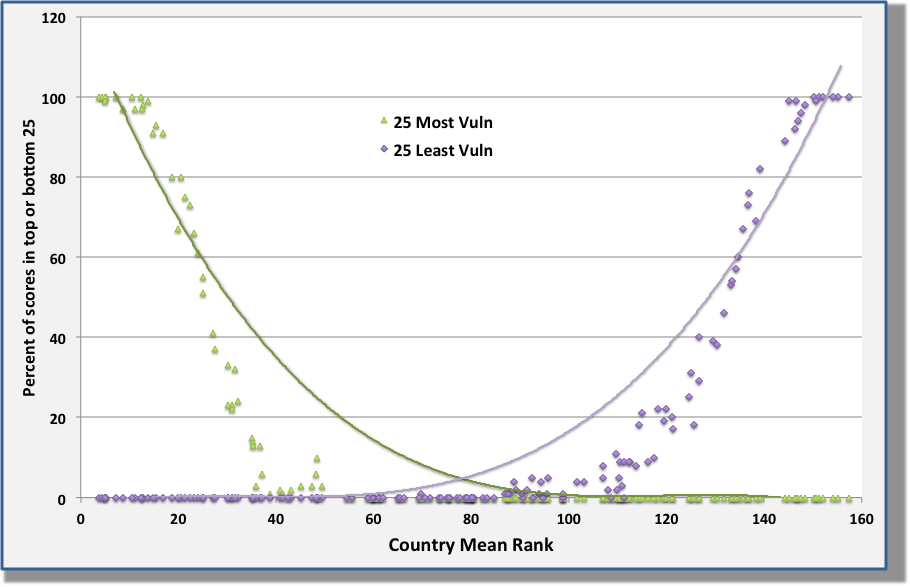


### Testing the derivation of the Index

Several tests have been performed to see how sensitive the outcomes from the index are to the method by which the index was calculated.

One test is to ask how sensitive the index is to the set of measures that were chosen for inclusion. It is not possible to estimate the effect of measures not chosen, but we can ask whether the index would vary if certain measures had been omitted.

**Figure 4. The results from a Monte Carlo simulation of omitting particular measures from the Vulnerability Index. See text for an explanation.**



To test this we ran 100 ‘Monte Carlo simulations’ in which we recalculated the index but each time randomly omitting a third of the measures that constitute the Vulnerability Index and then recalculating the country ranks. In Fig. 4 the countries are plotted in their original rank order across the X-axis and the Y-axis shows in how many simulations each country was ranked among the most or least vulnerable 25 (symbols). We also created a random set of data for the measures and did a similar Monte Carlo simulation with this random set and the results are show by the lines.

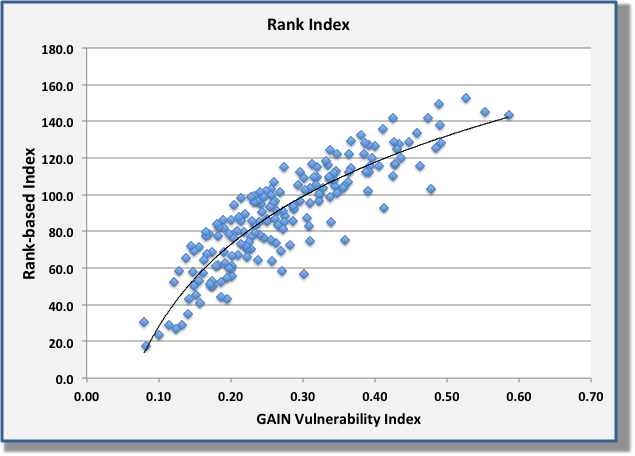
The results show that random omission of measures has only a small impact on the top and bottom rankings and especially on the most and least vulnerable scores. For example the countries ranked at about 25th (top or bottom) still had 60% chance of being in the top or bottom 25 with the random omission of a third of the measures. Those ranked in the top or bottom 10 have almost 100% chance of remaining in the top 25. Comparison with the random data shows that this tendency was far greater that for random data, i.e. than due to chance.

This suggests that the Vulnerability Index is robust to the inclusion or exclusion of the particular measures. It also suggests that calculating the Vulnerability Index for countries with a few missing measures probably still gives a good estimate of their GAINTM score.

There are other ways the Index could be calculated. For example, sometimes a geometric mean[[1]](#footnote-1) is used. However, geometric means are only sensible where the model underlying the index is appropriate because it will score a country that has any one measure scored as 0 as having no vulnerability. Our model for the GAINTM Vulnerability Index is not compatible with calculating geometric means as we have used what is essentially an underlying additive conceptual model.

Another approach is to use rank scores for each of the measures rather than the absolute values and then to average these ranks to get an overall index. This was tried for components of the GAINTM data. It showed than on the whole the results were similar, but that the ranked approach becomes less sensitive at higher vulnerabilities. This is because where there are a number of countries with similar scores, the additive approach used in GAINTM gives them similar index values, whereas the ranking method can separate the cluster of countries over a wide range of ranks leading to wide differences in the final index. This is shown in Fig. 5, which shows a comparison of the ranking and the GAINTM additive method in the water sector. The average difference in final ranked position for the two different approaches is 20 positions.

**Figure 5. A comparison of a ranking method to calculate a Water Sector index and the additive method used in GAINTM.**

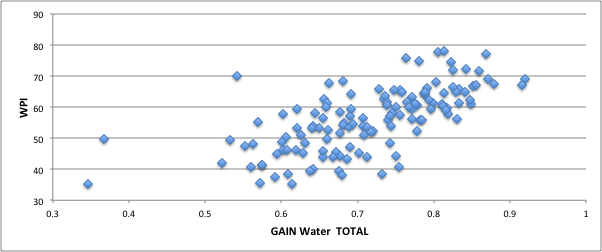


**Box 1. GAINTM Water Sector and the Water Poverty Index (WPI)**

|  |  |
| --- | --- |
| **WPI Component Data Used** | **GAIN** |
| **Resources** |  |
| 1. • internal Freshwater Flows | Indirectly included in the measure of water withdrawal as a percent of internal + external inflows |
| 1. • external Inflows |
| 1. • population | Not a measure of water resources |
| **Access** |  |
| 1. • % population with access to clean water | Included |
| 1. • % population with access to sanitation | Included |
| 1. • % population with access to irrigation adjusted by per capita water resources | Not included but was considered for the Food measures but excluded as the data is poorly reported. |
| **Capacity** |  |
| 1. • ppp per capita income | Not a measure of water resources |
| 1. • under-five mortality rates | Similar, but more specific, measure used – viz “Under 5 year-old Mortality due to water borne diseases”. The two measure are highly correlated, but the GAIN measure is more directly water related. |
| 1. • education enrolment rates | Not a measure of water resources |
| 1. • Gini coefficients of income distribution | Not a measure of water resources |
| **Use** |  |
| 1. • domestic water use in litres per day | Considered, but the most important measure is already captured in % population with access to clean water |
| 1. • share of water use by industry and agriculture adjusted by the sector’s share of GDP | Considered under agriculture, but included indirectly in the GAIN measure of water withdrawal as this is usually dominated by agriculture |
| **Environment** | Not considered in this version of GAIN |
| 1. • water quality |  |
| 1. • water stress (pollution) |  |
| 1. • environmental regulation and management |  |
| 1. • informational capacity |  |
| 1. • biodiversity based on threatened species |  |

The WPI does not deal with climate change or directly with climate impacts. It seeks to cover a wider domain than the water component of the GAIN with 17 measures compared to 6 for GAIN and the WPI includes environment and water pollution measures that are not considered in this component of GAIN. The WPI also includes socio-economic measures (e.g. GDP per capita, GNI etc) that are not considered for explicit inclusion in GAIN.

Nevertheless, the two indicators are highly correlated (r2 = 45%), but with no clear systematic differences. Some of the difference may arise from changes in reporting (the WPI data were gathered almost a decade ago) and from the inclusion of the climate change projections for temperature and precipitation in the GAIN, which reflects the different purposes of the two indices. This is borne out by removing the exposure (i.e. the climate projection) component from the GAIN index and the correlation with the WPI rises to r2 = 60%.

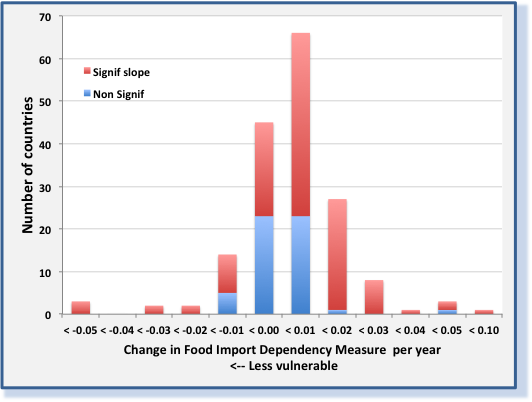


**Box 2. Is there evidence that the measures selected can be changed within reasonable timeframes?**

{The results for the recent history are not yet ready, but will be available this week – July 11th. This Box gives an example of the types of analyses being carried out.}

The rate of change in measures over the past 13 years (1995 to 2007) can be estimated by looking for trends in the value of the measure (up or down, or more complex). An example is shown in Fig. B2-1. Change in Food Import Dependency (a measure of Food sensitivity) was selected for analysis as the base data are reported annually. Simple linear trends in the measure were calculated for the 172 countries with data available. The results show that for this measure 119 countries showed a statistically significant trend with 38 becoming less vulnerable and 87 more vulnerable. Some countries showed changes of 0.05 units per year which if maintained for a decade would shift their GAINTM Vulnerability Index score by approximately 0.02 to 0.03 or 10 to 20 positions in an all country ranking.

**Figure B2-1. Rate of change in the Food Import Dependency measure over the period 1995 to 2007.**



Annex 1 Technical description of the Measures

Some components of this Annex are still being developed and in particular the Private and Public Sector Messages

Discussion of the water measures

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Sector |  | Exposure | Sensitivity | Capacity |
| Water  See Box 1 for the relationship between the GAIN and the Water Povert Index (WPI) | Quant  **** | **Projected change in precipitation (%).** **[PPT% ][[2]](#footnote-2)** Gross measure of threat to water. This is the commonly used indicator in both the scientific and response communities. However it is not a very effective measure as it does not take increased evaporative demand into account nor changes in the intensity and seasonality of the rainfall. It might eventually be replaced by a more integrating measure such as run-off or even precipitation minus evapotranspiration. The use of a single measure for an entire country is not very valid, especially for large countries where there are large gradients across the country.  **Source of data:** CRU data sets, http://www.cru.uea.ac.uk/  **Issues :** An increase in PPT% is taken to indicate reduced vulnerability. However, this might be misleading for dry countries where a large % increase does not imply a large absolute increase in rainfall or in rainfall effectiveness. The increased rain may come in flooding events. Similarly increased PPT% for already wet countries probably provides little useful additional water and may add to flood loads. There appears to be no objective way to correct for these problems but a subjective correction is suggested below.  It can also be argued that PPT% is is a reasonable approximation – for countries with low current precipitation an increase will be disruptive especially if flood frequency increases; for high precipitation countries additional precipitation is also disruptive. There is a range in the middle where additional rainfall might be beneficial but it is hard to adjust for this. Note however, that this is partially taken up in the Food Measures dealing with the projected impact of climate change on crop yields.  **Scaling :** The base value is taken to be no change and the index is scaled so that the most negative countries score -1 and the most positive +0.5. This partially accounts for the issues discussed in the previous paragraph.  **Cross Correlation :** Very low  **Reporting & Time Series :** All countries and a single measure only as it is a projection.  **Actionable :** Only via mitigation of GHG emissions.  **Private Sector Messages** **:** None {This is a mitigation issue. Obviously the private sector can play a role there but that is not the purpose of this index.}  **Public Sector Messages :** Actionable through mitigation.  **Alternate or related measures :** See comment on run-off above.  **Summary :** Acceptable for now, but seek eventually to update with a better measure of water impacts. | **% internal water extracted for all uses. [IWE% ]** An indication of how much of the nationally available water resource (originating internally or externally such as from inflowing rivers) is already being used. In the Index a high % extraction is taken as an indicator of vulnerability.  **Source of data:** FAO Aquastats,  <http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en>  **Issues:** Some countries (especially arid) use well over 100% of their internal water as it is either supplemented by desalination for example. These are capped to 100%.  **Scaling :** The base value is taken as 0% (=0) and 100% (=1).  **Cross Correlation :** Capped variable has low correlation with both GDP/Cap or HDI (r2 < 5%) with or without cap. It is in fact little correlated with most other measures.  **Reporting & Time Series :** Data is reported to FAO at 5 yearly intervals. About 40% compliance since 1990 with enough to detect trends in about half the countries.  **Actionable :** Water use includes domestic, industrial and agricultural of which agricultural water use is the dominant water use in most countries. Thus, this is more a measure of the threat to agriculture than the threat to domestic or industrial use.  **Private Sector messages :** This is a comprehensive measure whose value is determined by many different actions and policies. However, many of these actions are appropriate for private sector engagement ranging from water efficiency measures and recycling to desalination.  **Public Sector Messages :** Similar to those described above. Many opportunities for PPPs.  **Alternate or related measures** : Could exclude external water, but this leads to the anomaly of countries such as Zambia, with major river systems flowing through them, show as very water scare. Zambia uses only 2% of its total available water, but this greatly exceeds the amount of internally generated water. Could also include the volume of dam storage to give some idea of buffering capacity.  **Summary :** Solid measure by most criteria and one used in other indices. The main issue is whether it truly does reflect vulnerability. | **% population with access to improved water supply.** [**PIW%** ****]High % indicates capacity to deliver water to the population and hence lower vulnerability.  **Source of data:** WDI database,  SH.H2O.SAFE.ZS  **Issues :** Commonly used indicator. However, it saturates very quickly with most countries with a GDP/cap of >$5000 having close to 100% coverage  **Scaling :** Scale 0% as vulnerability of 1 and 100% as 0 vulnerability.  **Cross Correlation :** Highly correlated with HDI (r2 = 65%) and with GDP/cap (r2 = 25% and r2 = 50% with Ln(GDP/cap)). It is also correlated with PIS%.  **Reporting & Time series :**  **Actionable :** Directly actionable although many countries have already reached the highest score.  **Private Sector messages :** An activity with many opportunities for private sector engagement, especially through PPPs.  **Public Sector Messages :** See above.    **Alternate or related measures :**  **Summary :** Good indicator and commonly used in other indicators. |
| Water | Qual | **Projected change in temperature** (**TMP%** ****). Water quality issues rise in warmer conditions causing disease growth & spread; less water for sanitation etc.  **Issues :** This brings the most commonly used climate change indicator into the index. The use of a single measure for an entire country is not very valid, especially for large countries where there are large gradients across the country.  **Scaling :** The base value is taken to be no change and the index is scaled so that the most positive temperature increases (5.5C) score +1 and the lowest (1.5C) score 0.  **Cross Correlation :** Very low  **Reporting & Time Series :** All countries and a single measure.  **Actionable :** Only via mitigation of GHG emissions.  **Private Sector Messages** **:** None {This is a mitigation issue. Obviously the private sector can play a role there but that is not the purpose of this index.}  **Public Sector Messages :** Actionable through mitigation.  **Alternate or related measures :** No obvious alternatives.  **Summary :** A core measure of projected climate change and used as the basis of many projections, indicators etc. | **Existing incidence of water borne diseases (WBD )**. Measured as “Water, sanitation & hygiene deaths per 100'000 children<5 yr” to capture the effects on the most sensitive portion of the population.  **Issues :** There are similar data for all people affected but we have chosen to focus on children as they bear the bulk of the burden. There is obviously an overlap with health measures, but this reflects the strong links between vulnerability arising within the water and health sectors.  **Scaling :** The base values are taken to be no incidence (scoring 0) and 1500 incidences per 100,000 children per year, which will result in a small group of countries scoring close to 1.  **Cross Correlation :** Correlates with r2 of 50% to 60% with PIW% and PIS%. But only 35% with ln(GDP/cap).  **Reporting & Time Series :**  **Actionable :** Directly actionable with many countries having room for improvement. Overall improvement in PIW% and PIS% would improve WBD but there also a range of health related actions available.  **Private Sector Messages** **:** Opportunities for the private sector through a variety of clean water and health interventions. Probably a role for local SMEs in providing improved services to emerging cash economy farmers and middle class.  **Public Sector Messages :**  **Alternate or related measures** : A similar measure is available for the whole population. However, children under 5 account for the largest portion of deaths.  **Summary :** | **% population with access to improved sanitation [PIS% ]**. High % indicates capacity to deliver sanitation and quality water to the population and hence lower vulnerability.  **Issues :** Commonly used indicator. However, it saturates quickly, although slightly slower than PIW%, with most countries with a GDP/cap of >$12000 having close to 100% coverage  **Scaling :** Scale 0% as vulnerability of 1 and 100% as 0 vulnerability.  **Cross Correlation :** Highly correlated with HDI (r2 = 75%) and with GDP/cap (r2 = 35% and r2 = 50% with Ln(GDP/cap)). It is also correlated with PIS% (r2 = 60%) but there is still significant scatter among countries with low values of either variable.  **Reporting & Time Series :**  **Actionable :** Directly actionable although many countries have already reached the highest score.  **Private Sector Messages** **:** An activity with opportunities for private sector engagement, especially through PPPs. More difficult to achieve payments for service than for actions relating to PIW%.  **Public Sector Messages :**  **Alternate or related measures :**  **Summary :** Good indicator despite its high correlation with PIW%. There are differences between countries on the low end of both measures. |

Discussion of the Food measures

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Sector |  | Exposure | Sensitivity | Capacity |
| Food  See Box 1 for the relationship between the GAIN and the Water Povert Index (WPI) | Quant  **** | **ACDI (Wheeler2011).** **[Yld% ][[3]](#footnote-3)** country.  **Source of data:**  **Issues :**  .  **Scaling :** -20 to 100 which covers the full range observed.  **Cross Correlation :** Low  **Reporting & Time Series :** Most countries and a single measure only as it is a projection.  **Actionable :** This is actionable by better agricultural practice, although this will be difficult to pick up in the measure.  **Private Sector Messages** **:** Opportunities for improvements in agricultural practices.  **Public Sector Messages :** As above.  **Alternate or related measures :** There are alternative, similar indices. This is based on an analysis of several different approaches to estimating threat to future yields..  **Summary :** One of many alternatives and probably among the most comprehensive. | **% population dependent on rural livelihoods [Rur% ]** y.  **Source of data:** WDI database, SP.POP.TOTL & SP.RUR.TOTL  **Issues:** %.  **Scaling :** The base value is taken as 0% (=0) and 100% (=1).  **Cross Correlation :** Correlates strongly with GDP/cap (r2 = 47%) and also with other indicators sensitive to rural poverty such as malnourished children and population with access to electricity (r2 about 35%)  **Reporting & Time Series :** s.  **Actionable :** Readily actionable and a major development issue in many countries. Differing views over whether to facilitate rural to urban migration to reduce negative impacts, or whether to try to raise opportunities in rural areas.  **Private Sector messages :** Complex engagement including urban based development, but also opportunities to encourage rurally based enterprises.  **Public Sector Messages :** Similar to those described above.  **Alternate or related measures** :There are variants such as % of workforce employed in rural occupations. The measure used is the most generic as it is based on livelihoods.  **Summary :** Solid measure by most criteria and one used in other indices. Clearly correlated with vulnerability, but lowering its score will not reduce vulnerability if the new urban livelihoods are also vulnerable. | **Agricultural capacity.** [**AgC%** ****].  This is a combination of three separate measures of agricultural technology: the amount of fertilizer used per ha, the number of tractors per area of arable land and the proportion of arable land with irrigation facilities. The measure used here takes two of the above that give the best (i.e. least vulnerable) score. This allows for missing data but also for situations such as where irrigation or fertilizer is less necessary because of rainfall or good quality soils.  **Source of data:** WDI database,  AG.CON.FERT.ZS & AG.LND.TRAC.ZS & AG.LND.IRIG.AG.ZS  **Issues :** See discussion above. And, even with three elements, it does not capture the full range of relevant agricultural technologies. Also many countries already have reached the best (least vulnerable) scores.  **Scaling :** The measure is scaled to score between 0 and 1.  **Cross Correlation :** Has low correlation with other food measures, but moderate correlations with a cluster of health indicators (r2 about 35%), although there is no obvious reason other than a link to level of technological capacity.  **Reporting & Time series :**  **Actionable :** Directly actionable by both private and public sectors.  **Private Sector messages :** An activity with many opportunities for private sector engagement. The index, despite being a combination of three measures, may not capture all effective actions to reduce vulnerability.  **Public Sector Messages :** See above.    **Alternate or related measures :** None found  **Summary :** Solid indicator. |
| Food | Qual | **Coefficient of variation in annual cereal crop yields** (**CCV%** ****). Based on reported year to year variation in cereal yields. High variability is taken as indicating inherent exposure of yields to climate and non-climate variables (e.g. prices affecting inputs to crops). Cereals are the best available indicator of agricultural production for most countries, but clearly not valid or measurable for others. For each country the 19xx to 20xx data was detrended via an exponential function to allow for technological increases in yield and then the standard deviation of the yield calculated to give an estimate of the CV (Stdev/mean).  **Sources of data:** WDI database,  AG.YLD.CREL.KG  **Issues :** The quality of data for some countries is poor; usually reporting almost constant or regularly increasing yields. This will give these countries an artificially low vulnerability score.  **Scaling :**.  **Cross Correlation :** Very low.  **Reporting & Time Series :** Most countries and a single measure.  **Actionable :** Can be improved through better agricultural practices.  **Private Sector Messages** **:** Many opportunities for engagement and this could be reflected in the measure in a period of 5 to 10 years.  **Public Sector Messages :** Actionable as for private sector.  **Alternate or related measures :** No obvious alternatives.  **Summary :** This measure needs to be further explored. It potentially captures an important element of vulnerability, but the quality of the data needs to be further assessed. | **Food import dependency (FID% )**. Proportion of cereal consumption obtained from imports. This is taken as a measure of the countries sensitivities to food shocks in the future. Taken with the CV in national cereal yields, both internal and import dependent countries are covered to some degree.  **Sources of data:** FAO  **Issues :** Clearly the Coefficient of Variation (CV) in of cereal yields and this measure interact and could be part of a more complex measure of food security. This may produce a conceptually more satisfying model but would do less well against simplicity and transparency tests.  **Scaling :** Between 0 and 1.0.  **Cross Correlation :** Low correlations with other measures and GDP etc.  **Reporting & Time Series :**  **Actionable :** The value of the measure can be affected by government action and by major shifts in private markets, but the actions used to make these changes may affect other components of vulnerability.  **Private Sector Messages** **:** Opportunities – see above.  **Public Sector Messages :** See above.  **Alternate or related measures** : None found.  **Summary :** Acceptable at this stage but should be further considered as part of a food security measure. | **% Children under 5 showing “wasting” [Mal% ]**. A measure of malnutrition based on the percent of under 5 year-olds with a low weight for height ratio; usually taken as the best indicator of chronic malnutrition. This is taken as an indication of the lack of capacity to deliver basic nutritional needs to the most sensitive group in society.  **Sources of data:** WHO  **Issues :**  **Scaling :** From 0 to 10%. A few countries score higher than 10% but the reduced range is used to get more sensitivity among countries with less extreme problems.  **Cross Correlation**. Strong correlation with a number of water and health measures (r2 of 30% to almost 50%), but graphics suggest that it contains independent information.  **Reporting & Time Series :**  **Actionable :** Directly actionable by public and private sectors, with most responsibilities probably with the former.  **Private Sector Messages** **:** See above  **Public Sector Messages :** See above  **Alternate or related measures :** Other measures of poor nutrition considered. This was chosen as it is considered a good measure of chronic malnutrition and it does nor greatly overlap with measures in the health or water sectors  **Summary :** Good indicator. |

Discussion of the Health measures

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Sector |  | Exposure | Sensitivity | Capacity |
| Health | Quant  **** | **Climate Change Induced DALYs** **[DALY ][[4]](#footnote-4)** A model-based estimate of the quality adjusted loss of life years under several different climate scenarios. The most extreme scenario and for 2100 was used here to achieve maximum discrimination between country exposures.  **Source of data:** Ebi 2008  **Issues :** This index is calculated for regions of the world and for sub-groupings of countries within these regions (eventually xx different groups). Thus many countries share the same value of the measure as others.  **Scaling :** 0 to 0.4 which encompasses the full range found in the study.  **Cross Correlation :** Low  **Reporting & Time Series :** Reported for regions as described above.  **Actionable :** This is actionable by better agricultural practice, although this will be difficult to pick up in the measure.  **Private Sector Messages** **:** Opportunities for improvements in agricultural practices.  **Public Sector Messages :** As above.  **Alternate or related measures :** There are alternative, similar indices. This is based on an analysis of several different approaches to estimating threat to future yields..  **Summary :** One of many alternatives and probably among the most comprehensive. | **Medical staff [MEDS ]** Sum of the number of doctors, nurses and midwives per 1000 population in the country. The number of doctors is multiplied by 2 before the summation as there tends to be about twice as many nurses and midwives as doctors. This means that progress in proportional increasing either group will have the same effect on the measure.  **Source of data:** WDI data-base, SH.MED.PHYS.ZS & SH.MED.NUMW.P3  **Issues:** None.  **Scaling :** Between 0 and 25. A few countries have up to 50 staff per 1000 population, but most OECD countries only have about 20..  **Cross Correlation :** A number of correlations of 30% to 40% with other health related measures. R2 = 52% with ln(GDP/cap).  **Reporting & Time Series :**.  **Actionable :** Readily actionable and a major development issue in many countries. Differing views over whether to facilitate rural to urban migration to reduce negative impacts, or whether to try to raise opportunities in rural areas.  **Private Sector messages :** Complex engagement including urban based development, but also opportunities to encourage rurally based enterprises.  **Public Sector Messages :** Similar to those described above.  **Alternate or related measures** :There are variants such as % of workforce employed in rural occupations. The measure used is the most generic as it is based on livelihoods.  **Summary :** Solid measure by most criteria and one used in other indices. Clearly correlated with vulnerability, but lowering its score will not reduce vulnerability if the new urban livelihoods are also vulnerable. | **Longevity** [**LONG** ****]. Average life span of males and females. Used as a measure of the overall capacity of a country’s health services. This measure seems to differentiate countries within OECD countries as well as in LDCs.  **Source of data:** WDI database, SP.DYN.LE00.IN  **Issues :** none.  **Scaling :** Longevities between 35 and 85 are scaled to 0 to 1. Observed longevities are 44 to 83.  **Cross Correlation :** Many strong correlations with measures of health water quality and development (r2 50% to 60%).  **Reporting & Time series :**  **Actionable :** Directly actionable by both private and public sectors.  **Private Sector messages :** An activity with many opportunities for private sector engagement. The index, despite being a combination of three measures, may not capture all effective actions to reduce vulnerability.  **Public Sector Messages :** See above.    **Alternate or related measures :** None found  **Summary :** Solid indicator. |
| Health | Qual | **% mortality from communicable diseases** (**MCD%** ****). .  **Sources of data:** WHO, [http://apps.who.int/ghodata/?vid=99001#](http://apps.who.int/ghodata/?vid=99001)  **Issues :** The coverage of diseases.  **Scaling** : From 0 to 40% are scale to 0 to 1. Some countries exceed 50% and many countries cluster around 35 to 50%.  **Cross Correlation :** Very low.  **Reporting & Time Series :** Only a single estimate available for 2008.  **Actionable :** Can be improved through a wide range of health care practices.  **Private Sector Messages** **:** Many opportunities for engagement and this could be reflected in the measure in a period of 5 to 10 years.  **Public Sector Messages :** Actionable as for private sector.  **Alternate or related measures :** No obvious alternatives.  **Summary :** This measure needs to be further explored. It potentially captures an important element of vulnerability, but the quality of the data needs to be further assessed. | **% external resources for health care (Hext% )**. The percentage of external resources (e.g. bilateral payments, NGO operations etc) in total health expenditure.  **Sources of data:** WDI database, SH.XPD.EXTR.ZS  **Issues :**.  **Scaling :** 0 to 100% scale to 0 to 1. Most countries have scores of 0 or at least <10%, but some approach 100%.  **Cross Correlation :** Moderate correlation with some health and water related measures.  **Reporting & Time Series :**  **Actionable :** This measure should be responsive to a country taking action to improve internal support to health services.  **Private Sector Messages** **:** Most responsibilities are with public sector, but private action in providing low-cost health care will assist.  **Public Sector Messages :** See above.  **Alternate or related measures** : None found.  **Summary :** Solid indicator. | **% Life time risk of maternal death” [MatR% ]**. Measure of the capacity to deliver health services to a vulnerable and important group.  **Sources of data:** WDI database, SH.MMR.RISK.ZS  **Issues :**  **Scaling :** 0 to 4% is scaled to 0 to 1. The highest values are about 9%.  **Cross Correlation**. High correlation (r2>60%) with some health related measures..  **Reporting & Time Series :**  **Actionable :** Directly actionable by public and private sectors with opportunities for improved private actions in the provision of local maternity services. Rapid gains can probably be made.  **Private Sector Messages** **:** See above  **Public Sector Messages :** See above  **Alternate or related measures :**  **Summary :** Good indicator. |

Discussion of the Infrastructure measures

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Sector |  | Exposure | Sensitivity | Capacity |
| Coastal | **** | **% of area of country less than 5m above sea-level** **[DALY ][[5]](#footnote-5)** A commonly used measure of exposure to a range of coastal threats, including seal-level rise, storms and storm surge and salt water intrusion. It is not directly related to flooding due to rises in mean sea-level.  **Source of data:** WB DEC?  **Issues :** See discussion above. Also land-locked countries automatically score 0 vulnerability. Also the data is often missing for small islands. Where it is missing a high vulnerability score has usually been inserted as usually the entire area of a small island is subject to coastal impacts.  **Scaling :** 0 to 100% are scaled to 1 to 0  **Cross Correlation :** Low  **Reporting & Time Series :** Single value.  **Actionable :** Not actionable.  **Private Sector Messages** **:** None.  **Public Sector Messages :** As above.  **Alternate or related measures :** Some studies use 1 m rather than 5 m while other use a distance from the coast. All convey related, but different information.  **Summary :** Solid indicator, but further work on a synthetic measure combining elevation, distance from coast etc might be of use. | **% of population living less than 5m above sea-level** **[MEDS ]**. See opposite.  **Source of data:** WB DCE?  **Issues:** As opposite.  **Scaling :**. 0 to 100% are scaled to 1 to 0.  **Cross Correlation :** Low. Only an r2 = 48% for area below 5m.  **Reporting & Time Series :**.  **Actionable :** Managing coastal settlements is an important challenge to the public and, to a lesser extent, the private sector.  **Private Sector messages :** Role in protecting own facilities and in contributing to safer coastal planning.  **Public Sector Messages :** Similar to those described above.  **Alternate or related measures** : Some indices use % of GDP producing capacity exposed to seal-level effects. However, this is usually a modeled estimate based on elevation, population maps, night lights and similar indirect measures.  **Summary :** Good measure of a very direct component of sensitivity. |  |
| Energy |  | **% population with access to reliable electricity** (**Elect%** ****). .  **Sources of data:** UNDP & WHO analysis {url}  **Issues :** There is a question of what constitutes adequate access to reliable energy (not just electricity) sources and just what is reliable. Data is often missing and may still require quality checking.  **Scaling** : From 0 to 100% are scale to 0 to 1. Most countries score in the high 90% with a global average of 75% (i.e. average of country percentages, not proportion of people with access). We have maintained the full range of scores to encourage all countries to move towards 100%.  **Cross Correlation :** Has the highest correlation with water and health measure of any of the infrastructure measures (some r2 of 50% to 70%).  **Reporting & Time Series :**  **Actionable :** Can be improved through a wide range of public and private actions.  **Private Sector Messages** **:** Many opportunities for engagement and this could be reflected in the measure in a period of 5 to 10 years.  **Public Sector Messages :** Actionable as for private sector.  **Alternate or related measures :** No obvious alternatives with adequate data.  **Summary :** An important indicator. | **% energy (electricity) production at risk (ERisk% )**. This is an estimate of how vulnerable electricity production might be to climate impacts. Currently it is a measure of the percentage of total electricity (analogue for energy) that is either imported or derived from hydro-electricity. The rational is that imported energy could increase in price or be cut off in crises, while hydroelectricity is going to be subject to the impacts of change rainfall patterns and competing uses. See Issues below.  **Sources of data:**  **Issues :** This is an important measure of vulnerability, but further work is needed on constructing a better measure and in supplying data. The measure could be expanded to capture the risk to fossil fuel based energy production as imported supplies of fuel are just as subject to crises as imported electricity.  **Scaling :** 0 to 100% scale to 0 to 1. The average score is 43%..  **Cross Correlation :** Low correlations.  **Reporting & Time Series :** There is a lot of missing data. Estimates were inserted in many cases.  **Actionable :** This measure should be responsive to a country taking action to improve internal energy supplies.  **Private Sector Messages** **:** Most responsibilities are with public sector, but private action in providing infrastructure and managing distribution.  **Public Sector Messages :** See above.  **Alternate or related measures** : None found.  **Summary :** An important area of sensitivity that would repay further work. | . |
| Transport | **** | **Floods per decade per 100,000 km2** **[Flood ]** This is used as a measure of exposure as floods are usually the greatest threat to road infrastructure.  **Source of data:** CRED database for flood “disasters” over the period 1992 to 2007. 15 years is barely a long enough time span, but reporting prior to this becomes increasingly unreliable.  **Issues :** This is the only use of the CRED database as we wanted to use the historical record as a means of testing the validity of the measures chosen.  **Scaling :** 0 to 0.4 which encompasses the full range found in the study.  **Cross Correlation :** Low  **Reporting & Time Series :** Single value available for most countries.  **Actionable :** No, other than by reducing the likelihood that a flood will become a disaster.  **Private Sector Messages :** None.  **Public Sector Messages :** None.  **Alternate or related measures :** No obvious alternatives  **Summary :** Solid indicator of exposure. | **% Paved roads [Paved ]** Taken as a measure of the sturdiness of the road system.  **Source of data:** WDI database, IS.ROD.PAVE.ZS  **Issues:** None.  **Scaling :** 0 to 100% scaled to 0 to 1 with an all country average of 50%.  **Cross Correlation :** A number of correlations of 30% to 40% with a variety of measures.  **Reporting & Time Series :** .  **Actionable :** Readily actionable and a major development issue in many countries.  **Private Sector messages :** Multiple opportunities for engagement.  **Public Sector Messages :** Similar to those described above.  **Alternate or related measures** : No obvious alternatives  **Summary :** Solid indicator. |

1. A geometric mean is the 1/n root of the product of the n data values. [↑](#footnote-ref-1)
2. **** values for the measure indicate greater vulnerability; **** indicates that low values indicate greater vulnerability. Each measure is rescaled to a range from 0 to 1 with 1 indicating high vulnerability before being incorporated in the GAIN Vulnerability Index. [↑](#footnote-ref-2)
3. **** values for the measure indicate greater vulnerability; **** indicates that low values indicate greater vulnerability. Each measure is rescaled to a range from 0 to 1 with 1 indicating high vulnerability before being incorporated in the GAIN Vulnerability Index. [↑](#footnote-ref-3)
4. **** values for the measure indicate greater vulnerability; **** indicates that low values indicate greater vulnerability. Each measure is rescaled to a range from 0 to 1 with 1 indicating high vulnerability before being incorporated in the GAIN Vulnerability Index. [↑](#footnote-ref-4)
5. **** values for the measure indicate greater vulnerability; **** indicates that low values indicate greater vulnerability. Each measure is rescaled to a range from 0 to 1 with 1 indicating high vulnerability before being incorporated in the GAIN Vulnerability Index. [↑](#footnote-ref-5)