WORLD ECONOMIC AND SOCIAL SURVEY 2016:

Climate change resilience — an opportunity for reducing inequalities

BACKGROUND PAPER

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What data analytics are needed to identify and monitor populations vulnerable to climate change in developing regions?

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Summary:

This research note considers what statistics and indicators are needed to identify and monitor populations in developing regions which are vulnerable to impacts of climate change, especially poor populations, and to support analysis and development of policies to reduce these impacts in the short and long terms.

Section A provides a review of selected data on disaster impact associated with climate change from 2005 to 2014 and concludes that populations in low-elevation coastal zones, especially deltas and flood plains, are most at risk due to storms and floods, and populations in drylands, including mountain regions, from droughts and periods of extreme temperatures. Section B considers how data needs to be further developed, regularized, institutionalized and made widely available for civil society use and the development of modern data analytics, through open access data networks.

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1. Introduction

This research note considers what statistics and indicators are needed to identify and monitor populations in developing regions which are vulnerable to impacts of climate change, especially poor populations, and to support analysis and development of policies to reduce these impacts in the short and long terms. Section A begins with a review of selected data on disaster impact associated with climate change from 2005 to 2014 and concludes that populations in low-elevation coastal zones, especially deltas and flood plains, are most at risk due to storms and floods, and populations in drylands, including mountain regions, from droughts and periods of extreme temperatures. Globally, populations affected from 2005 to 2014, excluding earthquakes, were on average about 185 million people each year (table 1). These events, to varying degrees, are related to climate change and the impact will worsen as climate change, population growth, urbanization, sea level rise, delta subsidence and economic development continue.

This review shows that considerable progress has been made in developing the disaster statistics on persons affected and killed and the underlying reporting infrastructure for the statistics, as well as rapid progress in the climate and environment sciences on various risk scenarios involving disasters. At the same time, it must be recognized that disaster data cover only a portion of interrelated and synergistic climate and environmental impacts now foreseen. Other impacts include air and water pollution, ocean acidification and temperature increase, loss of pollination, epidemics (considered as "disasters" but not included in IFRC statistics), and terrestrial and marine species extinctions (IPCC, Oppenheimer et al., 2014).

The remainder of section A considers some studies which have developed statistics on the size, geographical distribution and characteristics of vulnerable populations in developing regions. Some basic numbers on exposed populations in low-elevation coastal zones, flood plains and deltas, and drylands and mountains and remote areas susceptible to droughts, are available from the research community. An estimated 628 million people were living in "low-elevation coastal zones," including delta populations, in 2000, of which 518 million in developing regions, and nearly 2 billion in dry land zones in 1995 (table 4). Total population of developing regions was 4.6 billion in 1995, and is estimated as 6.1 billion in 2015, an increase of 33 per cent from 1995 to 2015). While estimates of rural populations in vulnerable areas differ widely depending on sources and methods, the United Nations Population Division estimates per cent of developing region populations lived in rural areas in 2015, where extreme poverty (usually family based subsistence populations) and less extreme poverty (usually subsistence with some outside income) are concentrated (United Nations Population Division, 2015) .

Section B considers how these data need to be further developed, regularized, institutionalized and made widely available for civil society use and the development of modern data analytics, through open access data networks. As academic work, they have been prepared using various

and often inconsistent concepts, methods and classifications and cover only a few, and differing years. While this research provides a basic foundation for continuing work on concepts and methods, and for benchmark approximations, for official monitoring and policy purposes they must become part of official national and international programmes, compiled and issued on a regular basis by or in association with official specialized services. This requires harmonization and integration among a wide range of data programmes, including official statistics of population and its main characteristics and its distribution by ecozones, urban-rural, and extensive data on water and oceans, and weather. These statistics, with indicators to be technically specified in the context of the SDG indicators programme and produced on a regular, internally consistent and coordinated basis, are essential to routinely monitor populations at risk and support policy initiatives to address exposure, impact and adaptation at national, sub-national and local levels.

Sub-sections B2-3 note that complex statistical sources and methods, notably population censuses and surveys, are widely used in all countries to measure population, its social and economic characteristics and its growth, and for regional and international comparisons and analyses. However, these cannot easily or generally be integrated with the wide variety of sources and methods for linking geospatial measurement and environment conditions. This is due, among many reasons, to incompatible definitions and classifications among, for example, sub-national administrative boundaries and ecozones, geospatial identification of large cities and other urban and rural areas, and varying and irregular time periods covered. Intensive collaboration among data producers across a range of disciplines, including water management, ecology, agronomy, forestry, meteorology and demography, is essential to establish officially recognized and compatible guidelines and recommendations. Some basic statistics and indicators on population and environment that are needed are given in sub-section B3.

Institutional experience, capacity and responsibility for the statistics to monitor and analyse climate change, exposed populations and impact are widely dispersed across governments and international organizations and their collaborating institutions, and among and within governments, often with little communication among the different specialties In the developing regions, only a few governments have adequate capacities for the needed data collection and analysis, and these often still lack strong mechanisms for essential national and international collaboration in many instances. Among the least developed countries, land-locked developing countries, Small Island Developing States and other countries in special situations, such as conflicts, few have such capacities. These challenges are being taken up by the United Nations Statistical Commission and Statistics Division, the Food and Agriculture Organization of the United Nations, the United Nations Environment Programme, the United Nations Convention to Combat Climate Change Secretariat, the United Nations Office for Disaster Risk Reduction, the United Nations World Water Assessment Programme, the World Bank, the International Federation of the Red Cross and Red Crescent Societies, by programmes supported by these

international organizations such as Paris21, and by bi-lateral technical assistance and data development programmes, and non-governmental organizations such as opedatawatch.org, but will require unprecedented levels of new data development, integration and analysis to meet the challenges of development, population growth, urbanization and climate change.

A. Disasters and climate change vulnerabilities in developing regions

Public perceptions of climate change are especially conditioned by extreme events and resulting disasters, whether or not these can be individually linked to climate change. In the case of weather events, for example, linkage is difficult to establish but there is currently considerable progress being made research on attribution (Cornwall, 2016, Solow, 2015). And while earthquakes are unrelated to climate change, the impact of tsunamis is also affected by rising sea levels. The international definition of disaster for statistical purposes has been established by the International Federation of the Red Cross and Red Crescent Societies, in cooperation with the Centre for Research on the Epidemiology of Disasters (CRED, Louvain, Belgium). A "common accord" classification of disasters for operational purposes was published by CRED and the Munich Reinsurance Company (Munich RE) in 2009. For the World Disaster Report 2015 (IFRC, 2015), CRED compiled and analysed extensive data from its EM-DAT/International Disasters Database covering 2005-2014 to prepare tables on disasters by number, continent, phenomenon, numbers of people reported killed and affected, estimated damage and level of human development of countries of occurrence. The number of people affected is shown below according to the United Nations classification by continent.

Table 1. Population affected by natural disasters

Continent	*Pop. affected 2005-2014 (m's)*	*Total pop. 2005*
Africa	260	920
Americas	85	893
Asia	1579	3945
Europe	9	729
Oceania	2	33
Total	**1935**	**6520**

By type of phenomenon	
Droughts	539
Earthquakes	84
Extreme temperatures	88
Floods	866
Storms	349
Total*	**1935**

*Total exceeds components shown as some small categories have been omitted.
Note: Epidemics are classified as natural disasters and in some cases may be closely related to climate change (WHO, 2005) but are not covered in the IFRC report. Ambient and household air pollution, which may be partially related to climate change, is not included in the natural disaster classification and not further considered here. WHO estimates that in 2012 it caused 7 million deaths (WHO, 2016).
Source: IFRC, 2015, tables 2, 3 and 7.

Table 1 shows that droughts, floods and storms accounted for 90 per cent of all reported persons affected by disasters worldwide. Half of these, 683 million, are in medium and low-development countries, of which 325 million are in low-development countries including the least developed countries. One important disaster phenomenon, earthquakes, is not considered climate related, though of course the impact of tsunamis from undersea earthquakes is considerably affected by sea level rise.

The rural populations of the poorer developing countries in low-elevation coastal areas including deltas, drylands and mountains and other remote areas, seem generally the populations most vulnerable to climate change, more specifically the small-scale agricultural, pastoral, fishing and forest households and workers which predominate in these populations, who mainly depend on their own production for basic food security, water supply and housing. As the IPCC has stated, "coastal settlements, including in small islands and mega-deltas, and mountain settlements are exposed and vulnerable to climate extremes" (IPCC, 2012, pp. 7-8). These populations have been studied by FAO (2010a, 2015, 2016, no date) and IFPRI (2009a and b), but limited data have been compiled. In addition,, "Rapid urbanization and the growth of megacities … have led the emergence of highly vulnerable urban communities, particularly through informal settlements and inadequate land management ….Vulnerable populations also include refugees, internally displaced people, and those living in marginal areas" (IPCC, 2012, pp. 7-8).

The sections that follow look at exposed populations in low-elevation coastal zones and flood plains and deltas, susceptible to storms and floods, and in drylands, mountain and remote populations, susceptible to droughts.

A.1. Quantifying vulnerable populations in low-elevations coastal zones and deltas, including small island developing States

a. Low-elevation coastal zones and deltas

Neumann et al. (2015) calculate that 11 per cent of the population in developing regions in 2000 (518 of 4,912 million) were living in a "low-elevation coastal zone" (LECZ: land less than 10 meters above sea level, adjacent to the coast and hydrologically connected to the ocean). Nearly thirty per cent of this LECZ population in developing regions (148 million) were living in a 100-year flood plain, of which 87 per cent (129 m.) were in Asia (excluding Japan). In Africa, with a 13 m. flood plain population of a total population of 811 million in 2000, high rates of population growth and urbanization (in the United Nations 2015 estimates and projections, the Africa population is projected, in the medium variant, to more than double by 2030, to 1.6 billion, and the urban population to nearly triple), "will exacerbate the already high vulnerability of many African coast countries." In Africa, Egypt in particular is expected to have the fourth largest coastal flood plain population in the world in 2030, 13.8 million, following China, Viet Nam and India (Neumann et al., 2015, table 7). "Considering for subsidence in deltaic areas and in cities prone to subsidence due to drainage and ground water pumping would further enhance these numbers."

The world's largest deltas (those with populations over 2 million) were home to about 430 million people in 2015 and are growing centers of risk. "Population growth, urbanization, subsidence and rising sea levels are placing populations living in delta regions under increased risk. … Some deltas in countries with a high gross domestic product will be initially more resilient to these changes, because they can perform expensive maintenance on infrastructure. However, shot-term policies will become unsustainable if unaccompanied by long-term investments in all delta regions" (Tessler et al., 2015).

Table 2. Populations of low-elevation coastal zones and 100-year flood plains in developing regions (millions)

	Population		Low elevation pop.		100-year coastal flood plain pop.	
	2000	2030	2000	2030	2000	2030
Africa	811	1562	54	109	13	24
Asia[a]	3697	4845	461	649	137	201
Latin America & Caribbean	521	702	32	40	6	8

Pacific islands	7	12	1	2	0.3	0.4
Developing regions	4912	7002	518	767	148	224
Least developed countries	662	1257	93	136	13	21
World	6101	8298	625	893	189	271

Source: B. Neumann et al., 2015, tables 4, 5, 8, S2 and S3. Neumann's 2030 projections are based on the United Nations Population Division's 2010 medium variant population projections.
[a] Includes Japan.

Of the six largest deltas, shown in table 3, four are in Asia (Ganges-Brahnaputra in West Bengal-India and Bangladesh, Mekong in Viet Nam, Pearl and Yangtze in China), and two in Africa, the Nile in Egypt and the Niger in Nigeria. These are highly productive regions for agriculture and fishing and are also burgeoning centres for urban growth and development. However, their economic success is increasingly at risk from continued population growth (currently 1.4 per cent annually in southern Asia, 1.2 per cent in southeastern Asia, 1.9 per cent in northern Africa and 2.7 per cent in sub-Saharan Africa (United Nations Population Division, 2015)) and urbanization, diminishing underground water supplies essential to irrigation and

Table 3. Deltas in developing regions with population >2m.

	Population (2015 ests., m's)
Africa	
Nile (Egypt)	49.2
Niger (Nigeria)	31.5
Limpopo (Mozambique)	4.4
Total	85.1
Asia	
Ganges-Brahmaputra (West Bengal-India/Bangladesh)	166.2
Mekong (Viet Nam)	35.2
Chngjiang (Yangtze)(China)	33.1
Pearl (China)	27.1
Huanghe (Yellow)(China)	16.6
Chao Phraya (Thailand)	16.4
Red (Hong)(Viet Nam)	16.1

Irriwaddy (Myanmar)	12.1
Krishna (India)	6.8
Godavari (India)	5.9
Mahanadi (India)	4.5
Indus (Pakistan)	4.4
Total	344.4
World	429.5

Sources: Woodroffe, 2010, Overeem and Syvitski, 2009.

urbanization, subsidence resulting from underground water pumping and silt deposition chocked off upstream by dams and diminishing river flow, and sea level rise. As a study of the Lower Yangtze River Basin in China concluded, this pattern of development is not sustainable:

> "Increasing trends in provisioning ecosystem services within the [Lower Yangtze River Basin] region over the past 60 years reflect economic growth and successful poverty alleviation but are paralleled by steep losses in a range of regulating ecosystem services mainly since the 1980s…Regime shifts and heightened levels of variability since the 1970s in local ecosystem services indicate progressive loss of resilience across the region…. The long-term relationship between economic growth and ecological degradation shows no sign of decoupling as demanded by the need to reverse an unsustainable trajectory." (Zhang et al., 2014)

In the Bangladesh delta, a study based on household survey data (Demographic and Health Surveys and Bangladesh household income and expenditure surveys), found considerable progress in achieving the Millennium Development Goals 1990-2015 but, looking ahead, and concludes:

> "Achieving the SDGs by 2030 will be highly challenging because of a) the increasing likelihood of environment threats and ecological feedbacks affecting agricultural and fishing incomes and water availability; and b) the need to raise production levels through financial investment in poor households already constrained by high production costs." (Hossain et al., 2015)

Similarly in the Nile Delta, urban and rural populations are expected to continue to expand over this constrained area. "If the sea level increases by a meter by 2050, which is in the range of mainstream prediction, one third of the delta could be lost. Meanwhile the population here is growing by a million people per year—the delta is already home to 50 million, most crammed into an area no bigger than the state of Delaware [6447 kms2]." (Bohannon, 2010)

River flood plains are also vulnerable to floods, including, for example, those of the Indus River (Pakistan), China's principal rivers and limited areas of Latin America such as the Paraguay/Parana Basin (Aloe, 2015).

b. Urban and cities populations, rural populations, and poverty

"Rapid urbanization and the growth of megacities, especially in developing countries, have led to the emergence of highly vulnerable urban communities, particularly through informal settlements and inadequate land management" (IPCC, p. 8). The number of cities with 300,000 or more population in low-elevation coastal zones in less developed regions increased from 116 in 1950 to 1,256 in 2014 (United Nations Population Division, unpublished estimates, 2015).

Limited estimates of urban and rural populations in vulnerable zones are available. Neumann et al. provide estimates for urban populations in low-elevation coastal zones based on identification of densely built-up areas in satellite imagery. These are considerably lower, often less than half, of urban estimates for countries as a whole from national statistics offices and the United Nations Population Division, based mainly on analysis of national population censuses, where the underlying concepts and definitions are quite different (United Nations Population Division, 2015, United Nations Statistics Division, 2007 and 2015, notes to table 6). Clearly much more research is needed to understand the differences and establish compatible concepts and methods of compilation, so that the distribution of LECZ and flood plain populations by city size, other urban, and rural, can be determined, which is critical to assessing and planning for risks.

Poverty estimates are even more problematic. Urban-rural differences in extreme poverty rates ($1.25/day) are not available. However, date compiled by the World Bank comprising urban-rural rates based on nationally adopted poverty lines in the least developed countries especially but also in many other countries in developing regions, indicate rural rates 2-3 times urban rates (United Nations Statistics Division, 2016b) . If the premise of generally higher rural poverty rates in disadvantaged regions such as deltas, low-elevation coastal zones and drylands, at least in line with national rates, is accepted, then these areas are in general particularly disadvantaged by both higher poverty and greater exposure to climate change impacts.

c. Fishing populations

In coastal populations, fishing has historically played a major role in providing food security and income and more recently aquaculture has played a rapidly growing role, though it is traditionally low-wage or subsistence based. FAO has made limited estimates of the fishing population. "By 2006 the number of fishers increased to 43.5 million—nearly three quarters in capture fisheries. The absolute growth in numbers [is] largely explained by the wide expansion

of the aquaculture sector…. Fishers, aquaculturists and those supplying services and goods to them assure the livelihoods and well-being of a total of about 520 million, 7.9 per cent of the world's population." (FAO, Fisheries and Aquaculture Department). However, exploitation and climate change are threatening collapse of fishing livelihoods (Jackson, 2001).

Clearly fishing populations are a significant and mainly poor component of coastal populations and should be considered in assessing and planning adaptation to climate change in coastal regions.

A.2. Drylands, and mountain and remote populations

Drylands comprise arid, semi-arid and dry sub-humid aridity zones and were estimated to account for 40 per cent of the Earth's land surface and 39 per cent of the world's population in 1995. The 1995 drylands population has been estimated as follows (UNDP et. al., 1997):

Region	Population (m's)	Drylands population (m's)
Africa	720	326
Americas & Caribbean	1093	182
Asia	3451	1475
Developing regions	4533	1983
World	5702	2130

More recent comparable data on drylands population are not available but as a benchmark comparison, the total population of developing regions increased by 33 per cent from 1995 to 2015 (United Nations Population Division, 2015).

Rural populations in drylands mainly comprise nomadic, semi-nomadic, transhumant and sedentary agricultural populations. "Sedentary (smallholder) farmers practice rainfed or irrigated agriculture often combined with livestock production." (Koohafkan and Steward, 2008) As in the case of flood plain and delta zones, little or no data on rural and urban populations in drylands is available. "The central message is that better information about demographic distribution in the drylands is critical to understanding the interaction between man and the land. ... An estimated 1.7 billion inhabitants threatened by desertification and drought are found in developing countries" (UNDP with World Resources Institute, 1997).

To consider poverty in drylands, the working assumptions can be made that rural rates are higher than in the country as a whole, and that rural poverty rates, where population is engaged mainly in subsistence agriculture and livestock production, are much higher than in urban areas.

Two examples are provided by Ghana's and Kenya's Millennium Development Goals Reports. "From 1991 to 2006, the proportion of the population in extreme poverty declined in 8 of Ghana's 10 regions—in some by more than 70 per cent. However, in the Upper West and Upper East regions, the driest and most remote parts of the country, the proportion of the population in extreme poverty actually increased over the same period" (based on Ghana Millennium Development Goals Report, Accra, 2010). In Kenya, its "North Eastern province is marked by arid and semi-arid savanna grasslands, bush and woodland dominated by pastoral and agropastoral livelihoods. [It] has the country's highest poverty level: 70 per cent in 2005/06, well above the national average of 46.6 per cent" (based on Kenya Millennium Development Goals Report, Nairobi, 2010).

Table 1 show that the number of persons affected by drought disasters is second only to those affected by floods, putting drylands at considerable risk. the Intergovernmental Panel on Climate Change reported in 2012, "there is medium confidence that some regions of the world have experienced more intense and longer droughts…but in some regions [these] have become less frequent, less intense or shorter," but it is likely that anthropogenic influences have led to warming of extreme daily minimum and maximum temperatures at the global scale."

Particularly in Africa and large parts of central and southern Asia, large areas of populated drylands with growing subsistence populations pose particular challenges to agricultural development and food security, but in recent decades great strides have been made in rural development sustainable under frequent drought conditions, through improving land and labour agricultural productivity for both subsistence and cash crops. As described by the International Food Policy Research Institute:

> "In the late 1950s … scientists, policymakers, farmers, and ordinary people initiated a concerted push to boost agricultural production and productivity in developing countries. Great strides were also made in improving the quality of food and the ability of vulnerable people to access food needed for survival. All these efforts have done more than just feed millions. They are also demonstrated that agriculture can be a key driver of growth and development for many of the world's poorest countries." (IFPRI, 2009b)

In many of these countries susceptible to drought, such as Burkina Faso, Ethiopia, India and Mali, policy options have included, "improved in situ water conservation, water harvesting and reduction in evaporation. Improved management of soil organic matter and conservation agriculture will not only help small holders and pastoralists adapt to climate change, but also involve changing traditional agricultural practices to increase storage of C in soil and on the soil surface … Sifting agricultural zones, planning of drought resistant/fast maturing strain of crops and protection of local agro-diversity offer other ways by which smallholders and pastoralists can cope with the rapid rate of human-induced climate change" (Koohafkan et al., 2008. See also

FAO 2008, 2010a, b, IFPRI, 2007, Schultz, 2005, UNEMG, 2011, and White and Nackoney, 2003).

Climate change is also particularly impacting mountain populations in drylands and combined with population growth and migration is posing new challenges. “The over-riding factor limiting agriculture production productivity in the dryland areas today is climate change and variability….pressure and attention on the drylands is expected to increase in the next decade in light of specifically climate change compounded by growing populations in the regions migrating from the densely population highlands into the drylands areas” (FAO and Ethiopian Institute of Agricultural Research).
FAO estimates the global mountain population in developing regions in 2012 at 834 million of which 27 per cent urban. Countries with significant mountain populations include Bhutan and Nepal in Asia; Burundi, Ethiopia, Lesotho and Rwanda in Africa; and Bolivia and Guatemala in Latin America (FAO, 2015). Africa’s mountain population grow by 38 per cent between 2000 and 2012, Latin America and Caribbean by 22 per cent and Asia by 8 per cent. “Population in the highest elevation class saw a sharp decrease” in this period, while “middle elevation classes showed the most significant population growth, particularly in South America where many cities, including national capitals are located in mountain areas. … Current regional maps …show large areas already abandoned by vulnerable people who faced situations so dramatic that they were compelled to leave. Not only did their migration increase the population pressure on the already poor areas where they ended up settling, their leaving also resulted in losses in the areas they left behind—in terms of provision of ecosystem services and preservation of cultural agrobiological diversity” (FAO and Mountain Partnership Secretariat, 2015).

“Most [mountain dwellers in developing regions] are dependent on subsistence agriculture, working in fragile ecosystems that are easily affected by climate change, as shown by the increase there in food insecurity rates. “The number of food insecure people living in mountain regions in developing countries [grew] to nearly 329 million in 2012, up from 254 [by 39 per cent] in 2000” (FAO, 2015).

Forest populations are another population group whose vulnerability to climate change needs to be considered. They are vulnerable to changes in forest cover and composition, and species extinction, and are largely subsistence based or low-wage workers, including hunter-gatherers or shifting cultivators, and are often indigenous peoples or from minority ethnic groups. Little or no data or estimates on the size of forest populations are available (FAO, 1997).

B. Improving statistics and indicators on populations vulnerable to climate change

In every area of data analysis in part A above on populations vulnerable to climate change, critical gaps in data sources and methods have been cited by researchers as impeding compilation of reliable data series consistent over time and comparable across areas of research. While ongoing research and analysis covers a wide range of topics and develops many data sources, the results provide as yet only an incomplete patchwork of information and indicators on vulnerable populations and with very limited geographical detail, frequency or continuity.

B.1. Development of statistics and indicators for monitoring, analysis and policy on climate change impact on vulnerable poor populations in developing regions

The research considered in part A of this paper shows that the development of reliable and continuous statistics and indicators on climate change impact, relating to SDG 13 on "climate change and its impacts," is at an early stage and requires considerable additional research and practical testing, and development of capacities through advanced training and experience in basic data sources and methods of compilation across a number of fields. International organizations with responsibilities in the fields concerned can play a key role through development of guidelines, recommendations and, through partnerships such as Paris 21, training materials on methods, and coordinated technical cooperation. These fields include official statistics on:

(a) Population and demography, including income, occupation and poverty, education, health (United Nations Statistics Division, International Labour Organization, World Bank, United Nations Educational, Scientific and Cultural Organization, World Health Organization, United Nations Children's Fund);

(b) Economic activity in agriculture, fishing and forestry (Food and Agriculture Organization of the United Nations, United Nations Statistics Division, International Labour Organization);

(c) Cartography and geographic information systems (United Nations Statistics Division and Committee of Experts on Global Geospatial Information Management, Food and Agriculture Organization of the United Nations, United Nations Environment Programme);

(d) Meteorology (World Meteorological Organization);

(e) Geology and land use, hydrology, ecology (Food and Agriculture Organization of the United Nations);

(f) Disasters (International Federation of the Red Cross and Red Crescent Societies, United Nations Office for Disaster Risk Reduction and national emergency management offices).

B.2. Harmonization and integration of data sources, concepts and methods

Recommendations to improve statistical methods have been made by CRED, working with IFRC (2015), the United Nations Third World Conference on Disaster Risk Reduction 2015-2030, in the Sendai Framework for Disaster Risk Reduction 2015-2030015), endorsed by the United Nations General Assembly (A/RES/69/283), by the United Nations First High Level Forum on GGIM in the Seoul Declaration on Global Geospatial Information Management (2011), the United Nations Statistical Commission (2016), IFPRI (2007) and Hanson (2010) and Woodroffe (2010).

These particularly emphasize the need to establish international standards and recommendations to:

(a) Harmonize definitions and classifications relating to vulnerable ecozones and regions and their vulnerabilities in and among countries (Schulz, 2005). "The lack of systematization and standardization of data collection is a major weakness when it comes to long-term planning" (CRED, 2015);

(b) Ensure the capacity to "layer" detailed data on population and population characteristics such as occupation, urban-rural and poverty in small administrative areas in countries with country geographical ecozones and regions. In his study of coastal populations, Woodruffe (2010) states: "The population data are not a sufficient resolution for detailed hazard analysis. Such vulnerability analyses should be focused on detailed local topography and integration with other variables such as flood level, land use, and other relevant factors. The population does not adequately represent urbanization and growing rural-urban imbalance with growth of enormous cities in the mega deltas." Specifically with respect to the "poorest and hungry", IFPRI states, "Without context-specific it is *difficult* to design programs that fit their needs. It is thus important to broaden the collection of and access to accurate data on [them]." On a limited scale, case studies in Ecuador and Malawi on the vulnerability of mountain peoples to food insecurity, "based on real data from household data to verify the results obtained from the model, and to illustrate what could be achieved if georeferenced household were available and analysed for all countries" (FAO and the Mountain Partnership Secretariat, 2015);

(c) Establish comprehensive national capacities to compile time series on vulnerable populations in countries, from national and international sources. The Seoul Declaration (United Nations First High Level Forum on Global Geospatial Management (GGIM))recognizes "the need for full interoperability of multi-dimensional geospatial information and integration with other data sources at national, region, and global level, in order to provide an effective information base for the resolution of global and local issues" (2011). Interfacing data sources, especially official national statistics with global geospatial information, is a critical need in order to produce integrated data series which must rely on quite different collection methods. An example of the difficulties can be

seen in United States water statistics. Currently comprehensive and detailed national statistics on water are only compiled every five years, and for one year, as they must be prepared from hundreds of independent sources with their own mandates and responsibilities, using a multiplicity of concepts, methods and micro-data sources (Fishman, 2016). The Seoul Declaration on Global Geospatial Information Managements recognizes "the need for full interoperability of multi-dimensional geospatial information and integration with other data sources at national, region, and global level, in order to provide an effective information base for the resolution of global and local issues. …" (United Nations First High Level Forum on GGIM, 2011).

B.3. Data sources, open access and the new data analytics

Basic data in countries, developed according to national circumstances and priorities, provide the foundation for indicator compilation. This report has identified populations in low-elevation coastal zones and flood plains and deltas, and drylands zones, and mountain and remote areas, as particularly vulnerable to climate impacts. These populations are largely rural and rely to a large extent on their own subsistence production for food security, energy, water and sanitation, and shelter. Climate change impacts stem from rising sea levels and extreme temperature events and are compounded environmental pressures from population growth, urbanization, water shortages, delta subsistence and pollution.

For basic planning to anticipate and adapt to climate change impacts, basic indicators are needed on populations in vulnerable zones, which meet international criteria of standardized sources and methods, frequency and continuity, and are easy to understand. These should include, for each country:

- Institutionalized, standardized and periodic and measurement of areas of low elevation coastal zones, coastal flood plains and deltas, and drylands, mountain and remote regions, and their populations and population growth rates;
- Urban and rural population growth rates;
- Population urban and rural, and poor and non-poor in each area;
- Cities >300t population in each area.

Sources and availability of environmental data of all kinds are rapidly expanding in public and civil spheres. The Sendai Framework for Disaster Risk Reduction (United Nations Third World Conference on Disaster Risk Reduction, 2015) sets as a priority for actions at national and local levels, "To promote real time access to reliable data, make use of space and in situ information, including geographic information systems (GIS) and use information and communications technology innovation to enhance measurement tools and the collection analysis and dissemination of data." As statistical awareness and data-based analytical capacities have increased greatly among civil institutions and non-governmental organizations since the advent of the Millennium Development Goals indicators in 2002, open access to data and availability of

user-friendly analytical programs on Internet now play a significant and invaluable role in data development and testing, including in many fields of practice in environment statistics still in early stages of development.

Institutions and analysts across government departments and outside government, depend for their data analytics on easy access to well-organized data. As stated in the United Nations Fundamental Principles of Official Statistics, "Official statistics that meet the test of practical utility are to be compiled and made available on an impartial basis by official statistical agencies to honour citizens' entitlement to public information" (United Nations General Assembly 2014). As sophisticated users and data analytics increase, the demand is not just for basic series and tables but for the detailed underlying micro-data, whose release requires new policies and programmes by national offices to make the data easily available, and not just from national statistics offices but from all government offices, non-governmental organizations and private sector enterprises concerned with environment issues.

The international non-governmental organization opendatawatch.org observes, "There are many obstacles to opening statistical systems: some technical, some organizational, some political. To implement open data programs developing countries need technical and financial support. And they need to draw on the experience of others, building partnerships and sharing knowledge." An example of a proactive initiative to encourage data analytics in civil society is the US Bureau of the Census "The Opportunity Project" (opportunity.census.gov), which provides data and software support to outside programmes for data analytics.

Besides "official" statistics originating with traditional national and international statistical services, there is new emphasis on the importance of government statistical services partnerships in the development of new data and data analytic methods for the Sustainable Development Goals, being careful to observe the Fundamental Principles of Official Statistics and the continuity of data sources. There are good examples of such partnerships in the work of the international organizations and governments in the Inter-Agency and Expert Group on the MDG Indicators, where non-governmental organizations with long experience in specialized fields contributed to the data series used for monitoring implementation, such as the Internal Displacement Monitoring Centre and Refugees International, Audubon International, International Union for the Conservation of Nature, Nature Conservancy International, World Conservation Monitoring Centre, and the World Wildlife Fund.

The secretariats of international conventions also have mandates for data development and compilation for monitoring, in cooperation with governments, and continue to make unique and significant contributions to the development of official data in their fields, for example the Convention on Biological Diversity, the RAMSAR Convention, the United Nations Convention to Combat Desertification and the United Nations Framework Convention on Climate Change.

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