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Full Length Research Paper

Analyzing vulnerability and resilience of Turkey to climate change

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The purpose of this study was to analyze the vulnerability and resilience of Turkey to climate change impacts. The Vulnerability Resilience Index was developed to measure Turkey's vulnerability. Adaptive/coping capacity and exposure/sensitivity sectors were generated and used to determine the vulnerability value. First, these sectors were divided into related indicators. Economy, human resources, environment, and governance indicators were used to determine adaptive/coping capacity sector value. Exposure, settlement, food, ecosystems, health, and water indicators were used to determine exposure/sensitivity sector value. Later, proxies for each indicator were established. Proxy indexes were interpreted to indicators and these indicators were connected to sectors. The overall climate change vulnerability of Turkey was constructed based on sectors' values. Results showed that economic capacity was the most vulnerable adaptive/coping capacity indicator and ecosystem sensitivity is the most vulnerable sensitivity indicator for Turkey. It has been found that Turkey's vulnerability to climate change index value was 0.363 indicating low vulnerability.

Key words: Climate change, vulnerability, resilience, adaptive capacity, exposure, sensitivity, Turkey

INTRODUCTION

Climate change is considered one of the greatest challenges facing the world today (Copenhagen, 2009). It is evident that even if all greenhouse gas emissions were immediately halted, climate change would continue for the foreseeable future. Greenhouse gases that have already accumulated in the atmosphere would continue to alter climatic systems, ecological systems, and social systems (Ligetti et al., 2007; CCC, 2010). It is almost universally accepted that the consequences of climate change are likely to be severe and have cumulative or systematic effects on natural and managed systems in various sectors and regions (IPCC, 1997). In order to cope with the consequences and new challenges, regions or countries must develop adaptation policies or actual adjustments that might eventually enhance resilience and reduce vulnerability to expected climate change impacts.

Vulnerability is defined as the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including variability and extremes. Vulnerability research started in natural hazard studies focuses on the vulnerability of people to the effects of

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environment and became an important aspect in climate change and policy research (Brooks et al., 2005; Füssel, 2007; Hinkel, 2011, Janssen et al., 2006, Smit and Wandel, 2006). The increasing focus on adaptation has positioned vulnerability as an integral concept in climate change research today (Malone and Engle, 2011). The three components of vulnerability are exposure, sensitivity and adaptive capacity (IPCC, 2001). It is established that high vulnerabilities to climate change depend considerably on geographic location, sectoral and social contexts (Lynn et al., 2011).

Vulnerability assessment is an important tool for understanding the different vulnerability of regions and peoples. The methodological frameworks to investigate vulnerability to climate change embrace sensitivity and adaptive/coping capacity. These assessments are performed for several purposes but their primary objective is to identify the people or places that are most susceptible to harm and to permit vulnerability-reducing actions and improve adaptation planning, unveiling social injustices (Luers, 2005; Malone and Engle, 2011). Each of these purposes entails specific information and targeted approaches. The indexes developed for modeling vulnerability are intended to measure national, regional and local propensities and susceptibilities to the impacts of climate change that are beyond human control (Brooks et al., 2005; Brenkert and Malone, 2005; O'Brein et al., 2004; Parvin and Shaw, 2011). Therefore, vulnerability assessments enhance the capacity to cope with the events, climatic alteration and, hence, protect human well being.

Resilience is often considered to be opposite of vulnerability (Adger 2001; Davoudi et al., 2012). Resilience is the ability of social or ecological system absorb while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change (Ibarran et al., 2008). Resilience assessment is a specific methodology and framework for analyzing and managing the dynamics of resilience in social-ecological systems. It provides a set of participatory tools to help identify thresholds, drivers, dynamics, and actions that either contribute to or erode resilience in social-ecological systems (Resilience Alliance, 2010). It is also important to develop political and social solutions within the system.

Vulnerability assessment rooted in social-ecological systems and resilience research integrates the natural, physical, and societal capacities to cope in the shorter term and adapt in the longer term. In resilience research, this has led to a shift from thinking about always returning to an original state to thinking about preserving and the opportunity to move between multiple stable states (Malone and Engle, 2011). Both the vulnerability and resilience assessments are concerned with how systems respond to climate change. Both concepts together might, therefore, help to clarify the complexities of past environment–society relationships and could contribute to our understanding of how societies have coped with and adapted to past climate variability and weather or weather-related events (Endfield, 2012).

Turkey is a developing country in Western Asia with 76.4 million populations. It became a member of the United Nations Framework Convention on Climate Change in 2004 and the Kyoto Protocol in 2009. These attempts increased the attention given to climate change and its research. It has been stated that Turkey is especially vulnerable to the adverse impacts of climate change because it is located in Mediterranean Basin (IPCC, 2007). Turkish Ministry of Environment and Urbanization developed a national climate change strategy and combating climate change became a national vision in recent years (MEU, 2010a).

Fujihara et al. (2008) and Yano et al. (2007) have found that climate change could place an additional stress on Turkey's ecological and socio-economic systems. Besides, these systems already face tremendous pressures because of rapid urbanization, industrialization, and economic development (Fay et al., 2010). Therefore, it is important to identify Turkey's vulnerability and resilience to climate change impacts. The aim of this study is to assess the current sensitivity, adaptive/coping capacity, vulnerability and resilience of Turkey to climate change.

METHODS

The Vulnerability-Resilience Indicator Model (VRIM) was developed by Moss et al. (2001) to assess vulnerability. The modeling framework allows analysts to evaluate systematically an entity and/or set of indicators, and to indicate the likely vulnerabilities of an area (Brenkert and Malone, 2005). VRIM takes a hierarchical approach in constructing a vulnerability index as the geometric mean of various measures of sensitivity (how systems could be negatively affected by environmental stresses) and adaptive capacity (the capability of a society to maintain, minimize loss of, or maximize gains in welfare).This approach have the advantage of dividing their indicator into two major components - one that reflects sensitivity and a second that reflects adaptive capacity (Yohe et al., 2006). VRIM uses five indicators - settlement, food, ecosystems, health, and water, to assess the sensitivity sector and uses three indicators - economy, human resources, and environment, to assess the adaptive/coping capacity sector. Each indicator has two or three proxies in the model which evaluate their positive and negative relations. The VRIM measures vulnerability with the assessments of sensitivities to climate, and societal coping/adaptive capacities.

There are more data available for the climate change studies and these data is very beneficial to use in VRIM model. There had been some adaptations made on the VRIM in this study. Exposure indicator is included under exposure/sensitivity sector and it was calculated using proxies representing different climate change stress such as sea level rise, temperature change and precipitation change. There has been an affirmation that institutions, governance, and management play an integral role in determining a system's ability to adapt to climate change (Brooks et al., 2005; Brown et al., 2010; Eakin and Lemos, 2006; Engle and Lemos, 2010; Held and Hervey, 2009). Governance had been added as a fourth indicator to the adaptive/coping capacity sector.

Studies on climate change has shown that damage of particulate

matter (PM) will be worsened with the increased temperature (Jacob and Winner, 2009; Bell et al., 2007; Patz et al., 2005). It has been suggested that PM is a good proxy to assess air quality (Martuzzi et al., 2002). Deforestation is also important to proxy to assess environmental capacity (Spitalhouse and Steward, 2003). Current study assessed the PM_{10} proxy for one of the environmental capacity indicator proxies. Recent studies recommended that "endangered species" data could be used in ecosystem sensitivity assessment because it is a significant indicator of biodiversity loss (Thuiller, 2007). For the health sensitivity indicator, "ages 65+" and "under five mortality rate" were taken as additional proxies. These two proxies are also significant measures in assessing health sensitivity (Haines et al., 2006; Keim, 2008). The final versions of the vulnerability resilience index (VRI) and data sources are given in Table 1. Once the vulnerability-resilience index was structured, proxy index from 124 countries had been translated into dimensional indexes using dimension index formula (1). All countries which had no missing data were selected for this step. The World Bank, UNESCO and UNEP were the main data sources. Dimension index values were also compared with the world's mean values for each proxy.

$$\text{Dimension Index}_i = \frac{X_i\text{-Min Value}}{\text{Max Value-Min Value}} \quad (1)$$

The proxy index which was in different units and scales were normalized and scaled as maximum and minimum values to make them accountable. After the normalization process, the scores were settled between 0 and 1 (Table 2). By relating proxy index and vulnerability, positive and negative relationships between the proxy and indicator and between the indicator and sector were possible. Each dimensional index is a proxy for the capabilities of the corresponding dimension. The transformation function of income (GDP) to capabilities is likely to be concave. Therefore, using the natural logarithm of the actual minimum and maximum values is recommended for GDP (HD Report, 2011).

Arithmetic means were used to create indicator index. Subsequently, the dimensional index for each proxy was transformed into indicator values. Nine proxies for four indicators were utilized to calculate the adaptation/coping capacity; twenty proxies for six indicators were employed to determine sensitivity (Table 1). The difference between climate change sensitivity and adaptive/coping capacity create the overall vulnerability of a country.

RESULTS

Each country has different and possibly unique geographic, economic and social features that affect its vulnerability to climate change. Also, one country's vulnerability level would be differentiated due to its developmental pathway. Here, Turkey's adaptive/coping capacity, exposure/sensitivity and overall vulnerability to climate change is explained.

Adaptive/coping capacity of Turkey

Adaptive/coping capacity is the ability of a system to respond to and recover from the effects of stress or perturbations that have the potential to alter the structure or function of the system. Turkey's adaptive/coping capacity sector index value was found 0.592 indicating moderate adaptive/coping capacity to climate change impacts (Figure 1). Economic capacity, human resources, environmental capacity, and governance capacity were taken as the indicators of the adaptive/coping capacity sector in this study.

Results were analyzed to delve strengths or weaknesses of Turkey and its barriers or limits of adaptive/coping capacity against climate change impacts. Table 3 presents the proxy values of adaptive/coping capacity sector.

Economic capacity

One of the main variables affect the vulnerability of individuals and communities is economic capacity (Cutter et al., 2003). Economic growth and distribution of income among populations are economic aspects of resilience (Adger, 2000). Turkey's economic capacity indicator index value was found 0.528 pointing moderate adaptive/coping capacity. Turkey's low economic capacity seems an obstacle for adaptation to climate change. The GDP per capita (in US $) and income equity were used as proxies for assessing economic capacity in Turkey.

Apparent indicator that makes large contributions to reduce adaptive capacity of Turkey was low GDP per capita. Turkey's GDP proxy index value was found 0.420 indicating moderate adaptive/coping capacity. Gini coefficient is commonly used as a measure of inequality of income or wealth. Turkey's Gini coefficient proxy index value was found 0.636 indicating high adaptive/coping capacity. This indicates that the distribution of income is close to equal in Turkey.

Human resources capacity

A further aspect of social resilience is human capital which allows examination of links to changes in production, employment, and labor mobility (Adger, 2000). Human resources capacity helps to determine how citizens respond to job shifting caused by climatic variability. Turkey's human resources capacity indicator index value was found 0.759 pointing high adaptive/coping capacity. This result implies that Turkey has advantage against climate change in terms of human resources. Age dependency and literacy were used as proxies for assessing human resources capacity in Turkey.

Age dependency proxy index value was found 0.648 indicating high adaptive/coping capacity. It explains that economically active individuals can use resources to adapt the impact of climate change. The adult literacy ratio is the percentage of those that can understand, read

Table 1. Sectors, indicators, and proxies of the model.

Sector	Indicator	Proxy	Functional relationships	Source
Adaptive and coping capacity	Economic capacity	GDP per capita	Coping/adaptive capacity ↑ as GDP per capita ↑	WB, 2010
		Income equity (Gini)	Coping/adaptive capacity ↑ as Gini coefficient ↓	WB*
	Human resources	Dependency ratio (% of working-age population)	Coping/adaptive capacity ↑ as dependency ↓	WB, 2010
		Literacy (15+)	Coping/adaptive capacity ↑ as literacy ↑	UNESCO, CIA*
	Environmental capacity	Population density	Coping/adaptive capacity ↓ as population density ↑	UNEP, WB, 2010
		Air quality	Coping/adaptive capacity ↓ as PM_{10} emissions ↑	World Development Indicators,
		Deforestation	Coping/adaptive capacity ↓ as deforestation ↑	WB, 2013
	Governance	Voice/accountability	Coping/adaptive capacity ↑ as voice and accountability ↑	WB, World. Governance Indicators
		Government effectiveness	Coping/adaptive capacity ↑ as government effectiveness ↑	WB, World. Governance Indicators
Exposure/sensitivity	Exposure	Land area below 5 m elevation (%)	Exposure ↑ as land area below 5 m elevation ↑	WB, 2013
		Population living below 5 m elevation (%)	Exposure ↑ as population living below 5 m elevation ↑	WB (2000 population data)
		Population affected by droughts, floods, and extreme temperatures	Exposure ↑ as affected population ↑	WB, 2013
		Temperature change (%)	Exposure ↑ as temperature change ↑	WB, 2013
		Precipitation change (%)	Exposure ↑ as precipitation change ↑	WB, 2013
	Settlement/ Infrastructure sensitivity	Urban population growth (%)	Sensitivity ↑ as urban population growth ↑	WB, 2012
		Improved sanitation facilities (% of population with access)	Sensitivity ↓ as population with access ↑	WHO, WB, 2010
		Improved water sources, rural (% of rural pop. with access)	Sensitivity ↓ as population with access ↑	WHO, WB, 2010
	Food security	Cereal yield	Sensitivity ↓ as production ↑	WB, 2010
		Protein consumption per capita	Sensitivity ↓ as consumption ↑	WB, 2010
	Ecosystem sensitivity	Fertilizer use	Sensitivity is ↓ if use <60 kg/ha or >100 kg/ha; ↑ when use ≥60 and <100 kg/ha	WB, 2010
		Endangered species	Sensitivity ↓ as endangered species ↓	IUCN, 2010
		Terrestrial protected areas (%)	Sensitivity ↓ as terrestrial protected areas ↑	WB, 2013
	Health sensitivity	Fertility rate	Sensitivity ↓ as fertility rate ↓	WB, 2010
		Life Expectancy	Sensitivity ↑ as life expectancy ↓	WB, 2010
		Under-five mortality rate (per 1,000)	Sensitivity ↓ as under-five mortality rate ↓	WB, 2012
		Ages 65+ (%)	Sensitivity ↑ as % of ages 65+ ↑	UNICEF, WB, 2010
	Water resource sensitivity	Renewable internal freshwater resources per capita (m^3)	Sensitivity ↑ as freshwater resources per capita ↓	WB, 2010
		Annual freshwater withdrawals, total	Sensitivity ↑ as freshwater withdrawal ↑	AQUASTAT, WB, 2010
		Average annual precipitation	Sensitivity ↓ as average annual precipitation ↑	WB, 2013

Table 2. Index value categorization.

Index value	Category
0.000-0.200	Very low
0.201-0.400	Low
0.401-0.600	Moderate
0.601-0.800	High
0.801-1.000	Very high

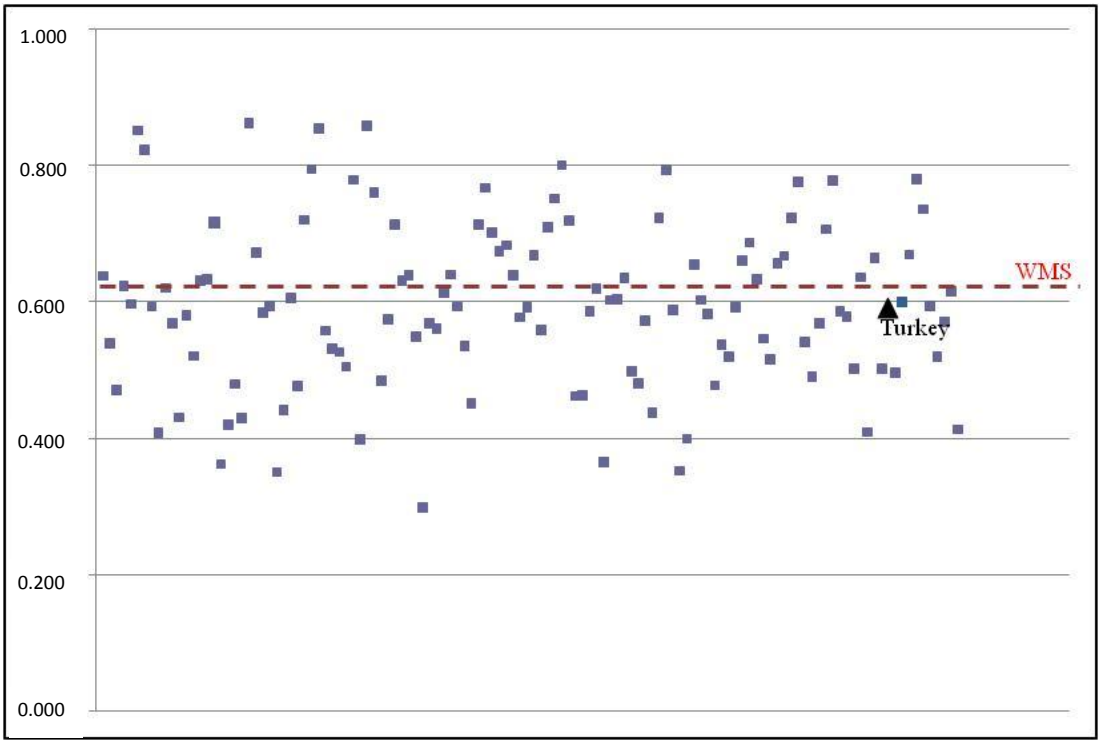


Figure 1. Adaptive/coping capacity of Turkey.

and write a short simple statement on their everyday lives. Turkey's adult literacy proxy index value was found 0.871 indicating very high adaptive/coping capacity.

Environmental capacity

Environmental capacity is an important factor in adaptation process also. Environmental capacity shows the current human pressure on natural resources and health of the environment where the people live. Results showed that Turkey have moderate environmental capacity with an index value of 0.663. Population density, particulate matter (PM_{10}) and average annual deforestation were used as proxies for gauging Turkey's environmental capacity.

It has been found that population density has the major negative effect. Population density proxy index value was found 0.392 indicating low adaptive/coping capacity. This result states that, Turkey's population density has a high pressure on natural sources. Air quality directly affects the quality of human's life. PM_{10} was used as a proxy for air quality. Turkey's PM_{10} proxy index value (0.766) was found high. PM_{10} proxy index value explains that Turkey has low level of air pollution. Deforestation is the process of destroying a forest and replacing it with something else, especially by an agricultural system. Turkey's annual deforestation proxy index was found very high (0.831). It means that deforestation in Turkey is low and this situation creates an advantage against climate change.

Governance capacity

Adaptation to climate change impacts must also be included in the debate on policy issues because of the integrated nature of the climate change (Adger, 2001).

Table 3. Adaptive/coping capacity indicator and proxies of Turkey.

Indicator / proxy	Turkey's score	Rank	Category	WMS
Economic capacity	**0.528**	**45**	**Moderate**	**0.636**
GDP (per capita)	0.420	31	Moderate	0.645
Income equity	0.636	58	High	0.626
Human resources	**0.759**	**69**	**High**	**0.654**
Age dependency	0.648	91	High	0.519
Literacy	0.871	54	Very High	0.789
Environmental capacity	**0.663**	**77**	**High**	**0.595**
Population density	0.392	48	Low	0.356
Air quality	0.766	44	High	0.761
Deforestation	0.831	113	Very High	0.668
Governance	**0.543**	**77**	**Moderate**	**0.499**
Voice and accountability	0.431	56	Moderate	0.500
Government effectiveness	0.655	88	High	0.498

Turkey's governance capacity indicator index value was found 0.543 pointing moderate adaptive/coping capacity. Voice and accountability, and government effectiveness were used as proxies for assessing governance capacity in Turkey. Voice and accountability proxy index value was found 0.431 indicating moderate adaptive/coping capacity. Government effectiveness proxy index was high (0.655). Turkey's government effectiveness rate reveals that Turkey has good public services and policy formulation which are important for implementing climate change adaptation policies. Turkey also has been involved in international negotiations on climate change since 1992 and policies have been regulated in accordance with other UNFCCC members (MoF, 2013).

Exposure/Sensitivity of Turkey

Exposure is degree of climate stress upon a particular unit analysis; due to changes or variability in climate conditions. Sensitivity is basically the biophysical effect of climate change; but sensitivity can be altered by socio-economic changes. Exposure/sensitivity of a country to climate variability and change is based on the degree of changes and its biophysical effects. Turkey's exposure/sensitivity sector index value was found 0.283 pointing low exposure/sensitivity to climate change impacts (Figure 2). Exposure, settlement-infrastructure, food, ecosystems, health, and water sensitivities were taken as the indicators of the sensitivity sector.

Results were analyzed to explore strengths or weaknesses of Turkey and its barriers or limits of exposure/sensitivity sector against climate change impacts. Table 4 presents the proxy values of exposure/sensitivity sector.

Exposure

Exposure indicator measures climate change impacts to a country or region. Turkey's exposure indicator index value was found 0.087 indicating very low exposure/sensitivity. Land area below 5 m elevation, population living in areas below 5 m elevation, temperature change, precipitation change and population affected by droughts, floods, and extreme temperatures proxies were used for assessing exposure of Turkey.

The most significant proxies of exposure indicator were precipitation change and temperature change for Turkey. Precipitation change measures the projected change in annual precipitation in the years 2045 to 2065, relative to the control period 1961 to 2000 (World Bank, 2013). The range reflects the results from nine general circulation models (GCMs), employing the A2 storyline and scenario family. Turkey's precipitation change proxy index was found 0.345 indicating low exposure/sensitivity. Temperature change proxy is the projected change in annual temperature in the years of 2045 to 2065, relative to the control period 1961 to 2000 (World Bank, 2013). The range reflects the results from nine general circulation models (GCMs) at a standardized 2-degree grid, employing the A2 storyline and scenario family. Turkey's temperature change proxy index value was found 0.043 indicating very low exposure/sensitivity. Even though Turkey's temperature change is very low, Turkey is getting warmer than the WMS (0.024). IPCC indicated that Turkey is one of the countries which will be moderately affected from temperature change (IPCC, 2007). Land area below 5 m elevation measures the percentage of a countries land area to its total land area. Turkey's land area below 5 m elevation proxy index value was found very low (0.010). Land area below 5 m

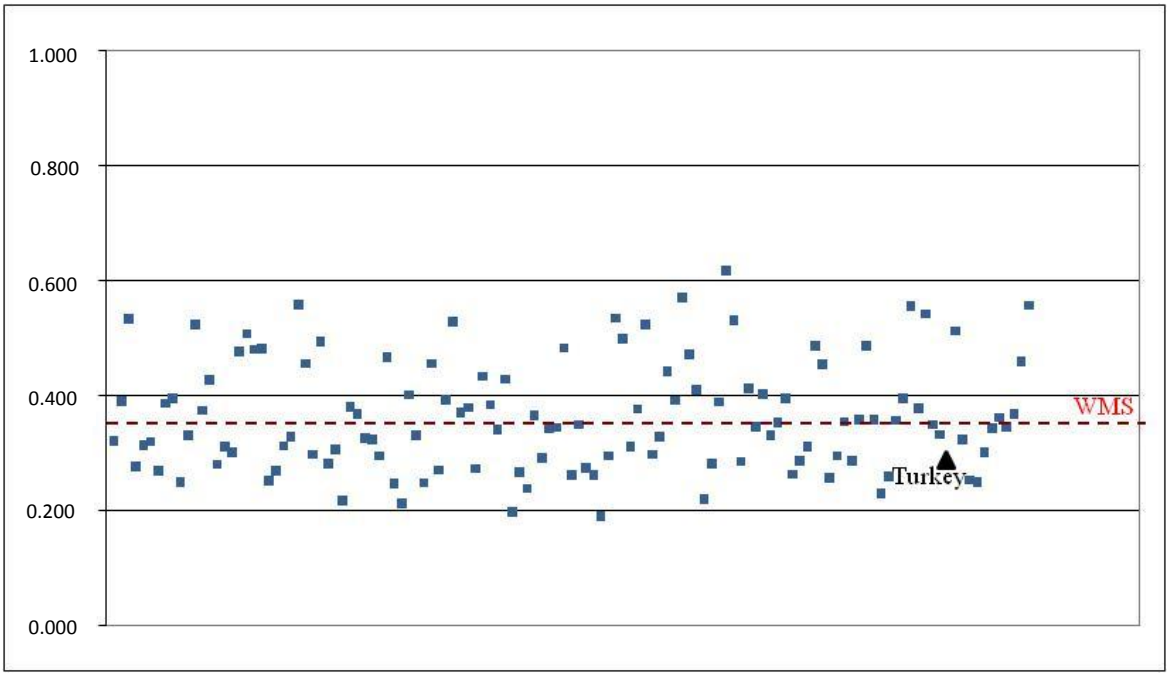


Figure 2. Exposure/sensitivity of Turkey.

Table 4. Exposure/sensitivity sector indicators and proxies of Turkey.

Indicator/proxy	Turkey's score	Rank	Category	WMS
Exposure	**0.087**	**58**	Very low	**0.075**
Land area below 5 m elevation	0.010	76	Very low	0.018
Population living in areas below 5m elevation	0.024	72	Very low	0.066
Population affected by droughts, floods, and extreme temperatures	0.015	76	Very low	0.127
Temperature change	0.043	36	Very low	0.024
Precipitation change	0.345	23	Low	0.139
Settlement/infrastructure sensitivity	**0.210**	**75**	**Low**	**0.319**
Urban population growth	0.505	47	Moderate	0.452
Access to sanitation facilities	0.110	71	Very low	0.297
Access to drinking water	0.014	100	Very low	0.207
Food sensitivity	**0.510**	**88**	**Moderate**	**0.598**
Cereal yield	0.713	61	High	0.660
Animal protein	0.307	100	Low	0.536
Ecosystem sensitivity	**0.329**	**74**	**Low**	**0.304**
Fertilizer use	0.390	74	Low	0.341
Endangered species	0.565	19	Moderate	0.314
Terrestrial protected areas	0.031	118	Very low	0.257
Human health sensitivity	**0.192**	**105**	**Very low**	**0.294**
Fertility rate	0.167	74	Very low	0.283
Life Expectancy	0.257	79	Low	0.373
Age 65+(%)	0.261	73	Low	0.304
Under-five mortality rate (per 1,000)	0.084	72	Very low	0.217
Water sensitivity	**0.369**	**102**	**Low**	**0.622**
Annual freshwater withdrawals per person	0.257	46	Low	0.267
Renewable internal freshwater resources per capita	0.484	58	Moderate	0.859
Average annual precipitation	0.365	97	Low	0.739

elevation proxy index value indicates that Turkey's land area below 5 m will be slightly affected from sea level rise because of its topography and location. Population living in areas below 5 m elevation proxy measures the percentage of the country's population to its total population. Turkey's population living in areas below 5 m elevation proxy index value was found very low (0.024). This proxy index indicates that sea level rise will slightly affect the people living in areas below 5 m in Turkey. It is also stated by other researchers that vulnerability related to sea level rise will be very low in Turkey (Simav and Seker, 2013; Karaca and Nicholls, 2008). Droughts, floods and extreme temperatures are the annual percentage of the population that is effected by natural disasters classified as either droughts, floods, or extreme temperature events. Population affected by droughts, floods and extreme temperatures proxy index value was found 0.015 indicating very low exposure/sensitivity. Turkish population will be slightly affected from droughts, floods and extreme temperatures.

Settlement-infrastructure sensitivity

Settlement-infrastructure sensitivity indicator measures climate change impacts on human settlements and infrastructure. Results showed that Turkey have low settlement-infrastructure sensitivity (0.210). Urban population growth, access to sanitation facilities, and access to drinking water in rural areas were used for assessing settlement sensitivity in Turkey.

Turkey's urban population growth proxy index value was found 0.505 indicating moderate exposure/sensitivity.

Access to improved sanitation facilities refers to the percentage of the population with at least adequate access to disposal facilities that can effectively prevent human, animal, insect contact and excreta. Turkey's access to improved sanitation facilities proxy index value was found 0.110 indicating very low exposure/sensitivity. The improved sanitation facilities proxy index value indicates that Turkey has almost sufficient infrastructure. Access to an improved water source in rural area refers to the percentage of the rural population with reasonable access to an adequate amount of water from an improved source, such as a household connection, a public standpipe, a borehole, a protected well or spring, or rainwater collection. Turkey's access to improved water source in rural area proxy index value was found 0,014 indicating very low exposure/sensitivity.

Food sensitivity

Food sensitivity indicator explains future food disruptions or shortages. Turkey's food sensitivity indicator value was found 0.510 pointing moderate exposure/sensitivity. Cereal yields and protein consumption per capita proxies were used to measure food sensitivity in Turkey. It has been stated that corn and wheat are the most vulnerable crops to the climate change (Kanber et al., 2007; Atik et al., 2007). Cereal yields measured as kilograms per hectare of harvested land include wheat, rice, maize, barley, oats, rye, millet, sorghum, buckwheat, and mixed grains. Turkey's cereal yield proxy index value was found 0.713. This result indicates that Turkey's cereal yield production is highly sensitive in the adaptation to the climate change. Protein consumption per capita refers to the supply side. Turkey's animal protein proxy index value was found 0.307 indicating low exposure/sensitivity.

Ecosystem sensitivity

Ecosystem sensitivity indicator explains alterations in pollution, land cover changes and biodiversity. Ecosystem sensitivity indicator index value was found 0.329 pointing low exposure/sensitivity. This result indicates that Turkey's ecosystem will be fairly affected from climate change. Fertilizer use, endangered species and terrestrial protected areas proxies were used to measure ecosystem sensitivity in Turkey.

Industrial agricultural activity has a direct and profound impact on the environment. Turkey's fertilizer use proxy index value was found 0.389 indicating low exposure/sensitivity. The endangered species proxy includes the percentage of critically endangered, endangered or vulnerable animal species classified by the International Union for Conservation of Nature (IUCN). Parmesan (2006) stated that climate change effects the survival of animal species. Endangered species proxy index value was found 0.565 indicating moderate exposure/sensitivity. This result points that Turkey's biologic diversity is under threat. Terrestrial protected areas proxy is the percentage of protected areas to country's total land area. Terrestrial protected areas are totally or partially protected areas of at least 1,000 hectares that are designated according to IUCN's classification and serves as scientific reserves with limited public access. Terrestrial protected areas proxy index value was found 0.031 indicating very low exposure/sensitivity. It has been suggested that climate change will slightly affect terrestrial biodiversity.

Health sensitivity

Health sensitivity includes the direct or indirect effects of climate change. Direct effects refer to deaths caused by excessive heat. Climate change also has the potential to alter the patterns of vector-borne diseases. Health sensitivity indicator index value was found 0.192 pointing very low exposure/sensitivity. This result shows that health sensitivity will be slightly affected from climate change impacts. The fertility rate, life expectancy, age

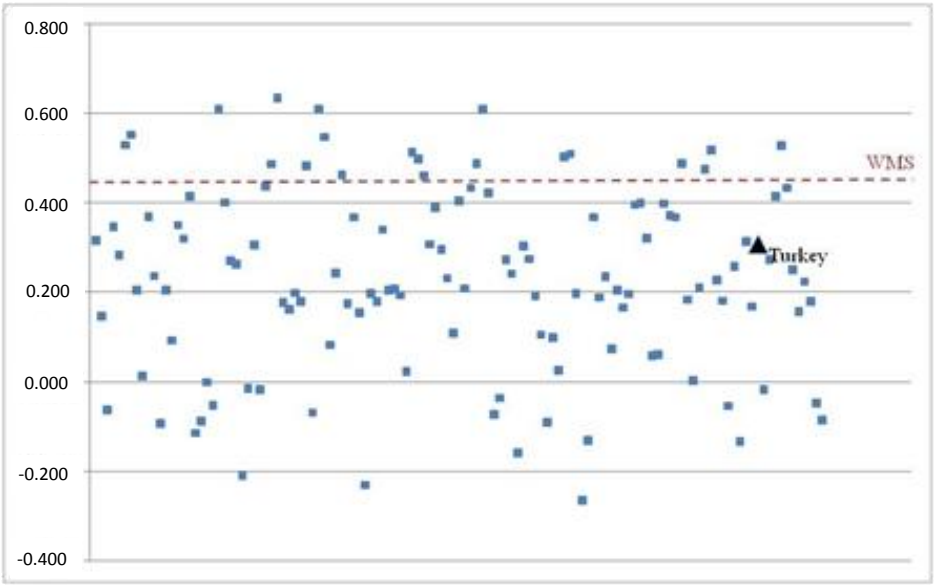


Figure 3. Vulnerability-resilience of Turkey.

65+, and under age five mortality were used as proxies for assessing health sensitivity in Turkey.

Turkey's fertility proxy index value was found 0.167 indicating very low exposure/sensitivity. Life expectancy at birth explains the number of years of a new-born infant would live. Life expectancy proxy index was low (0.257). Life expectancy proxy index value shows that life expectancy in Turkey will be slightly affected from climate change. Senior citizens and new-born infants are the fragile link in the chain of proper care needed group (Martens, 1998; Shea, 2007). Age 65+ proxy index value was found 0.261 indicating low exposure/sensitivity. Under age five mortality rate proxy index was very low (0.084). These results indicates that while senior citizens of Turkey will be moderately affected from climate change, new born infants will be slightly affected.

Water sensitivity

Water sensitivity is an important issue because it is estimated that approximately five billion people of the world will be experiencing water stress (Arnell, 1999). Water sensitivity indicator index value was found 0.369 pointing low exposure/sensitivity. The annual fresh water withdrawals, renewable internal fresh water resources, and average annual precipitation were used as proxies for assessing water sensitivity.

Annual fresh water withdrawals proxy index value was found 0.257 indicating low exposure/sensitivity. The annual fresh water rate indicates that Turkey will experience fresh water shortage. The renewable internal freshwater resources refer to national internal river flows and groundwater from rainfall per capita. Renewable internal fresh water resources proxy index value was found moderate (0.484). Internal fresh water rate indicates that Turkey's internal fresh water will be moderately affected from climate change impacts. Average annual precipitation is the sum of the rainfall and the assumed water equivalent of the snowfall for the year in the country, averaged over the years 1961 to 1990. Average annual precipitation proxy index value was found 0.365 indicating low exposure/sensitivity. National Climate Change Adaptation Action Plan also states that water shortages in Turkey will reach a critical point especially in agriculture and energy production (MEU, 2010b; Maden, 2008; Ozlu, 2007).

Vulnerability of Turkey

The Vulnerability-Resilience Index (VRI) is constructed through the calculation and aggregation of 29 proxies reflecting country-level vulnerability. These proxies are combined into ten indicator categories reflecting adaptive capacity or exposure/sensitivity sectors. Data from 124 countries were used for the vulnerability-resilience assessment. Results are presented in Figure 3.

It has been found that Turkey's vulnerability to climate change index value was 0.363 indicating low vulnerability. Data suggests that Turkey will be fairly affected from the impact of climate change. Turkey's vulnerability value is slightly above the WMS (0.431). Turkey ranks the 80th place of 124 countries for vulnerability (Figure 4). Even though Turkey's vulnerability value is far above those of the most vulnerable countries such as Niger (0.999), and Guinea (0.961); it is noticeably below those of the most resilience countries such as Denmark (0.000), and Finland (0.027).

Turkey's low vulnerability to climate change impacts

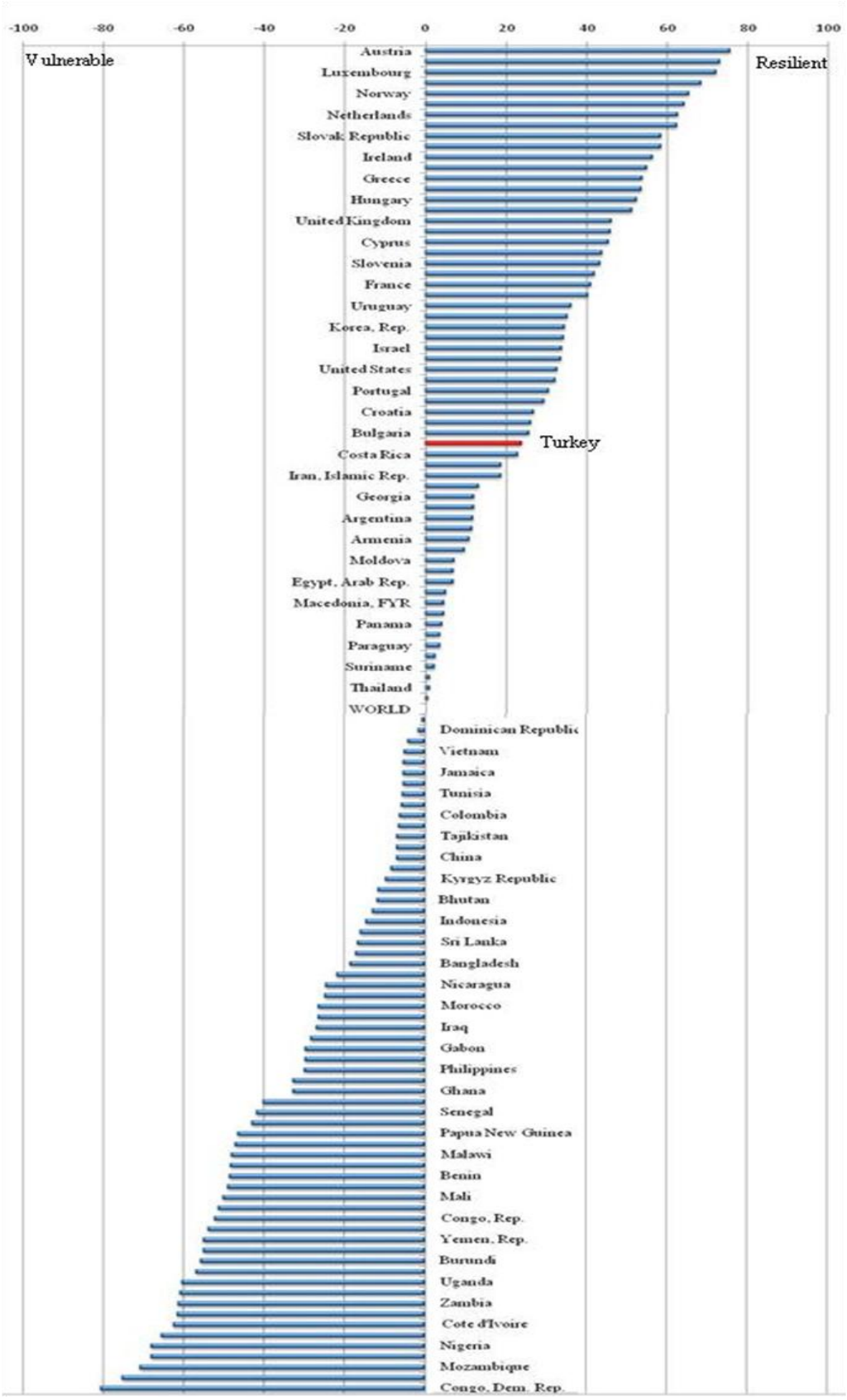


Figure 4. The climate change vulnerability of Turkey scaled for global values (0-axis represents world mean).

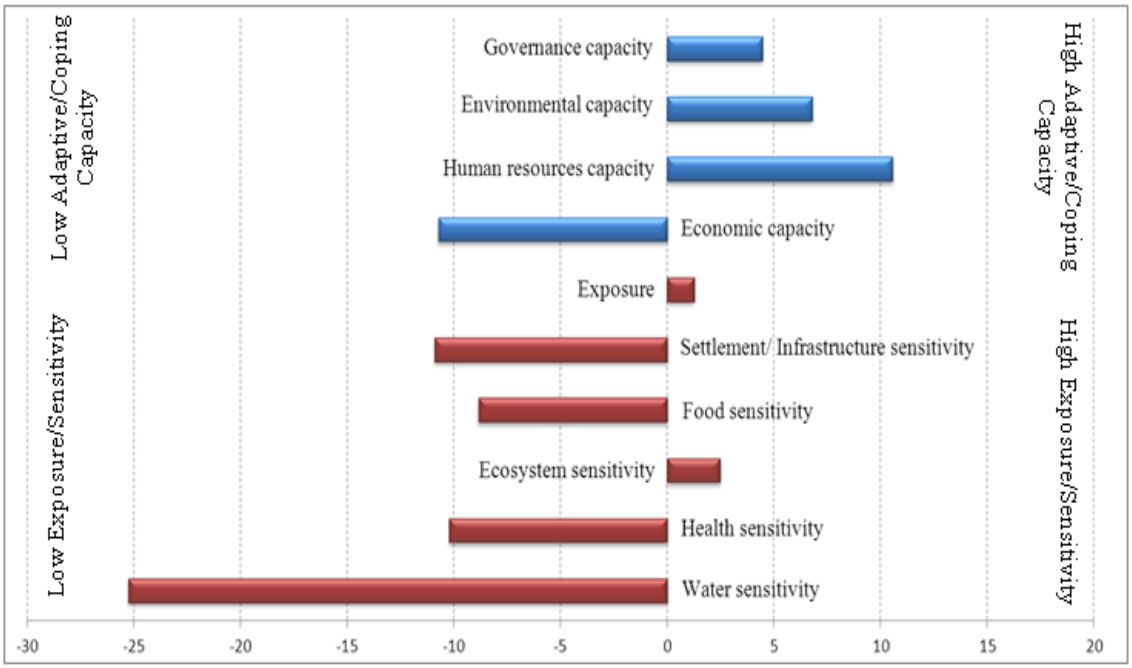


Figure 5. The adaptive/coping capacity indicators and exposure/sensitivity indicators for Turkey (0-axis represents world mean).

was also confirmed by other indexes. Environmental Performance Index (EPI) indicators are for environmental purposes, Vulnerability Resilience Indicator Model (VRIM) and Climate Vulnerability Monitor (CVM) indicators are for climate change vulnerability. It has been observed that the current study (VRI) is very consistent with these indexes in terms of Turkey's vulnerability.

Adaptive/coping capacity and exposure/sensitivity sectors were analyzed and related to WMS to understand Turkey's strengths and weaknesses in vulnerability. Results are presented in Figure 5.

Adaptive/coping capacity sector index value for Turkey was found 0.592 indicating moderate vulnerability. It shows that Turkey's adaptive/coping capacity is moderate against combating climate change impacts.

It is seen that Turkey's human resources capacity is relatively high. This indicates that Turkish individuals could respond to job shifting caused by climatic variability because of their education level and readiness for the labor force. Apparent indicator that makes large negative contributions to coping/adaptive capacity is economic capacity. 1005 U.S.D GDP per capita is low and this creates a disadvantage for the Turkish society causing limited access to resources that can be used to adapt to climatic variability and change.

Exposure/sensitivity indicator value for Turkey was found 0.087 indicating very low sensitivity. It means that Turkey's exposure/sensitivity is durable against climate change impacts. It was found that one of the indicators, the ecosystem sensitivity index value is 0.329 indicating low sensitivity. This indicates that there is a low pressure on ecosystems or natural resources of today. However, other countries' index values showed that Turkey's ecosystem sensitivity is relatively high comparing to them. It can be said that ecosystem sensitivity in Turkey's, is the weakest indicator compare to other countries (Figure 5). Apparent indicator that makes large positive contributions to exposure/sensitivity sector is water sensitivity. Water sensitivity indicator has been found 0.369 indicating low sensitivity. This result explains that Turkey will fairly be experienced water stress due to climate change.

CONCLUSION AND RECOMMENDATIONS

One nation's future vulnerability depends not only on climate change but also on development pathways (IPCC, 2001). In this context, assessing vulnerability in developing and least developed countries is an important component in formulating national and international adaptation strategies. It is also significant in increasing the sustainability of development. IPCC (2001) emphasizes that the adaptive capacity dealing with climate change risks is closely related to sustainable development and equity. Because enhanced adaptive capacity has a constructive effect on sustainable development. Turkey's adaptive capacity needs to be improved in order to ensure a sustainable development. Previous studies assessed Turkey's vulnerability with an impact assessment approach (UNFCCC, 2009; MEU, 2010b). It was underlined that the vulnerability of a nation

to climate change impacts in next ten to twenty years will be dominated by socio-economic factors and legacy issues (Fay et al., 2010). While current research took climate change impacts in consideration, it has also assessed the quantitative measures of Turkey's coping/adaptive capacity, sensitivity, and vulnerability. It is clearly pictured that Turkey will be facing socio-economic, governance, and environmental challenges. Besides, the negative effects of climate change will include increased summer temperatures, decreased winter precipitation, loss of surface water, and increased frequency of droughts, land degradation, coastal erosion, and floods. Governance institutions should put internal and external sanctions into practice to lessen negative impacts of climate change in all sectors. Because each sector has an effect on the others, the overall vulnerability of development will be greater than expected.

There is still a need for a more comprehensive understanding of the role of institutions and culture in shaping adaptive capacity. While this research was based on quantitative data, the study of climate change could also include qualitative data to explain its impacts in all sectors.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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Notes

Country List: Albania, Algeria, Angola, Argentina, Armenia, Australia, Austria, Azerbaijan, Bangladesh, Belarus, Belize, Benin, Bhutan, Bolivia, Bosnia and Herzegovina, Brazil, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameroon, Canada, Chile, China, Colombia, Congo, Dem. Rep., Congo, Rep., Costa Rica, Cote d'Ivoire, Croatia, Cyprus, Denmark, Dominican Republic, Ecuador, Egypt, Arab Rep., El Salvador, Estonia, Ethiopia, Finland, France, Gambia, The Georgia, Germany, Ghana, Greece, Guatemala, Guinea, Guyana, Honduras, Hungary, India, Indonesia, Iran, Islamic Rep., Iraq, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Korea, Rep., Kyrgyz Republic, Latvia, Lithuania, Luxembourg, Macedonia, FYR, Madagascar, Malawi, Malaysia, Maldives, Mali, Mexico, Moldova, Mongolia, Morocco, Mozambique, Namibia, Nepal, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Norway, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Portugal, Romania, Russian Federation, Rwanda, Senegal, Slovak Republic, Slovenia, South Africa, Spain, Sri Lanka, Sudan, Suriname, Sweden, Switzerland, Syrian Arab Republic, Tajikistan, Tanzania, Thailand, Togo, Trinidad and Tobago, Tunisia, Turkey, Uganda, Ukraine, United Kingdom, United States, Uruguay, Uzbekistan, Venezuela RB, Vietnam, Yemen Rep., Zambia.