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Extract of an Introduction to this paper

"The objective of the paper is to present the importance of consumption vis-à-vis population and development and to discuss their direct linkages. It draws on the Vallentyne 'demotechnic' index to combine and interrelate population and consumption, obtaining estimates which allow fair comparisons of countries in terms of their global environmental stress.

The conclusions obtained from these estimates of population adjusted by consumption seriously question the assumption that countries with larger populations pose a greater environmental risk. They show, for example, that the US and former USSR each with relatively low populations, have 'consumption adjusted populations' that dramatically surpass those of the more populated but less developed countries of China and India. Sustainable development … is premised on a balance between population and consumption within the overall limits imposed by nature. It has become clear … that not only population but also consumption have to be reduced if sustainability is to be achieved. What is needed … is rolling back consumption levels in the North and reducing population growth in the South."

Sir Shridath Ramphal at the International Conference on Population & Development, Cairo, September 6, 1994

Consumption: the other side of population for development*

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ABSTRACT: World population is growing at an alarming rate, and thus population has become a major topic in sustainable development fora. In these debates, it is often asserted that developing countries with large populations pose a greater world environmental threat than developed countries with smaller populations. Because of this view, developed countries often appeal to developing countries to reduce their population growth. However, it is well known that developed countries have higher levels of consumption than developing countries and that consumption also exerts pressure on the environment. Although awareness of the importance of consumption for development and the recognition of the relationship between population and consumption are increasing, population still takes precedence over consumption as a major concern for sustainability. Our objective here is to present the importance of consumption vis-à-vis population for development and to discuss their direct linkages. We draw on the work by Vallentyne (1978: Verh Int Verein Limnol 20:1–12; and 1982: Biol Int 5:10–12), and use his 'demotechnic' index to combine and inter-relate population and consumption. By doing so, we are able to adjust population by consumption, obtaining estimates that allow fair comparisons of countries in terms of their global environmental stress. The conclusions obtained from the estimates of population adjusted by consumption seriously question the assumption that countries with larger populations pose a greater environmental risk. Sustainable development is premised on a balance between population and consumption within the overall limits imposed by nature. Therefore, it becomes clear that not only population but also consumption have to be reduced if sustainability is to be achieved.

KEY WORDS: Population · Consumption · Development · Sustainability · Demotechnic · D-index

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INTRODUCTION

World population is growing at an alarming rate. According to projections by the United Nations, annual increments in the world population above 90 million persons are likely to occur until the year 2015.

This increase in the world population, added to the fact that we live on a finite planet with many non-renewable resources, presents a pessimistic scenario for the future generations. Therefore, population has become a major topic of discussion in sustainable development fora. Although population is one important factor to achieve sustainability, consumption is another important factor that often tends to be disregarded altogether. However, the birth of a child in a developed country imposes more stress on the global environment than the birth of a child in a developing country because of differences in consumption patterns. Furthermore, population and consumption are interrelated.

The Rio Declaration 1992 (www.un.org/documents/ga/conf151/aconf15126-1annex1.htm) and Agenda 21 1992 (www.un.org/esa/dsd/agenda21/index.shtml) recognize the importance of population and consumption for sustainable development. Agenda 21 in particular proposes (1) to incorporate demographic trends and factors in the global analysis of environment and development issues; (2) to promote patterns of consumption and production that reduce environmental stress and at the same time meet the basic needs of humanity; and (3) to develop a better understanding of the role of consumption and how to bring about more sustainable consumption patterns. However, while the importance and implications of a growing population are well understood, the 'growing recognition of the importance of addressing consumption has not yet been matched by an understanding of its implications' (Agenda 21, Ch. 4, Sec. 4.6). Furthermore, in spite of the fact that the Rio Declaration and Agenda 21 acknowledge the relationship between population and consumption, no concrete proposals have yet been made on how to integrate these 2 development variables.

Population and consumption are also reflected in the International Conference on Population and Development (ICPD) Programme of Action (www.un.org/ecosocdev/geninfo/population/icpd.htm). However, there is an explicit predominance of population in its programme as expressed in the objective 'to fully integrate population concerns into development strategies, planning, decision-making and resource allocation at all levels and in all regions, with the goal of meeting the needs, and improving the quality of life, of present and future generations' (ICPD Programme of Action, Ch. 3, Sec. A).

If population dominates the development discussion, then it is natural to consider population as a valid sustainable development indicator. In this view, sustainability can be operationalized by limiting population below the carrying capacity of the Earth. The international action called for, then, is to induce countries to limit their populations (see ICPD Programme of Action, Ch. 6).

Sustainable development is based on the premise that population and per capita consumption operate within the ability of the ecosystem to carry the demand on resources and assimilate the wastes, indefinitely. Population effects vary widely due to vast regional differences in effects and sensitivities. While large populations exert considerable stress on their ecosystems, small populations with high rates of consumption can eclipse the effect of larger populations operating at lower rates of consumption. Sustainable development requires that both population and consumption be taken into account. Per capita consumption of energy may exceed many times the physiological energy requirements of humans (Vallentyne 1982). Other authors have also suggested that the consumption multiplier is an important part of the 'net effect' on environment and sustainability (Goodland et. al. 1994). The consumption factor and its ability to amplify even small populations are examined further in the present study.

INTEGRATING POPULATION AND CONSUMPTION

Humans not only exert pressure on the environment because of basic physiological needs for survival, but also due to their activities aimed at converting raw materials into products and services. Therefore, a measure of the stress of humans on the environment must reflect the needs of the physiological system as well as those of the technological system used for production and consumption.

In this regard, technology can be considered as an extension of human metabolism, and the requirements for this technology can be related to physiological needs. This argument provides the basis for calculating a 'consumption-adjusted population', which is obtained by adding to the existing population an equivalent number of individuals with energy demands for their physiological needs equivalent to the country's energy requirements for its technological system. This conversion is analogous to the use of 'horsepower' in inter-relating the power of horses and machines. The adjustment to the population is made by means of the demotechnic, or D-index (Vallentyne 1982), which is equal to the ratio of technological energy consumption to physiological energy consumption, expressed in the same units (see Appendix 1 for details on calculation).

Estimating the consumption of resources is extremely difficult, and thus energy consumption, although imperfect, is the best available surrogate for consumption (Goodland et al. 1994). Therefore, we use the D-index to interrelate population and consumption.

POPULATION ADJUSTED BY CONSUMPTION

Table 1 presents the D-indexes, populations and consumption-adjusted populations for countries ordered in descending magnitude by D-index for 1990 (see the supplement at www.int-res.com/articles/suppl/e012p015_supp.pdf for this information ordered alphabetically by country). The D-indexes vary from 198.49 in Qatar to 0.39 in Comoros. Countries towards the top of the list use a higher proportion of energy for their technological system (production/consumption) as compared to the physiological needs of their inhabitants, revealing larger consumption patterns. This list is headed by countries in which energy is relatively cheap and financial resources are available. Developing countries, on the other hand, are at the bottom of this list.

Fig. 1 shows the national populations and consumption-adjusted populations in 1990. Clear differences between these 2 maps can be observed. The USA and the (former) USSR, each with relatively low

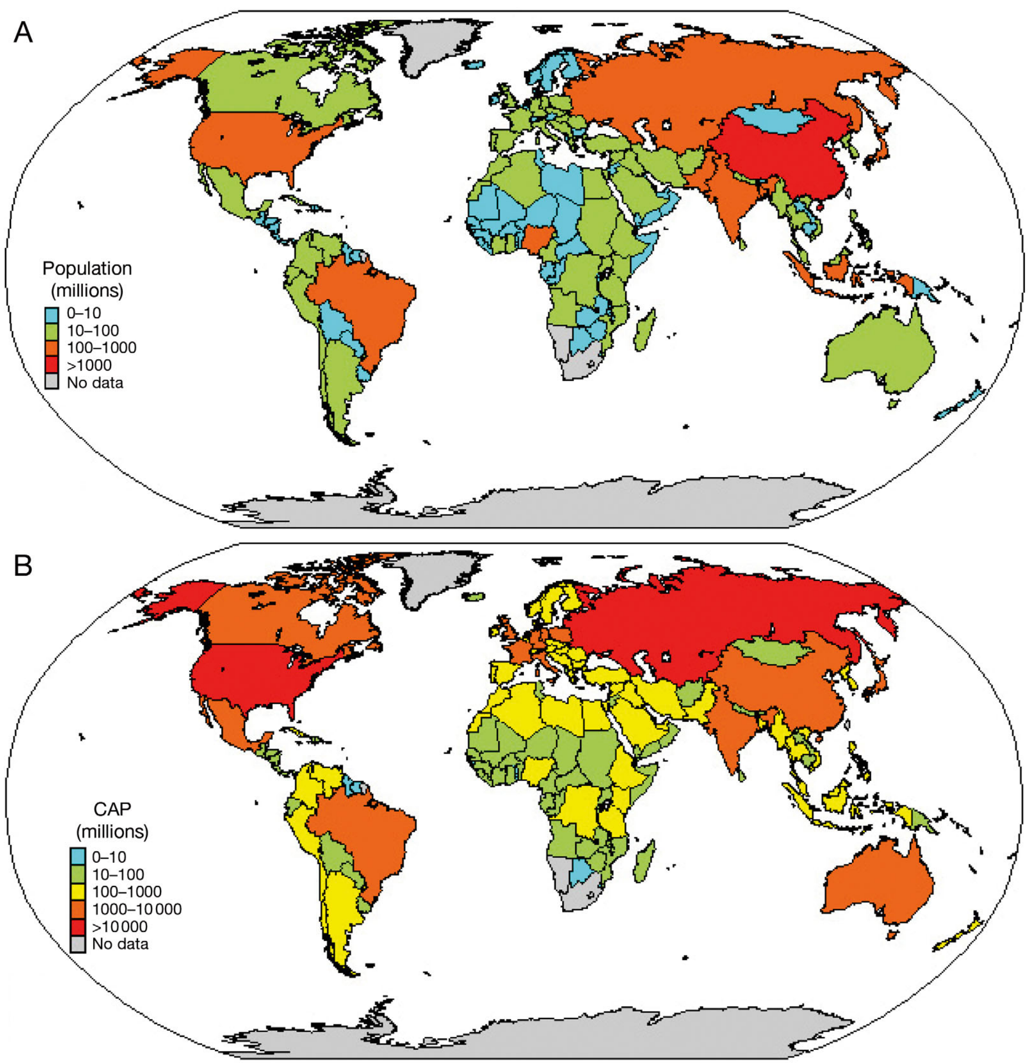

Fig. 1. Map of the world showing (A) population and (B) consumption adjusted population (CAP) by country

Table 1. Demotechnic (D-) indexes, population (in thousands), and consumption-adjusted population (CAP, in thousands) by country for 1990 ordered by D-index. Data are taken from the Human Development Report 1993 (http://hdr.undp.org/en/reports/global/hdr1993/) and the World Resources Data Base 1992–93 (now known as the World Resouces Institute [WRI] Earthtrends Data Base; http://earthtrends.wri.org/searchable_db/index.php?theme=6&variable_ID=351&action=select_countries). The D-indexes for 1990 use population data for 1990 and energy data for 1989 due to the availability of published data at the time of preparation of the present study

Rank	Country	D-index	Population	CAP
1	Qatar	198.49	368	73412
2	United Arab Emirates	163.38	1589	261200
3	Bahrain	128.50	516	66822
4	Canada	118.11	26521	3158916
5	Norway	109.24	4212	464331
6	USA	91.26	249224	22993406
7	Iceland	83.23	253	21310
8	Sweden	78.55	8444	671720
9	Kuwait	68.17	2039	141038
10	Finland	65.73	4975	331982
11	Germany, Dem. Rep.[a]	64.50	16249	1064310
12	Australia	63.42	16873	1086959
13	USSR[a]	57.31	288595	16827974
14	Belgium	55.84	9845	559590
15	Netherlands	55.74	14951	848320
16	New Zealand	55.46	3392	191512
17	Czechoslovakia[a]	53.29	15667	850561
18	Saudi Arabia	52.26	14134	752777
19	Germany, Fed. Rep.[a]	49.75	61324	3112193
20	Trinidad & Tobago	47.03	1281	61526
21	Switzerland	45.93	6609	310160
22	UK	44.36	57237	2596270
23	France	44.13	56138	2533508
24	Bulgaria	42.97	9010	396170
25	Austria	42.59	7583	330543
26	Singapore	40.89	2723	114066
27	Denmark	40.73	5143	214617
28	Romania	39.02	23272	931345
29	Japan	37.75	123460	4784075
30	Poland	37.65	38423	1485049
31	Hungary	35.62	10552	386414
32	Italy	34.06	57061	2000559
33	Libya	33.29	4545	155848
34	Ireland	30.37	3720	116696
35	Oman	28.19	1502	43843
36	Venezuela	27.09	19735	554356
37	Greece	26.78	10047	279106
38	Korea, DPR	26.52	21773	599193
39	Israel	24.72	4600	118312
40	Spain	24.36	39187	993782
41	Yugoslavia[a]	24.06	23807	596603
42	Korea, Rep.	20.91	42793	937595
43	Cyprus	20.91	701	15359
44	Argentina	18.16	32322	619290
45	Gabon	17.56	1172	21752
46	Cuba	17.34	10608	194551
47	Mongolia	17.26	2190	39989
48	Malta	16.80	353	6283
49	Guadeloupe	16.54	343	6016
50	Portugal	16.34	10285	178342
51	Hong Kong	15.91	5851	98940
52	Mexico	15.25	88598	1439718
53	Suriname	15.09	422	6790
54	Barbados	15.09	255	4103
55	Brazil	14.00	150368	2255520
56	Albania	13.74	3245	47831
57	Malaysia	13.40	17891	257630
58	Iran, Islamic Rep.	13.04	54607	766682
59	Chile	12.92	13173	183368
60	Lebanon	12.73	2701	37085
61	Reunion	10.90	598	7116
62	Uruguay	10.80	3094	36509
63	Colombia	10.38	32978	375290
64	Costa Rica	9.68	3015	32200
65	Fiji	9.36	764	7915
66	Swaziland	9.30	788	8116
67	Turkey	9.04	55868	560915
68	Panama	9.01	2418	24204
69	Zimbabwe	8.77	9709	94857
70	Iraq	8.77	18920	184848
71	Syrian Arab Rep.	8.66	12530	121040
72	Yemen, PDR[a]	8.52	2491	23714
73	Ecuador	8.36	10587	99094
74	Thailand	8.33	55702	519700
75	Jordan	8.29	4009	37244
76	Algeria	7.91	24960	222394
77	Mauritius	7.88	1082	9608
78	Jamaica	7.70	2456	21367
79	China	7.19	1139060	9328901
80	Zambia	6.92	8452	66940
81	Tunisia	6.90	8180	64622
82	Liberia	6.79	2575	20059
83	Papua New Guinea	6.71	3874	29869
84	Egypt, Arab Rep.	6.62	52426	399486
85	Peru	6.42	21550	159901
86	Paraguay	6.26	4277	31051
87	Botswana	6.04	1304	9180
88	Mauritania	5.92	2024	14006
89	Bhutan	5.72	1516	10188
90	Congo	5.66	2271	15125
91	Nicaragua	5.30	3871	24387
92	Kenya	5.25	24031	150194
93	Honduras	4.99	5138	30777
94	Cameroon	4.98	11833	70761
95	Guatemala	4.88	9197	54078
96	Malawi	4.83	8754	51036
97	Guyana	4.81	796	4625
98	El Salvador	4.74	5252	30146
99	Dominican Rep.	4.59	7170	40080
100	Ghana	4.54	15028	83255
101	Philippines	4.52	62413	344520
102	Indonesia	4.42	184283	998814
103	Nigeria	4.24	108542	568760
104	Bolivia	4.14	7314	37594
105	Cote d'Ivoire	4.09	11997	61065
106	Gambia	3.81	861	4141
107	Central African Rep.	3.62	3039	14040
108	Tanzania	3.60	27318	125663
109	India	3.58	853094	3907171
110	Zaire[a]	3.43	35568	157566

Table 1 (continued)

Rank	Country	D-index	Population	CAP
111	Nepal	3.39	19143	84038
112	Benin	3.38	4630	20279
113	Morocco	3.27	25061	107010
114	Senegal	3.26	7327	31213
115	Djibouti	3.16	409	1701
116	Pakistan	3.14	122626	507672
117	Somalia	3.12	7497	30888
118	Mozambique	3.03	15656	63094
119	Laos, PDR	3.01	4139	16597
120	Sudan	2.91	25203	98544
121	Haiti	2.91	6513	25466
122	Burkina Faso	2.79	8996	34095
123	Guinea	2.78	5755	21754
124	Afghanistan	2.73	16557	61758
125	Sierra Leone	2.57	4151	14819
126	Sri Lanka	2.53	17217	60776
127	Rwanda	2.49	7237	25257
128	Ethiopia	2.41	49240	167908
129	Burundi	2.28	5472	17948
130	Angola	2.25	10020	32565
131	Uganda	2.22	18794	60517
132	Madagascar	2.10	12004	37212
133	Niger	2.06	7731	23657
134	Cambodia	2.01	8246	24820
135	Vietnam	1.99	66693	199412
136	Myanmar	1.84	41675	118357
137	Chad	1.84	5678	16126
138	Mali	1.84	9214	26168
139	Guinea-Bissau	1.83	964	2728
140	Yemen, Arab Rep.[a]	1.34	9196	21519
141	Togo	1.28	3531	8051
142	Bangladesh	1.25	115593	260084
143	Cape Verde	0.84	370	681
144	Comoros	0.39	550	765

[a]Country names reflect the prevailing political boundaries at the time the data were collected

populations, have consumption-adjusted populations that dramatically surpass those of China and India. Similarly, Canada, with less than 4% of the population of India, has almost the same consumption-adjusted population as India. Table 2 presents the data for these 5 countries.

Table 2. Population and consumption-adjusted population (CAP), in millions for selected countries in 1990

Country	Population	CAP
China	1139	9329
India	853	3907
USSR	289	16828
USA	249	22993
Canada	27	3159

Table 3 lists countries that have the greatest opportunities and responsibilities to lower the consumption-adjusted population of the Earth.

CONCLUSIONS

Population by itself is not a good indicator of global environmental stress. Countries with small populations can have greater environmental stress than countries with large populations. Population can be used to measure one facet of environmental stress,

Table 3. Highest contributing countries according to consumption-adjusted population (CAP; in thousands) in 1990

Rank	Country	CAP	Contribution (%)
1	USA	22993406	22.08
2	USSR	16827974	16.16
3	China	9328901	8.96
4	Japan	4784075	4.59
5	India	3907171	3.75
6	Canada	3158916	3.03
7	Germany, Fed. Rep.	3112193	2.99
8	UK	2596270	2.49
9	France	2533508	2.43
10	Brazil	2255520	2.17
11	Italy	2000559	1.92
12	Poland	1485049	1.43
13	Mexico	1439718	1.38
14	Australia	1086959	1.04
15	Germany, Dem. Rep.	1064310	1.02
16	Indonesia	998814	0.96
17	Spain	993782	0.95
18	Korea, Rep.	937595	0.9
19	Romania	931345	0.89
20	Czechoslovakia	850561	0.82
21	Netherlands	848320	0.81
22	Iran, Islamic Rep.	766682	0.74
23	Saudi Arabia	752777	0.72
24	Sweden	671720	0.64
25	Argentina	619290	0.59
26	Korea, DPR	599193	0.58
27	Yugoslavia	596603	0.57
28	Nigeria	568760	0.55
29	Turkey	560915	0.54
	Total	**89270886**	**86**

namely the use of resources to satisfy basic human needs. However, populations can vary in their demands for resources needed for production/consumption. A better indicator of global environmental stress is obtained by adjusting population by consumption.

The reduction of population has been the driving force in international events and negotiations regarding sustainable development. But population and consumption are 2 sides of the same coin. Sustainability is a function of scale. On a national level, population tends to be more important than consumption-adjusted population, whereas the reverse is true on a global level. Therefore, a reduction of population growth in developing countries and a reduction of consumption in developed countries are both needed to achieve sustainability.

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Appendix 1. Calculation of the demotechnic (D) index

Demotechnic calculations and conversions

The word 'demotechnic' (*demos* meaning population; *techne* meaning technology) expresses the combined energy expended through the activities of humans and their technology, in common units. The comparisons can be made in terms of population and consumption-adjusted population. The comparison is similar to that between horses and machines in terms of horsepower.

To make this conversion, a common energy unit is needed. This unit is called a D unit (demotechnic unit). One D unit is defined as the physiological energy consumption of an average human over the course of a year (365.25 d) calculated at a rate of 2333 kcal d^{-1}. This value corresponds to the daily calorie requirement per capita 1988–90 for medium human development countries as reported in the Human Development Report 1993 (http://hdr.undp.org/en/reports/global/hdr1993/) One D unit is thus 852249 kcal yr^{-1}. Population number and physiological energy consumption in D units are numerically equal.

The D-index (demotechnic index) is defined as the ratio of technological energy consumption to physiological energy consumption with both expressed in common units. This provides a measure of the technological metabolism associated with an average person in a specific national or regional setting.

Another key concept is consumption-adjusted population. This is defined as the population of a country plus the population multiplied by the D-index. The population component is a measure of physiological (food) energy consumption, and the consumption-adjusted population is a measure of total energy consumption (physiological plus technological energy consumption).

An example may help to make this clear. Table 21.2.6 in the World Resources Data Base 1992–93 (now known as the World Resources Institute [WIR] Earthtrends Data http://earthtrends.wri.org/searchable_db/index.php?theme=6&variable_ID=351&action=select_countries) lists the population of Canada in 1990 as 26520000, and the total technological energy consumption in 1989 as 421.76 gigajoules per capita. Based on a conversion factor of 1 D unit = 3.5709 gigajoules, the D-index for Canada can be calculated to be 421.76/3.5709 = 118.11. Similarly, the total energy consumption for Canada in 1989–90, or consumer-adjusted population in D units, was 26520000 (118.1 + 1) = 3158790.

Strength snd weakness of the demotechnic approach

Strengths

(1) Data on consumption-adjusted populations provide a more realistic basis for viewing the effects of human activities on the biosphere than data on populations.

(2) Because demotechnic units are expressed in energy consumption per unit time, consumption-adjusted population and ecosystem energy production (e.g. photosynthesis, fish catches, plant harvests) are directly relatable. This could eventually permit the calculation of carrying capacities of ecosystems for human populations of different technological lifestyles.

Weaknesses

(1) The relationship between consumption-adjusted population and environmental impacts varies depending on the type of energy considered. Different types of energy also have different environmental impacts on different scales. Coal burning, for example, creates local pollution from particulates, regional pollution from sulphur oxides, global pollution from carbon dioxide, and the loss of a nonrenewable resource. Hydroelectric power, on the other hand, is primarily local or, at the most, regional, in its effects, and represents a renewable resource. While it is feasible to calculate environmental impacts on various scales, this has not been done in the present study.

(2) Demotechnic data do not reflect specific classes of waste (e.g. solid waste, toxics, radioactives) that have different impacts on environment.

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