ICID TASK FORCE (TF - 2)

A STATUS PAPER
ON
GLOBAL ISSUES RELATED TO FOOD PRODUCTION, SECURITY AND TRADE

ICID·CIID

SEPTEMBER 2005

International Commission on Irrigation and Drainage
48 Nyaya Marg, Chanakyapuri, New Delhi 110-021, India

COMPOSITION OF THE TASK FORCE

Prof. C. Fasso (Chairman)
Director, Department of DIIAR, Politecnico di Milano (Italy)

Members

Dr. Dia El-Din Ahmed El-Quosy
Director, Water management Research Institute (Cairo)

Dr. Thierry Rieu, Secretary General, Association Francaise pour l'Etude des Irrigations et du Drainage (AFEID), France

Dr. Ricardo A.L. Brito
Former Chairman, Erstwhile Latin American Regional Working Group (Brazil)

Dr.(Mrs.) Kamla Krishnaswamy
Former Director & Emeritus Medical Scientist (ICMR), National Institute of Nutrition, Hyderabad India

Dr. Mark Rosegrant, IFPRI (USA)

Mr. Yasunobu Matoba
Executive Director, Agricultural Development Consultants Association (Japan)

Mr. Chris Perry, IWMI Fellow, IWMI (Sri Lanka)

Dr. C.D. Thatte
Former Secretary General, ICID (India)

Er. M. Gopalakrishnan, (Member Secretary)
Secretary General, ICID (India)

Dr. Vijay K. Labhsetwar
Director, ICID (India)

ICID STATUS PAPER
GLOBAL ISSUES RELATED TO FOOD PRODUCTION, SECURITY AND TRADE

CONTENTS

ICID Status Paper
GLOBAL ISSUES RELATED TO FOOD PRODUCTION, SECURITY AND TRADE

I. Background

Food nourishes the body and the mind and keeps both in a fit condition, to continue to remain an asset for the society. Next to drinking water, food is the most basic need of mankind, which has been met with by practicing agriculture. Globally, about 52% of the population is engaged in agriculture, providing food for itself and for the remaining 48% who use a part of their income from other sources, to buy it. Poor people either have to utilise a very large proportion of their income on buying food or can't buy enough and remain hungry and undernourished. Almost 15% of the global population mostly from developing countries, at present falls in this category of chronic mal-nutrition mainly in terms of protein intake. Presently the absolute number of hungry, food insecure and the undernourished remain stubbornly high above 840 million, highlighting the need for not only maintaining food sufficiency but also ensuring the food security.

Agricultural products like cereals besides vegetables, pulses, legumes, fruit, nuts, roots, tubers, oil-seeds, spices are directly consumed as food. Alternatively, cereals and some of these crops are fed to animals to get food products like milk, meat and others. Fish from both fresh and marine waters and sea weeds; poultry, pigs, goats, sheep and land based animals make up other components of the food basket. Humans require from these different foods, a balanced nutritious diet comprising carbohydrates, proteins, fats, vitamins and minerals. Sufficiency in quantity and quality both make the food basket complete.

The technical background document No 12 of World Food Summit (WFS), 1996 defined house-hold food security as 'a situation in which all households have both physical and economic access to adequate food for all members, and where households are not at a risk of losing such access'.

There are three dimensions implicit in this definition: **availability, stability** and **access**. Adequate food availability means that, on an average, sufficient food supplies should be available to meet consumption needs. The stability refers to minimising the probability that in difficult years or seasons, food production might fall below consumption requirements. 'Access' draws attention to the fact that, even with bountiful supplies, many people may still go hungry because they do not have the resources to purchase the food they need. Affordability is closely related with poverty, which is often defined as a function of the inability to consume and invest.

Further, **Food self-sufficiency** means the satisfaction of food needs as far as possible from domestic supplies with minimal or nil dependence on trade. The

concept of **food self-reliance** takes into account the possibilities of international trade. All in all, food sufficiency or reliance supported by requisite governance i.e. conduct of national affairs on various fronts, leads to food security.

The Millennium Development Goal (MDG), which have set out an agreed framework for future directions in the international cooperation for development, recognizes the eradication of poverty as its overarching goal. Infact, most of the countries in the categories of least developed and developing depend upon funding support from International Agencies to achieve the set targets of MDG. In due cognizance of this factor, World Bank and other funding agencies have adopted poverty reduction as one of the thrust areas. The rural sector still depends on agricultural and related activities for the livelihoods in developing countries mainly. The key driver while addressing the Global Agriculture and Food Security should keep in mind the interest of rural people of over 1.2 billion who are extremely poor and engaged in agriculture and related activities with very little scope to engage in other activities. In the 4th Ministerial Conference of the World Trade Organisation held in Doha, Qatar in November 2001 members sought to place the needs and interest of developing countries at the heart of a new round of multi-lateral trade negotiations. This round envisioned as the "Doha - Developed Agenda" promised to build up a multi-lateral trading system which will provide opportunities for the developing and the least developed countries to trade out of poverty and contribute to the goals of MDG.

However, could the goal of self-sufficiency or food self-reliance by themselves be a panacea for solving the global challenge of food security? Perhaps, not. The options could vary from place to place depending upon supporting resource base. This inter-alia, take us to available land, water and ecosystem services and products.

The report "Let it Reign: The new Water Paradigm for Global Food Security" released by IPFRI, IUCN, IWMI (April 2005) has expressed concern that because of climate change some 40 poorest countries with a total sum of 1 to 3 billion will loose on an average upto 1/5th cereal production potential. There is also a phenomenon of agricultural land getting converted to urban areas due to expanding cities, growing needs of cities for industry and water. Thus, there is an increase in competition among users of water which interfere with irrigation / agricultural allocation.

Table 1 indicates population and food production, splitting the scenario between `developed' and `developing countries'. Continent scenario on World Cereal Production is seen in **Table 2** (FAO-1999-2004)

Table 1: Population and Food Production Growth

Variable	Period	World		Developed countries		Developing countries	
		Total	Annual growth	Total	Annual growth	Total	Annual growth
		Million	%	Million	%	Million	%
Population	1961	3081	-	988	-	2099	-
	1990	5349	1.9	1253	0.8	4088	2.3
	1997	6055	1.3	1304	0.4	4750	1.5
Food Production index (1989-1991 average =100)	1961	49	-	61	-	40	-
	1990	101	2.5	100	1.7	103	3.4
	1997	124	2.1	101	0.1	144	3.4

Source: Molden (2001)

Table 2: World Cereal Production (MT)
(FAO, 1999 – 2004)

	1999	**2000**	**2001**	**2002**	**2003*)**	**2004**)**
Asia	1031	996	1001	982	993	1032
Africa	112	113	118	114	130	129
Americas	525	531	518	472	560	602
Europe	385	386	429	433	354	463
Oceania	36	35	40	20	40	32
World	**2088**	**2060**	**2106**	**2020**	**2077**	**2258**
Developed countries	857	862	887	843	846	988
Emerging countries	1118	1081	1099	1070	1105	1124
Least developed countries	114	118	119	112	132	130
Global stock in MT	611	630	599	575	484	411
Global utilization in MT				1926	1955	2013

*) estimated **) forecasted Note : Among Cereals Rice is included as paddy.

II. Status of Food Production

Subsequent to the World War-II, there were sustained efforts around the globe to increase world food production and avoid impacts of devastation. There were sustained efforts to enhance the productivity in agriculture (especially with the backing of considerable investment in irrigated agriculture) in order to ensure risk free production capability. As it appears from Table 1, in the second half of last century food production consistently outstripped population, so that in average people are eating better today than they did few decades ago. Notwithstanding this, presently 840 million people, mostly rural poor in both developed and developing countries, still suffer hunger. The new challenges therefore, will be to look critically and focus on the aspect of not only doubling the production for the teaming billions but also addressing the issues of the rural poor in the developing world by measures that are sensitive to their situations. In these developing and least developed countries, the population growth has not yet stabilized and in some cases decline from the high level of growth only marginally. Though, there

is an expectation that the global population growth rate would decline from present 1.3 per cent to below 1 per cent by 2020, food production rate would grow at 2 per cent per annum during the same period. Thus this could ensure keeping pace with the increase in food demand.

Until the middle of the 20th century, expansion of cultivated area roughly kept pace with population growth. But in the last 40 years, the doubling of cereal output came from the three sources: expansion of cropped and irrigated area, increased intensity of land use mainly through expanded irrigation, and the consequent yield increases with the help of improved management and high yielding varieties.

The future demand for food will increase by 50% every generation expectedly (or double by 2050) and though an efficient ecosystem management would enhance the yield basket, the role of agriculture (especially irrigated land) would be crucial. Thus, doubling of food production no doubt has still to come more from increased productivity and expansion of irrigation where water and land potential is still available (as in several populous developing countries). The challenge is to realise it, while sustaining the natural resource base.

The World Cereal Production and Utilization from 1993 to 2005 is shown in **Figure 1.** The World Cereal Production is declining ever since 1998 (with exception of 2003-04), whereas utilization has continued to increase (FAO 2005). This means that the World Cereal Stocks are on decline. The decline is therefore, not a favourable sign to achieve food security by 2025. Stocks will have to be at the desired safe stock level of 18% if not higher during the next two decades, to take care of lows in yearly production due to climate changes / natural disasters / wars etc. Global Cereal Food Stocks in 2003/2004 point to a significant draw down for the fourth consecutive year (**Table 2, Figure 2**). The world food stocks by end of 2003 and 2004 are forecast at 484 and 411 million tones, respectively. Although, a bigger global production of 2250 million tones is expected in 2004, the projected cereal utilization in 2003-04 would still be larger than the expected production, thus reducing the stocks further. In order to ensure against the risk associated with decline in the stock of foodgrains globally, a question arises as to how much increase of the optimum level of minimum stock, which is presently about 18 per cent is desirable. **Could it be raised to 23 per cent i.e. 5 per cent above the present level?**

The World, as a whole, has been making a steady albeit slow progress, towards improved food and nutritional status during the past half a century. The progress has been uneven for many countries. Several population groups have remained deficient in access, suffering setbacks in their already fragile food security and nutrition status. Though the proportion of malnourished children has been declining, the absolute number is increasing. In future, the needs for food,

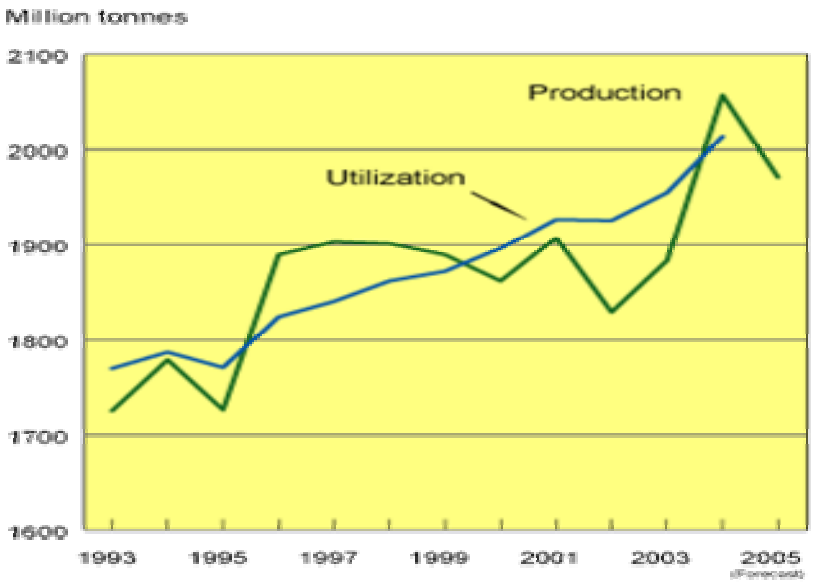


Figure 1: **World Cereal Production and Utilization *(FAO, 2005)***

Note : There are some inconsistencies between the curve "Production" in Figure 1 and the numerical data in Table 2 because rice is included as `Paddy' in Table 2.

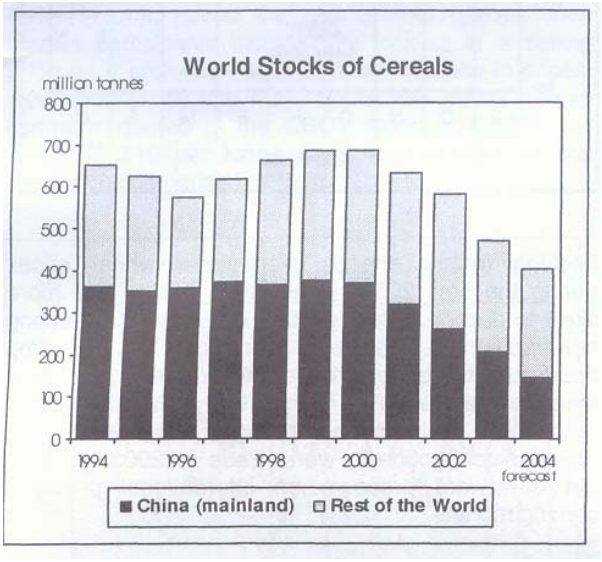


Figure 2: **World Stock of Cereals (*FAO, 2003)***

agricultural products including fibre, and energy will greatly increase due to increasing population and due to needed increase in per capita consumption. It is evident from the substantial increase in *per caput* food supplies achieved globally, that for a large proportion of the population of the developing world, the food availability is increasing. However, malnutrition continues to plague several

regions of the world with severe consequence on the growth, health, cognitive development and productivity. Almost one third of the children in the developing countries are malnourished with half of adults having a very low body mass index (BMI), which indicates a relationship between weight and height that is associated with body fat and health risk (weight in kg/ht.^{2} in m).

The concerns related to food security in low GNP countries are yet to be tackled. **Table 3** shows incidence of undernourishment in the population by country and geographical region (FAO, 2000), which shows that 35% or more of their population is undernourished. Further, this undernourishment leads to severe health problems specially when a country is least developed (LDC). The UN Economic and Social Council defined LDCs as those suffering from long-term handicaps of growth, in particular low levels of human resource development and/or severe structural weaknesses. A list of least developed countries (LDCs) is shown in **Table 4**. Some of these, like Democratic Republic of Congo, Haiti, Eritrea, Burundi, Afghanistan and Somalia, show more than 60% population as undernourished. African continent has 35 LDCs and 19 of them have 35% or more population undernourished, whereas 13 LDCs are in Asia and 1 in Latin America.

III. Status of Population

It took about 50 centuries for the world, from the dawn of civilisation, to reach the population of 1 billion around 1830. It took another century to reach 2 billion marks in 1930. Three billion people occupied the world in 1960, 4 billions in 1975, 5 billions in 1986 and 6 billions in 1999. The world population is 6.5 billion already (2005).

By 2025, the median variant of world population projection by United Nations suggests a figure of 8.5 billion people (**Table 5**). Most of the addition will be in developing countries. In 1985, 75 percent of the world's population lived in developing countries. It will rise to 83 percent by 2025. Regionally, the population in Asia will nearly double to over 4 billion, while that in the sub-Saharan Africa will more than triple from 420 million in 1985 to nearly 1.3 billion in 2025.

Table 3: Incidence Of Undernourishment In The Population By Country, Geographic Region (33 % Or More Population Undernourished)

S.No.	COUNTRY	UNDERNOURISHED IN THE TOTAL POPULATION				
		Proportion population	Proportion population	Absolute Nos. (1996-98)	Geographic Region	Population
		1990-92 (%)	1996-98 (%)	(Millions)		(Millions)
1	Zimbabwe	41	33	3.8	AF	11.5
2	Chad*	58	38	2.8	AF	7.4
3	Rwanda*	37	39	8.2	AF	21.1
4	Madagascar*	33	40	6.2	AF	15.5
5	Tanzania	31	41	13.4	AF	32.8
6	Central African Rep.*	46	41	1.5	AF	3.6
7	Kenya	47	43	12.7	AF	29.5
8	Angola*	51	43	5.4	AF	12.5
9	Sierra Leone*	45	43	2.1	AF	4.8
10	Zambia*	40	45	4.1	AF	9.0
11	Liberia*	49	46	4.1	AF	9
12	Niger*	42	46	1.4	AF	3
13	Ethiopia*	Na	49	29.9	AF	61.1
14	Mozambique*	67	58	11.2	AF	19.3
15	Congo, Dem. R.*	37	61	30.7	AF	50.3
16	Eritrea*	Na	65	2.4	AF	3.7
17	Burundi*	44	68	6.6	AF	6.5
18	Somalia*	67	75	7.2	AF	9.6
19	Korea DPR	19	57	26.5	ESEA	46.5
20	Haiti*	64	62	5.0	LA	8.1
21	Afghanistan*	63	70	15.3	NENA	21.9
22	Yemen*	37	35	6.1	NENA	17.4
23	Bangladesh*	35	38	49.2	SA	129.6
24	Mongolia	34	45	1.2	SA	2.6
Total			48	257.0		536.3

Source: FAO Statistics (2000)

NENA: Near East & N. Africa (2); AF: Africa (18); SA: South Asia (2); ESEA: East & SE Asia (1); LA: Latin America (1)

* Least Developed Countries (LDCs) = 19

Table 4: Region-Wise List Of Least Developed Countries (L.D.Cs)

Africa	**Asia**
1. **Angola***	36. Afghanistan
2. Benin	37. **Bangladesh***
3. **Burkina Faso***	38. Bhutan
4. Burundi	39. Cambodia
5. Cape Verde	40. Kirbati
6. Central African Rep.	41. Maldives
7. Chad	42. **Myanmar***
8. Comoros	43. **Nepal***
9. Dem. Rep. of Congo	44. Samoa
10. Djibouti	45. Solomon Island
11. Equatorial Guinea	46. Tuvalu
12. Eritrea	47. Vanuatu
13. **Ethiopia***	48. Yemen
14. Gambia	
15. Guinea	
16. Guinea Bissau	
17. Lao People's Dem. Rep.	
18. Lesotho	
19. Liberia	
20. **Madagascar***	
21. Malawi*	
22. Mali	
23. Mauritania	
24. **Mozambique***	
25. Niger	
26. Rwanda	
27. **Sao Tome & Principe***	
28. **Senegal***	
29. Sierra Leone	
30. Somalia	
31. **Sudan***	
32. Togo	
33. **Uganda***	
34. **United Rep. Of Tanzania***	
35. **Zambia***	

*** ICID Members**

Note: America: Only `Haiti' is LDC in Latin America.
Europe: Nil.

Source: United Nations General Assembly - Economic and Social Council (www.un.org)

At present, approximately 31 percent of the people of developing countries live in cities, although there are strong regional differences. It will rise to 57% by 2025. The number of people living in cities will quadruple from 1 billion to 4 billion. By 2020, there may be 10 cities with 18 million or more inhabitants. Nine out of these ten viz. Mumbai, Dhaka, Delhi, Jakarta, Karachi, Kolkatta, Mexico City, Sao Paulo, and Tokyo will be in the developing world, the lone exception being New York. Five of them will be in South Asia. This could lead to enormous civic problems including concerns about the urban food security.

Table 5 : Global Population And Distribution Patterns

Year	World	Developed Countries	Developing Countries (1960-2025)				
			Sub-Saharan	Latin America	Asia & Pacific	West Asia & North Africa	Total
			Population (Millions)				
1960	3,019	964	209	218	1,505	123	2,055
1985	4,855	1,210	421	404	2,575	245	3,645
2010	7.191	1,365	916	631	3,810	469	5,826
2025	8,467	1,422	1,296	761	4,379	609	7,045
DISTRIBUTION (percentage)							
1960	100.0	31.9	6.9	7.2	49.8	4.1	68.1
1985	100.0	24.9	8.7	8.3	53.0	5.0	75.1
2010	100.0	19.0	12.7	8.8	53.00	6.5	81.0
2025	100.0	16.8	15.3	9.0	51.7	7.2	83.2

Source: CGIAR, 1990.

Although over the past 15 years, world population growth rate has declined by 40 percent, Indian census for instance counted 1028.7 million inhabitants in 2001(recording a 21.3% increase over 1991 Census data). The Indian population is estimated to be 1080 million in 2005. This population could grow to over 1.6 billion by the year 2050, overtaking China. China has a population of 1306 million in 2005 after implementing one child per family norm for decades.

The population engaged in agriculture is about 23.6 and 26.5% in Americas and Europe (**Table: 6**) where average per farmer land holdings are very large, whereas it is 61.9 and 62.2% in Asia and Africa, respectively, where the land holdings are small. The contribution of agriculture to GDP and incidence of poverty in the former is small while that in the latter, it is large. Obviously, the size of population plays a crucial role in deployment of water and land resources of a country. Therefore population control has to be on every agenda related to food security.

IV. Sources of Food

Agriculture remains the main source of food for humans besides fish and meat. Meat again is primarily dependent on agriculture as feed and fodder comes from agriculture. Whereas fish comes from fresh or marine waters, receiving nutrients from animal life on land.

Presently, the total cultivated area on earth is about 1534 Mha, (**Table 6),** which is about 11.4 percent of the total land area. Irrigation covers about 277 Mha, which is about 18 percent of world's arable land. Asia accounts for 188 million hectares (67%) followed by Americas at 41 million hectares (15%), Europe at 24 Mha (9%), Africa at 12 Mha (5%), and Oceania at 3 Mha (1%) (ICID, 2005). About 190 Mha of cultivated area also has some water resources system like drainage or protection system for floods. Agricultural activities take place on 1087 Mha without a water management system (**Table 6**) and hence there is scope to increase area under irrigation, contrary to the belief and many a learned projection.

Table 6. Global and regional irrigated, drained and cropped areas (ICID Country Network)

Sl. No.	Continent	Economic Status	Total Geographical Area	Irrigated Area	Drained Area	Arable & Perm. Crop Area (APC)	% of APC to Geog. Area	% of Irrigated Area to APC	Population	Population in Agriculture	Population Density with ref. to Total Geographical Area	Area with No System	Population Density with ref. to APC	Food Production (Cereals)
		(2003)	(2002)	(2002)	(2000)	(2002)			(2002)	(2002)			(2002)	(2003)
			(Mha)	(Mha)	(Mha)	(Mha)			(Million)	(Million)	(People/Sq.km)	(Mha)	(People/ Sq.km)	(MT)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Asia	L=10	3002	188	59	556	19	34	3685	2267	123	309	663	976
2	America	L=0	3796	41	65	378	10	11	793	171	21	272	210	550
3	Europe	L=0	2172	24	46	293	13	9	690	175	32	223	236	339
4	Africa	L=20	2199	12	4	177	8	7	685	417	31	161	387	119
5	Oceania	L=0	801	3	2	52	6	5	23	2	3	47	45	39
	Total (104 countries)	L=30	11970	268	176	1455	12	18	5876	3033	49	1011	404	2023
	WORLD	L=61	13428	277	190	1534	11	18	6225	3234	46	1068	406	2075
	% (104 Countries to World)	-	89	97	92	95			94	94		95		98

Sources : World Bank Atlas (2003)

FAO Year Book (2003) : Production

ICID National Committees : 2005

Note : (1) Number of ICID participating countries = 104
(2) NA = Not Available; Mha = Million Hectare
(3) L = Low; LM = Lower Middle; UM = Upper Middle; H = High

Region-wise top three countries based on irrigated area are shown in **Table 7**. Egypt (3.4 Mha), Sudan (1.9 Mha), South Africa (1.5 Mha) in African continent; USA (22.5 Mha), Mexico (6.3 Mha), Brazil (2.9 Mha) in Americas; India (56.8 Mha), China (55.9 Mha), Pakistan (18 Mha) in Asia; and Russia (4.6 Mha), Spain (3.8 Mha), Italy (2.7 Mha) in European continent. Further, top 20 countries based on irrigation are indicated in **Table 8**.

Irrigation is responsible for 40 percent of crop output and employs about 30 percent of population spread over rural areas. It uses about 70 percent of water withdrawn from global river systems. Drainage of the rain fed crops covers about 130 Mha that is about nine percent of world's arable land. The drainage of irrigated lands covers about 60 Mha as well. About 15 percent of crop output is obtained from 130 Mha of rain-fed drained land (Schultz, 2001). Growth in net irrigated area is indicated in **Figure 3**. Since food yield response to irrigation is almost double as compared to rain-fed agriculture, the human societies will continue to rely on areas under irrigation (drainage) for food security. This can be achieved in following ways: 1. Develop irrigation along with improvement in management, where untapped water resources potential exists. 2. Increase water use efficiency at each project and basin level and use the saved water to increase crop intensity or expand irrigation and drainage. 3. Reclaim waterlogged / saline / otherwise unused lands and provide irrigation and drainage.

The rainfed agriculture produces more than half of the world's cereal crop. Better rainfed agricultural management calls for better harvesting techniques. In many cases, in the absence of desired interventions in rainfed areas, an inefficient use of the resource results and crops suffer drought whereas an avoidable quantum of sheet flow runs off to the oceans. Various in-situ and ex-situ water conservation and harvesting techniques can improve the rainfed agriculture. An integration of rainfed and irrigated agriculture, wherever possible, can improve water and land management and lead to food security at local, basin and national levels.

Table 7 : Region wise Top Three Countries Based On Irrigated And Drained Area
(ICID Country Network)

Irrigated Area

	Region							
S.No.	**Asia**	Irrigated Area	**Africa**	Irrigated Area	**Americas**	Irrigated Area	**Europe**	Irrigated Area
1	India	56.8	Egypt	3.4	USA	22.5	Russia	4.6
2	China	55.9	Sudan	2	Mexico	6.3	Spain	3.8
3	Pakistan	18.0	South Africa	1.5	Brazil	2.9	Italy	2.7
Regional Total		**188**		**12**		**41.0**		**24**

Drained Area

	Region							
S.No.	**Asia**	Drained Area	**Africa**	Drained Area	**Americas**	Drained Area	**Europe**	Drained Area
1	China	20.0	Egypt	3.0	USA	47.5	Russia	7.4
2	Pakistan	6.0	Sudan	0.56	Canada	9.46	Germany	4.9
3	India	5.8	Morocco	0.12	Mexico	5.2	UK	4.7
Regional Total		59		4		65		46

Source: ICID (2005) and FAO Production (2003)

The demand and production figures of *per caput* food for direct human consumption by major commodities are summarized in **Table 9**. The threshold used by FAO/WHO for undernourishment corresponds on average depending upon sex, age, body mass of concerned population - to 1800 kilocalories/day. By and large, it is expected that in most developing countries the trend towards increasing *per caput* food supplies will continue.

Table 8: Top Twenty Countries based on number of large dams registered and irrigated area

BASED ON IRRIGATED AREA			**BASED ON NUMBER OF ALL LARGE DAMS**		
Sr.No.	**Country**	**Irrigated Area (Mha)**	**Sr.No.**	**Country**	**No. of Dams Registered**
1	India	56.8	1	USA	9265
2	China	55.9	2	China	4688
3	USA	22.5	3	India	4636
4	Pakistan	17.8	4	Spain	1267
5.	Iran	8.1	5.	Korea (ROK)	1205
6.	Mexico	6.3	6.	Japan	1121
7.	Turkey	5.2	7	South Africa	915
8	Thailand	4.9	8	Canada	793
9	Indonesia	4.8	9	Brazil	635
10	Bangladesh	4.7	10	Turkey	625
11	Russia	4.6	11	France	597
12	Uzbekistan	4.3	12	Italy	549
13	Spain	3.8	13	Mexico	536
14	Iraq	3.5	14	UK	517
15	Egypt	3.4	15	Australia	507
16	Romania	3.0	16	Norway	335
17	Vietnam	3.0	17	Albania	306
18	Brazil	2.9	18	Germany	306
19	Japan	2.8	19	Zimbabwe	253
20	Italy	2.7	20	Romania	246
	Total	**220.4**		**Total**	**29302**
	World Total	**277**		**World Total**	**32569**
	% of top 20/World	**79.6**		**% of top 20/World**	**90.00%**

Source: ICID (2005), FAO (2003) and ICOLD (2003)

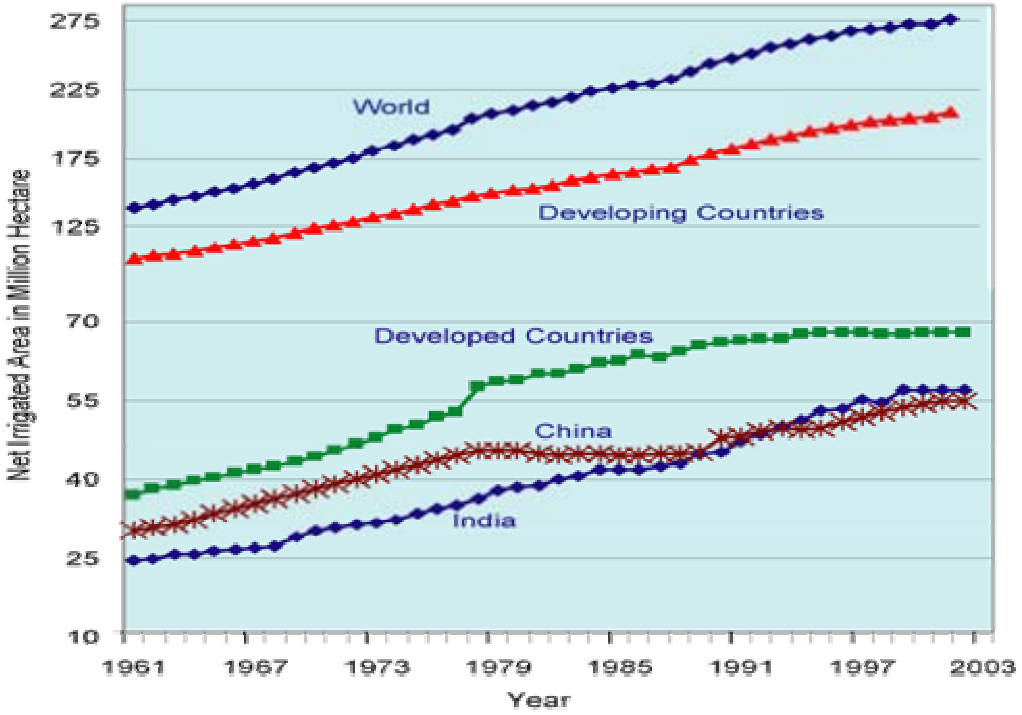


Figure 3: Net Irrigated Area of the World, Developed Countries, Developing countries, and in China and India (***FAO, 2003).***

Note: On Y-axis, there is a break after 70…125 and onwards numbers are correct.

Table 9: Per Caput Food Supplies (Past And Future) For Direct Human Consumption (Kg/Caput)

Commodity	World			Developing countries			Developed countries		
	1969/71	1988/90	2010	1969/71	1988/90	2010	1969/71	1988/90	2010
Cereals	146.3	164.6	167	145.3	170.5	173	148.6	146.3	141
Cereals (all uses)**	305	331	325	190	235	254	(583)*	(637)*	(633)*
Roots/tubers/ plantains	82.3	65.7	65	80.3	63.1	64	87.0	73.9	70
Pulses, dry	7.6	6.3	7	9.3	7.4	8	3.6	2.9	3
Sugar raw equivalent	22.1	22.7	24	14.4	18.0	20	40.6	37.5	37
Vegetable oils	6.7	10.1	13	4.7	8.2	11	11.6	16.2	19
Meat	26.0	31.9	37	10.5	16.4	25	63.3	80.5	87
Milk	74.6	75.3	72	27.4	35.9	42	188.4	199.1	198
All food (kcal/day.caput)	2430.0	2700.0	2860	2120.0	2470.0	2730	3200.0	3400.0	3470

***Source:** Nikos Alexandrators, World Agriculture Towards 2010, FAO, 2001*

***** Data and projections for the ex-centrally planned economics (ex-CPEs) are before revision of the ex- USSRs Cereals production data from bunker to clean weight.

****** All uses may include crops harvested for hay or harvested green food, feed or silage or used for grazing.

The average food supply for the projected 2 billion population of East Asia will reach just over 3000 kcal/day. The Near East/North Africa and the Latin

America/Caribbean region will follow closely behind. In all the three regions the prevalence of under nutrition may fall by the year 2030 to a relatively low level of 3-6 percent of the total population **(Table 10)**. This possible evolution could be hastened by reduction in inequality to access to food supply or more equitable distribution of food by improved governance (Krishnaswamy, 2002).

South Asia is expected to make significant progress, but the initial conditions are such that by 2010, the *per caput* food supply would still be in low middle level (2450 kcal/day). Accordingly, the extent of under-nutrition is likely to remain high, particularly in terms of the absolute numbers. With respect to sub-Saharan Africa, only little progress can be expected. Under-nutrition will probably remain disturbingly widespread and will continue to nearly one third of the population by the year 2010 due to a very low *per-caput* national income in both South Asia and Sub-Saharan Africa.

Table 10: Projected Trends in Undernourishment

Region	1996-98	2015	2030
	Percent of population		
Sub-Saharan Africa	34	22	15
Near East/North Africa	10	8	6
Latin America and the Caribbean	11	7	5
China and India	16	7	3
Other Asia	19	10	5
Developing countries	18	10	6

Source: Agriculture: Towards 2015/30, Technical Interim Report, FAO, April 2004

For the world as a whole, the rate of growth of gross food production has already shown the signs of slowing down. This is in line with the long-term historical observation of decline on annual growth rate of agriculture production and domestic demand gradually from 3.0 per cent in the 1960s to 2.3 percent in 1970s and to 2.0 percent in 1980-1992. Some surmise that the growth rate will fall further to 1.8 percent in the period upto 2010 (**Table 11**). The lesser growth trend in food production could be partially due to a shift of agricultural land to urbanization / industrialization, but mainly due to inadequate finance for new infrastructure. This is so even when some countries have significant unused water and land potential and require more production to meet their growing internal demand due to increasing trend in population, presently. The overall negative trend in food production needs a reversal.

The options that are applicable in the approach of ensuring food security could vary from place to place and country to country. For example

- In case of countries where development has taken place to the full extent (land and water resources exploited fully or to the desired extent), integrated water resources management.

- In respect of countries where there is a growing demand for food due to increasing population growth rate coupled with meeting with the nutritional demand requirements, (especially in respect of developing countries in Asia and Africa), expansion of crop and irrigated area, increased intensity of land use mainly through expanded irrigated and consequent yield increases with the help of high yield varieties and improved management.

Table 11: Growth rates of gross agricultural production and domestic demand, all uses (%p.a.)

Regions	Production				Domestic demand (all uses)			
	Total		Per caput		Total		Per caput	
	1970-90	1988/90 - 2010	1970-90	1988/90 - 2010	1970-90	1988/90 - 2010	1970-90	1988/90 - 2010
World	2.3	1.8	0.5	0.2	2.3	1.8	0.5	0.2
93 Developing countries	3.3	2.6	1.1	0.8	3.6	2.8	1.4	0.9
Africa (sub-Sahara)	1.9	3.0	-1.1	-0.2	2.6	3.3	-0.4	0.1
Near East /North Africa	3.1	2.7	0.3	03	4.5	2.8	1.7	0.4
East Asia	4.1	2.7	2.4	1.5	4.1	2.8	2.4	1.6
South Asia	3.1	2.6	0.7	0.6	3.1	2.8	0.8	0.8
Latin America + Caribbean	2.9	2.3	0.6	0.6	2.9	2.4	0.6	0.6
Developed countries	1.4	0.7	0.6	0.2	1.2	0.5	0.5	0.0
Ex-CPEs	1.2	0.4	0.4	-0.1	1.4	0.2	0.6	-0.4
Other developed countries	1.5	0.8	0.7	0.4	1.2	0.7	0.5	0.2

Source: Nikos Alexandrator, World Agriculture Towards 2010 (FAO, 2001)

V. Reducing Food Insecurity

As discussed in Section I, food security implies physical and economic access to food by all people at all times. Thus it involves concurrent steps in production and distribution. Countries that have achieved self-sufficiency should work rigorously towards attaining food security. To ensure self sufficiency with future trend in population growth might also warrant further development of water resources if there is some scope in due consideration to an improved integrated water resources management. Some of the issues involved in reducing food insecurity such as land and water resources, human resources (population) governance (country issues), trade (WTO), GM food (bio-technology) and research and development are briefly covered in this section.

V-A. Role Of Water Resources

Water resources (irrigation, drainage, and flood management) play a crucial role in reducing food insecurity. During late sixties, the era of green revolution, the expansion of irrigation, high yielding seed varieties and fertilizers comprised the main factors for achieving increases in food production. The world is once again looking forward to the second green revolution through improved management and development of remaining water resources for irrigation to meet with the increasing and diversified food demands of future. The addition will also be by way of increasing water use efficiency, enhancing productivity, going in for precision irrigation and utilising the saved water. Due emphasis should be given to drainage, especially in (semi-) arid regions of the world, to avoid (re-) salinization of the soils. Flood Management may become crucial for food security in humid tropics where floods inundate large areas destroying the crops altogether.

Water Management: Water Resources have been developed and irrigation potential created in many countries around the world, especially in the developed countries,. However, In a few cases, it is seen that the utilization lack behind the developed potential, significantly. . Proper water management is the key to improve the project water use efficiency. Water management includes management of on-farm and off-farm water distribution network. On-farm distribution network primarily includes field channels and irrigation methods and some structures, whereas off farm network includes secondary and tertiary distribution network and the structures. In order to improve the performance, training of irrigation professionals and farmers is a must. This training component is often not given enough emphasis leading to deficit project water use efficiency and hence poor crop yields, which otherwise would contribute to food production significantly.

Integrated Water Resources Development and Management (IWRDM): In order to utilise the land and water resources effectively, ICID incorporated the Integrated Water Resources Development Management (IWRDM) as a cornerstone of the ICID's Vision and Strategy Document (2000) on "Water for Food and Rural Development". It recognised that IWRDM in consultation with and with participation of stakeholders would ensure speedy realization of the object of adequacy of water supplies in requisite quantity and quality. Conflicts on sharing of waters, costs and benefits of facilities also will reduce if concept of IWRDM is put in practice. Maximization of basin-level water use efficiency, integration of mega to micro level facilities, surface and ground waters, of consumptive and non-consumptive uses, of demands and supply will be necessary at basin level and where necessary across basin boundaries. Water resources policies have to be designed at the country level for integrating the needs optimally and making appropriate allocations to different sectors viz., food, people and nature. IWRDM will have a positive impact on farm income through

increased output levels and this may result in lower food prices at local or national level, which will be favourable for reducing food insecurity in majority of the rural and urban poor.

On similar lines, during the 3rd World Water Forum (WWF3), ICID hosted a Session on "Water for Food and Rural Development: IWRDM for Ensuring Food Sufficiency and Security" in which the participants reiterated the ICID strategy of providing food sufficiency for as many nations as possible. But the sufficiency does not mean security automatically. Appropriate governance and various mechanisms are called for upgrading food sufficiency to food security from family level to community and national level. The developed and developing world obviously have different perceptions due to poverty, population and resource constraint as evidenced in land, water, human resources and finance for IWRDM. The recommendations of ICID Session on IWRDM at WWF3, 2003 were:

- Double the food production by adopting the IWRDM approach. Go in for food self-sufficiency goals in large and populous countries and in those not having financial capacity to buy food from world market instead of seeking perpetually an external support.
- Increase water availability by way of WRD to meet the demand of all sectors, specially irrigated agriculture in developing countries.
- Increase area under agriculture by reclaiming wastelands and area under irrigation by new storages, particularly in Africa and Asia, by improving in water use efficiency and by recycling waste water.
- Adopt better and effective watershed management approach for rain-fed areas.
- Evolve strategies for improving water and land productivity in irrigation and also to reduce the substantial gap between irrigation potential developed and utilized.
- Improve governance to elevate food sufficiency to food security status.
- Evolve guidelines to involve all stakeholders in the process of IWRDM. Integrate the principles of equity, efficiency, economy and efficacy in IWRDM.
- Increase investment by international funding agencies and local governments for modernization, rehabilitation, replacement and new constructions where needed.

Water Resources Development (WRD) By 2025, one-third of the population of the developing world may have to face water shortage unless the presently un-harnessed resource is developed through dams especially in arid-semiarid regions like South Asia and Sub-Saharan Africa where water potential is yet to be fully tapped.

By 1997, there were an estimated 800,000 dams in the world, 45,000 of which were large dams. Top 20 countries based on the numbers of dams registered as

per World Register of Dams (2003) are listed in **Table 8**. The aggregate design storage capacity of the world's large dams is presently about 6000 cub km. Out of all the registered large dams in the world only 5% are in Africa, where most of the seriously water scarce countries are located. Fifty percent of the large dams are in North America and Europe where serious shortages are not likely, because of these dams (Keller et al., 1998). Statistics on 798 recent large dams built from 1998 to 2001 is indicated in **Figure 4a & b**. Seventy-one percent (71%) of these dams are built in Asia.

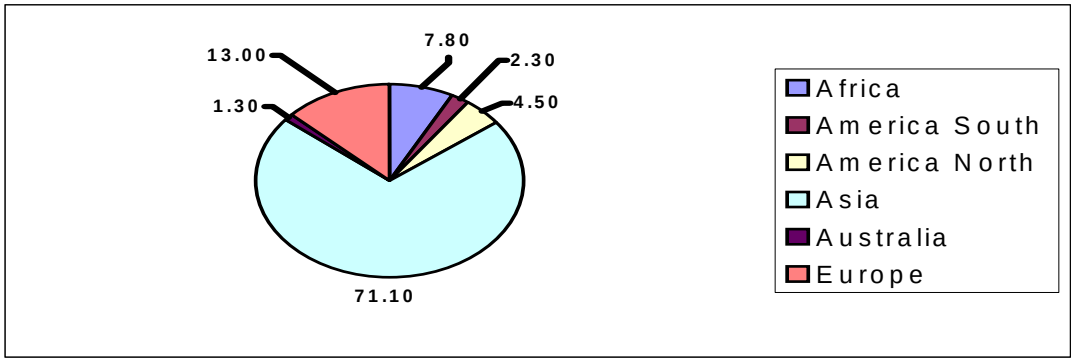


Fig. 4a : Statistics on 798 Recent Large Dams Built from 1998 to 2001

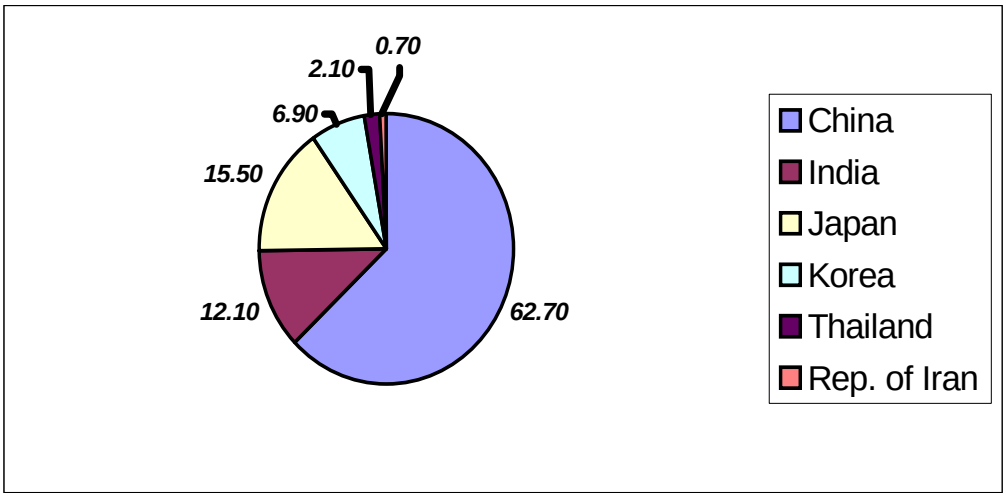
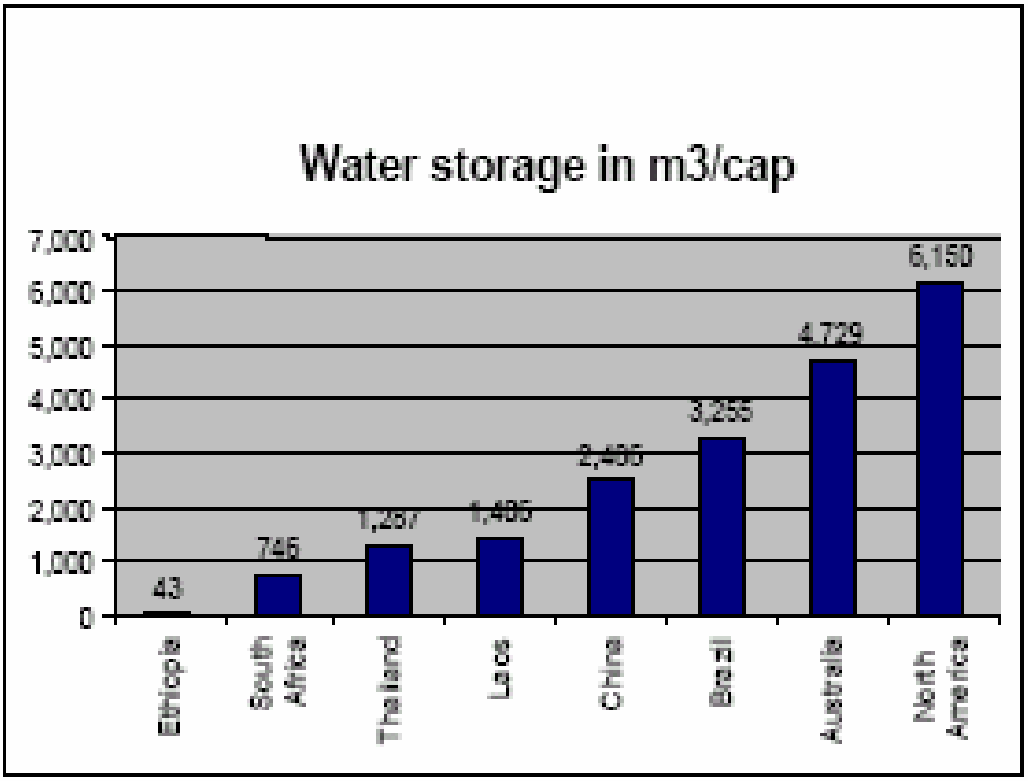


Figure 4b : Statistics on Large Dams Built in Asia (589 Dams) from 1998 to 2001

In North America, for instance, the storage capacity is about 6150 m^3 per person, whereas it is 2455 m^3 / person in China, 2003 m^3 / person in India, 43 m^3 / person in Ethiopia (**Figure 4c**, World Bank:2005). Given the present situation in respect of dams for storage, for countries with strong seasonal variation in precipitation and inadequate storage back up to meet the demands, will be needed to bridge the gap. The amount of infrastructure facilities required for such storages varies tremendously in the world.



Source: Palmieri, The World Bank (2000)

Figure 4c : Water Storage capacity of selected countries

Since water plays a key role in almost all economic activities, including agriculture, huge investments will be necessary, especially in Africa and Asia, where water storage per person is still very low.

Global Irrigation: Presently 277 Mha of land worldwide is irrigated accounting for 18 per cent of total arable and cropped area (1534 Mha). This means that crops are grown on 1068 Mha without a water management system. Therefore, there is tremendous scope to increase area under irrigation by way of more storage dams, where possible, especially in Asia and Africa. The global and

regional distribution of irrigated, drained and cropped land is shown in **Table 6** and covered in Section IV. Further, potential irrigation demand will grow by 12 per cent in developing countries, while it will actually decline in developed countries by 1.5 per cent. The fastest growth in potential demand for irrigation water will occur in Sub-Saharan Africa, with an increase of 27 per cent, and in Latin America, with an increase of 21 per cent. Each of these regions has a high percentage increase in irrigated area from a relatively low 1995 level. India is projected to have the highest absolute growth in potential irrigation water demand, 66-cub km (17 per cent), owing to relatively rapid growth in irrigated area from an already high level in 1995. West Asia and North Africa will increase by 18 per cent (28 cub km, mainly in Turkey), while China will experience a much smaller increase of 4 per cent (12 cub km). In Asia, as a region, potential irrigation water demand will increase by 8 per cent (100 cub km). Unless, the aforementioned irrigation potentials are developed, population expansion will force millions of impoverished people to undertake unsustainable farming systems.

To assess the potential benefits from new irrigation investment, one may compare the with and without-irrigation scenarios. To justify the massive investments necessary to make existing irrigation sustainable, one should also compare “with” and “without maintenance and rehabilitation” scenarios. A wide range of technical obstacles must be overcome to ensure the sustainability of irrigation. These include flooding, waterlogging, salinity, silting of reservoirs and deterioration of infrastructure etc. All these problems can be overcome in principle provided the necessary economic resources are deployed.

Irrigation in Asia: The continent has the highest area under irrigation, viz. 188 Mha, which is about 34 per cent of its arable land. Also this is where about 60 per cent of the world population lives. India (57 Mha), China (56 Mha) alone account for 58 per cent of the irrigated area in Asia. Eight countries (India, China, Pakistan, Iran, Indonesia, Thailand, Turkey and Bangladesh) account for 81.6 per cent of the total irrigated land in Asia. Five most populous countries (China, India, Indonesia, Pakistan and Bangladesh) out of the top ten in the world are from Asia accounting for 46% of world population. To feed this increasing population, food production needs to be doubled and that is only possible by WRD, thereby bringing more arable land under irrigation.

Irrigation in Americas: The continent has the second highest area under irrigation, viz. 41 Mha, which covers about 10.7 per cent of the total cultivable land. USA has the highest area (22.5 Mha) accounting for about 53.6 per cent of the continent. Six countries (USA, Mexico, Brazil, Chile, Argentina and Peru) account for 87 per cent of the total irrigated land. These countries have relatively low population and high food production, with high to upper middle GNP, really don’t face the problem of food security, excepting Haiti in Latin America, which is a least developed country with 65% of its population being undernourished.

Irrigation in Europe: The continent has 24 Mha areas under irrigation, which is about 8.2 per cent of its arable land. Russia tops the list with 4.6 Mha under irrigation followed by Spain (3.8 Mha) and Romania (3.0 Mha). Six countries (Russia, Spain, Italy, Romania, Ukraine and France) account for about 76.3 per cent of the irrigated land. Like Americas, Europe also has relatively low population (727 million) accounting for 11.7 per cent of world and with high GNP. It also doesn't face problem of food security with the exception of Serbia and Montenegro (former Yugoslavia) and Chechnya in the Russian Federation.

Irrigation in Africa: The total irrigated land on the African continent is about 12 Mha representing 6.2 per cent of arable land, but large differences are seen between countries. As an extreme case, Egypt has almost 100 per cent of its cultivated land under irrigation, while a country like Uganda or Ghana have only 0.1-0.2% of their arable land under irrigation. Five countries (Egypt, Madagascar, Morocco, South Africa, and Sudan) account for almost 71.3% of the total irrigated land in Africa, whereas 17 other countries include only 1 % of the irrigated land. African continent has 35 LDCs out of the 49 in the world (**Table 4)** and 19 LDCs have 35% or more population undernourished. About 22 countries of Africa are at present food insecure.

Assessing the potential for expansion of irrigation in Africa is not an easy task. Future developments will be dictated by a whole set of factors, including political choices, investment capacity, technological improvements, as well as social and environmental concerns. North Africa has already reached more than 75% of its potential, whereas large potential remains untapped in Central African countries where waters resources are relatively abundant. Substantial investments will be required for its WRD.

Irrigation in Oceania: It has only 3 Mha under irrigation accounting for about 5.6% of its arable land. Australia leads with 2.55 Mha, followed by New Zealand (0.29 Mha) both together accounting for almost 95% of irrigated area. Both countries have relatively low population and with high GNP and food production, face no food insecurity.

Ground Water and Energy Use in Irrigated Agriculture

The extent of ground water resources is enormous and useable ground water exists almost everywhere. Many countries, including the USA, China, Iran, and Mexico make intensive use of ground water in their agricultural sectors. In these countries, ground water irrigation affects a small proportion of their people, energy used in agriculture is a small proportion of the total energy used, and the cost of energy used in farming is a small proportion of the total value added farming. However, South Asia's ground water economy defers in unique ways from those of other intensive ground water countries. India, Pakistan, Bangladesh and Nepal constitute the biggest ground water user countries in the world. Between them, they pump around 210 km3 of ground water every year. In

doing so, they use almost 20-21 million pumpsets, of which approximately 13 million are electric and around 8 million are powered by diesel engines. It is assumed that an average electric tubewell lifting water in an average head of 20 meters uses 0.5 kWh per m3 of water lifted, the total electricity equivalent of energy used in these countries for lifting 210 km3 of ground water is around 100 billion kWh per year. Supplying such an output costs, approximately US$ 5.2 billion and the market value of the extent of irrigation is around US$ 12 billion (Shah et al, 2003). In these emerging low-income economies, pump irrigation has significant impact on the national economy.

According to a World Bank estimate, ground water irrigation contributes around 10 per cent of India's GDP (World Bank and the Government of India, 1998), but this is made possible because ground water irrigation accounts for between a quarter and a 1/3rd of the total national electricity consumptions. Therefore, the burning issue has been that of electricity pricing and supply to agriculture. The pricing options could be (i) flat tariff; (ii) metered tariff. Metered tariff is not recommended due to exceedingly high transaction costs involved. However, flat tariff, in particular context of South Asia, will have to be rationalized and raised with fixed but assured power supply during the year, if ground water is to be used in a sustainable manner. Further, in long run a separate power distribution agency may need to be established for agricultural sectors with specialized competence and skills. The contribution of ground water to farm incomes and rural livelihoods is crucial. In this way, sustainable ground water used is likely to enhance the food security in the country.

Drainage and Food Production

In an irrigation system, water logging occurs due to surface flooding (surface water logging) or due to rise in water table (sub-surface waterlogging) or due to both surface flooding and rise in water table (a common waterlogging phenomenon). The excess water inflow as compared to outflow may be either on account of excess rains, over irrigation and congestion of drainage. The development of waterlogging is a common problem across numerous irrigation projects around the world. On introduction of irrigation, the process of water conveyance and distribution through canals involves huge water losses to the ground water aquifers which amount to about 30 to 50 per cent of the total water diverted. The water table level rises and in a few years becomes very close to the ground surface. This situation of waterlogging is very harmful for the development of crops because of: (i) the limiting depth of the root system which prevents the crop growth; and (ii) soil salinization by capillary action.

The excess soil moisture due to water logging in the root zone affects the crop production in several ways: (i) prevents growth of soil micro-organisms that helping the development of plants; (ii) plant diseases and parasites develop in humid environment; (iii) high water table limits root penetration; (iv) prolong saturation adversely affects soil structure; (v) salts, if present in the soil or ground

water, tend to concentrate in the root zone or at the soil surface; (vi) excess soil moisture prevents timely farm operation.

The drainage operations are planned for removal of excess ground water to maintain a favourable water and salt regime in the root zone for sustainable crop production. In addition to improving crop production, the drainage water from natural or artificial land drainage systems can be successfully utilized by adopting following strategies of *conjunctive use*: (a) using the drainage water as a sole supply of irrigation; (b) using a blend of drainage and fresh water supplies; (c) using drainage water in serial cyclic mode with fresh water supply; (d) using the drainage water alongwith shallow ground water for deficit irrigation and (e) using the drainage water by means of a combination of sub-surface irrigation and drainage system, and controlling the water table depth to optimize its use by the crops.

Surface drainage waters are usually of normal quality, unless contaminated due to sewage effluent or salt load in surface run-off. Sub-surface drainage waters are usually of poor quality, the exact composition would, however, depend upon the nature and amount of salts present in the soil profile, and the quality of shallow ground water. Due to wide variations in the water quality, re-use and disposal alternatives have to be site specific.

By following quality parameters and recommended guidelines for drainage water reuse, area under irrigation can be increased, thereby increasing food production and security to some extent.

Rainfed Agriculture: Globally, 1534 Mha area is under Arable and Permanent Crops (APC) out of which 277 Mha (18 % of APC) is irrigated leaving 1257 Mha (82 % of APC) as rainfed area (FAO, 2003). Irrigation is responsible for about 40 % of crop output whereas the remaining comes from rainfed area.

It is often argued in some quarters that rainfed agriculture especially has a sizeable contribution to make and should receive more attention in future. One another factor in its support is the spread and its relevance to smallholder farms and its links to livelihood for the farmers. Undoubtedly, depending on the extent of rainfall and it’s near uniformity of occurrence matching with the type of crops that the farmers raise, rainfed may have an useful role to play. However it is opined in certain quarters that to help an assured production and enhance productivity, supplementary irrigation would be helpful. A recent study by IWMI has brought out that the real classification of irrigated and rainfed agriculture world over is rather difficult as such an intervention means irrigation; many times Ground water abstraction is resorted to provide such supplementary dosages for crops where feasible. Water harvesting also helps in such cases.

Rain-fed agriculture cannot keep up with growing demands for food. Without continued irrigation investment, food prices are bound to rise and the poorest

segment of the population is likely to continue to suffer. The implications regarding national welfare are so serious that neglect of irrigation is unthinkable. However, that is just what is happening in many countries as a consequence of economic problems, competing priorities, inadequate management and governance, and growing environmental concerns.

Nevertheless, it should be kept in mind that the rainfed agriculture produces more than half the world's cereal crop. Often the use of rainwater is inefficient and the resource largely runs off to the oceans. Various in-situ and ex-situ water conservation and harvesting techniques can improve the rainfed agriculture. Integrated rainfed and irrigated agriculture for wider diversity of crops can potentially contribute to solving the problem of food security.

Rainfed agriculture need not be confined to foodgrains production, but be diversified to include, among others, aquaculture, sericulture, milk and meat, horticulture, vegetable production, floriculture, medicinal and aromatic herbs and other economic crops depending upon the market feasibility.

Watershed approach for rain-fed agriculture: In ultimate stage also, irrigation cannot reach globally more than 1/3rd of arable area. The productivity and livelihood deficit will continue to haunt the planners. Increase in productivity of rainfed area is extremely difficult beyond a threshold level. Still, recent years have seen emergence of watershed programs as a major thrust area for rural development in India and in many other countries in the world. International Water Management Institute (IWMI) advocates the need to promote the wide-spread use of small scale irrigation technologies such as rain water harvesting in Africa for poverty and mal-nutrition alleviation. Watershed development, contribute to moisture supplementation to spreaded out arable rainfed lands, generating rural employment and income resulting in consequent food security.

V-B Suggested Interventions for Food Security

Increased agricultural productivity is a key to reducing poverty in many developing countries. In Asia, for example, rural and agricultural development between 1970 and 1990 triggered high economic growth, increased incomes and improved nutrition. Because irrigation raises yields, it is essential to increasing productivity.

Farmers benefit from irrigation directly through increased and more stable incomes and the higher value of irrigated land. Communities benefit through better wages, lower food prices, a more varied diet and the health benefits of greater water availability. Studies in India and Bangladesh have shown that every job created in irrigated agriculture yields another job in agricultural services and the processing industry.

While large-scale irrigation schemes play an important role in improving food security, benefiting farmers who have more land, many low-cost small-scale techniques can be used by poorer farmers to increase yields.

A study of three small-scale schemes in Burkina Faso, Mali and the United Republic of Tanzania found that irrigation improved incomes, diets and health. For example, when women no longer had to fetch water from far away, they had time to start market gardens, thereby improving their incomes and diets. FAO-Water & Food Security key facts in website www.fao.org/worldfoodsummit/english.

Doubling global food production may be required in view of following arguments:

(i) world population is likely to increase from current 6.5 billion to 8.5 billion in 2025;
(ii) presently world food production is on decline with the exception of a peak in 2003-04
(iii) world food stocks declined down to 411 million tones (estimate) of food grains in 2004 (June 2005);
(iv) annual growth rate of agricultural production is also declining from 3% in 1960s to 2% during 1980-1992 and further declined 1.8% is expected by 2010;
(v) urban population is likely to increase from present 31% to 57% by 2025 resulting in a changed pattern of demand due to changes in life style; incase under nutrition there will be an increase in food demand with better income;
(vi) as communities develop they tend to consume and waste more food; and
(vii) communities where there is presently a sizeable vegetarian groups, a tendency to become non-vegetarian is likely as their socio-economic status goes up; this will also require an increased demand of grains as feed stuff for producing more non-vegetarian food (beef, chicken, fish and pork).

Considering all the above, an estimated 70% increase in food production may be required to cater to the increase in population and a 30% increase may be required to satisfy other arguments stated under (v) (vi) and (vii) above.

While we are at suggested strategy for and interventions for food security, we can look at some of the background issues related with food availability, sufficiency, access, and affordability. Some of these are discussed below:

Productivity Potential: Every individual farmer and for that matter rural communities have their own productive potential. In order to make the communities productive, they could be provided with basic inputs and some economic space to operate in. As far productive crop yield is concerned, traditionally, it is expressed in terms of production per unit of land. But as water is

a limited resource `more crop per drop' or `more crop (production) with less water' has emerged as a crucial issue.

Diversification of Agriculture: In countries where surplus food stocks coexist with hunger, malnutrition and a large food insecure segment, effort to move from mere food sufficiency to food security is crucial. Agriculture need not be confined to growing food crops alone. Reduction of cereal production in favour of other cash crops (horticulture, floriculture, sericulture and other economic crops) through diversification of cropping may well provide the answer to food insecurity, as the additional income will increase their purchasing power.

Food for Work (FFW): Availability, accessibility and affordability of the right quantity and quality of food became important issues in FFW programme. The FFW itself is considered as an appropriate intervention to motivate a community to create productive assets while ensuring their food security. In emergency situation (natural disaster or war) FFW at first ensures household's food security, reduces migration and enhances the purchasing power.

Crop Improvement for Arid and Semi Arid Tropics: Crop yields are low in arid and semi arid tropics, where one-sixth of the world's population lives. The effort therefore has to focus on crop improvement for drought and salt tolerance, biotic stress resistance and nutritional quality improvement. Agricultural biotechnology can play a key role in crop improvement.

Agri-clinics and Agri-business Centers: Many developing countries have a large pool of agricultural graduates. They can be enabled to set up Agri-clinics or Agri-business Centers and offer professional extension services to serve farmers. They would provide paid services for enhancement of agricultural production and income of farmers. E-fora could also be thought of in local language to provide agricultural services including marketing to farm communities.

World Food Prices: The problem of low and highly volatile prices for some major agricultural export commodities of the developing countries will continue to loom large. FAO's forecast for global cereal production in 2004 was 2256 million tonnes, a substantial increase from previous year, but still less than the expected utilisation in 2004/05. As a result, global cereal stocks are expected to be drawn down to 411 million tones (FAO, 2005).

Prices for most cereals remained under downward pressure. The World Market Prices for certain important basic crops is shown in **Fig. 5.** The figure shows that the food prices have been stabilized during 2002-03 and a gradual rise is expected in years to come. International prices of rice have increased in early 2005, whereas prices for wheat and coarse grains remained below 2004 level, reflecting large availabilities in the major exporting countries (FAO, 2005). Export prices for nearly all types of coarse grains remained generally stable over the

same period. The present prices, however, will still make it very difficult to find adequate economically feasible solutions and investments for agricultural water management (Schultz et al, 2005).

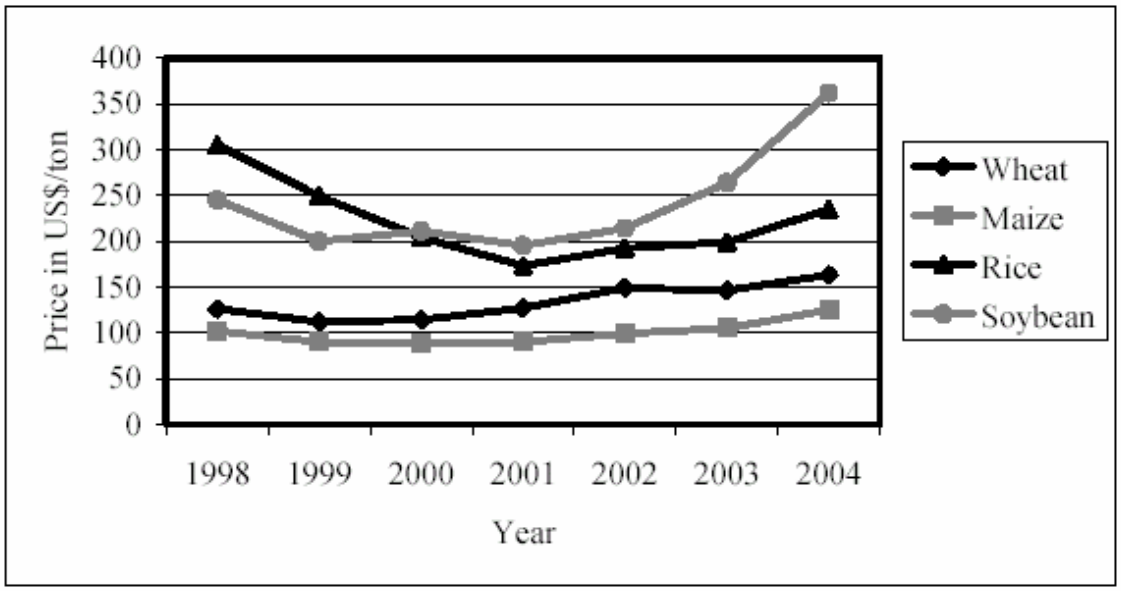


Figure 5: Development of world market prices for certain important basic crops

To cope with the decline and stabilise international agricultural prices, the main way has been through the Uruguay round of multilateral trade negotiations. They have had the objective of boosting agricultural trade and prices via substantial reductions in protectionism, mainly in the developed countries. The other main approach to arresting price decreases and to stabilise them is to develop market demand via export promotion, commodity development policies and diversification. **Fig. 5** indicates a general rising trend in world food prices after reaching the bottom in past years, which is a welcome sign.

Community Food Banks (CFB): The concept put forth by Dr. M. S. Swaminathan (India) in 2001, proposes establishment of a global grid of CFBs to begin with, in the hunger hotspots of the world. Ideally, a CFB set up either with national resources or with the support of the international community through for instance, the world food programme, could store in appropriately designed bins (Silos), the needed quantities of the staple grains to meet the energy needs of the local population for a year. Ideally, a CFB could serve as a conduit for transferring to the local population their entitlements such as subsidized grains for the poor and grains for school feeding and for pregnant and nursing women. A CFB can thus play multiple roles such as fulfilling entitlements and mitigating the adverse impact of natural calamities as well as of ethnic conflicts at local level. The CFB grid across a country or region has potential to minimise food insecurity in an effective and economical way.

Seed Village Concept: The Concept with farmers' participation can be promoted with full technical guidance by the agricultural universities and the agricultural research institutions. Availability of good quality seed is a pre-requisite for higher yields and if quality seeds are produced at local level, production will increase to satisfy the ultimate goal of food security at state or regional scale.

Infrastructure to facilitate transport and communication: In most of the Least Developed Countries (LDCs) and many emerging economies, improvement in infrastructure to facilitate transport and communication is required in order to facilitate cost effective transport of high yielding seeds, fertilizers and food to desired locations.

Water Services cost in Context with Agriculture: Water services cost has been and continues to be the fundamental characteristic of irrigated agriculture. The extent of water service cost varies from region to region but its effectiveness determines the success of the irrigation projects in terms of sustainability. Governments in developing countries are increasingly under financial stress, thereby unable to effectively support rural services/subsidise water cost. Therefore, these days it is desirable in many countries to transfer the responsibility of management to beneficiaries, e.g., water user associations, and recover the cost of water towards repair and maintenance.

However, for long-term sustainability, full cost recovery is also advocated in some developed countries. There argument is that if an activity incurs some costs, it must be paid for by all beneficiaries. The next question is, who are the beneficiaries? The logical answer is the direct users i.e. farmers and indirect beneficiaries i.e. the community/citizens in general. The next question is how much to be charged? It should be decided by mutual dialogue amongst stakeholders i.e. government, farmers and the community.

The ICID Task Force 3 on "Socio-Economic Sustainability of Services Provided by Irrigation, Drainage and Flood Control Schemes in Water Resources Sector" (Tardieu et al. 2003) has identified five following principles consistent with the ICID strategy:

1. Transparencies of cost recovery
2. User empowerment
3. Sustainability cost recovery
4. Economic incentives towards "Best practices"
5. Clear policies

On the basis of discussion on above issues, ICID in its 56th IEC accepted the Report of the TF 3 on *"Developing a position paper on Socio-economic Sustainability of Services provided by Irrigation, Drainage and Flood Control Schemes in Water Resources Sector"*, which had suggested the following:

1. To be very clear on the water service definitions and on the identification of the beneficiaries.
2. Contracts between service providers and clients should be clarified as the very first step to create the awareness of the deficiencies of irrigation systems.
3. To maintain the control of the government in decision making, since government represents the society as a whole.
4. To establish priorities in sustainable cost recovery (finance, management and social options)
5. To have a dialogue on the economic incentives because `pricing system' could be efficient, only if it is well understood and appreciated by the stakeholders.
6. To have a dialogue on desirable policies with other water sectors in order to address the specific complexity in approaching sustainability in irrigated agriculture.

However, for those countries where majority of the rural population depends on agriculture for their livelihood and do not have alternatives available for earning a living, water service cost either may be subsidized or waived off, depending on their capacity, whereas in developed countries where communities have alternative choices to earn living, full water services cost may be practiced.

In this way water services cost may play a crucial role in context with irrigated agriculture towards food security especially in developing and Least Developed Countries.

V– C. Country Specific Issues

Numerous countries in Africa, Asia, Central America and Europe are severely 'food insecure'.

In **Africa**, civil strife and/or weather adversities are causing food supply difficulties in parts, increasing the number of people in need of food assistance. In eastern Africa, serious food shortage has emerged mainly due to drought. Over a third of the population in Eritrea, faces food shortage. In Ethiopia, poor rains similarly cause distress, repeatedly. Also conflicts in northern areas have displaced many people aggravating the food supply situation. In Burundi, emergency food assistance was required to be provided following deteriorating security situation in recent times. In southern Africa, about 14.4 million people are in need of emergency food assistance - in Lesotho, Malawi, Mozambique, Swaziland, Zambia and Zimbabwe. In western Africa, the food situation is very serious in parts of Mauritania, following three consecutive poor harvests. Agricultural activities in Liberia have been disrupted by civil unrest, while emergency food assistance is needed in Cote d'Ivoire following resurgence of civil strife and Sierra Leone and Guinea due to large number of refugees. In Central Africa, the escalation of civil conflicts in Central African Republic and the

Democratic Republic of Congo has displaced people and therefore, food assistance to refugees continues.

In **Asia**, Korea (DPR) showed an improvement in cereal production but the country still required about one million tones of cereal food aid in 2002/2003. Even in the recent past (June 2005) USA had to provide 50,000 tones of foodgrains to Korea. In Mongolia, severe drought affected the agricultural population. In Afghanistan, though agricultural output in 2002 recovered dramatically, large parts of the population have little access to food due to lack of purchasing power and continue to require food assistance.

In **Central America and the Caribbean**, many families are food insecure in parts of El Salvador, Guatemala, Honduras and Nicaragua due to a fall in incomes linked to the '*international coffee crisis'*. In Europe, food assistance continues to be necessary for refugees, the internally displaced and vulnerable population in the Federal Republic of Yugoslavia and Chechnya in the Russian Federation.

While no country can claim to be 100% food secure, there are many countries that have achieved some degree of food security. The broad sample collection of country cases presented below illustrates policy experiences in different regions that could be adopted elsewhere in the world to achieve food security.

In Burkina Faso, a mix of policy measures including macro economic policies for restructuring of the public finance, soil conservation and water harvesting measures, settlement, household level income generating measures and their transfer have been successful in curbing food insecurity and promoting human welfare (FAO, 1996).

In China far-sighted policies in population control, infrastructure development and education were the keys to success. Concerted efforts in research, extension activities and farmers participation helped China perform better in hybrid rice production. China is conducting trials at different locations on a super rice hybrid, which has a yield potential of 10 to 12 tonnes per hectare. The success is attributable to rapid advances in breeding generations of good seeds and crops, extensive training on mass production techniques, intensive cultivation, greater attention by government, involvement of private seed companies and a well organized extension system. Adoption of better agronomic and crop management practices and cooperation from farmers also contributed to the success. However, currently the cereals stocks in China are on decline **(Fig. 2)**.

Costa Rica improved its food security through strong emphasis on anti poverty measures. The shift in emphasis to export allowed financing of food imports.

In Ecuador, the main indicators of food security show substantial improvement over the last three decades. The impact of changing macro economic and sectoral policies was specially strong on per caput food supply, which declined under increasing macro imbalances prior to the 1980s and had significantly improved with the implementation of stabilisation and structural policies since then.

India geographically covering a total area of 329 Mha, with a population of just over 1050 million people, a per caput gross national product (GNP) of about US$ 540 (US$ 2880 as PPP). India has experienced moderately high economic growth of around and above 5 per cent per annum since the late 1980s, well above the average annual population growth rate of slightly above 2 per cent for the same period. India has maintained self-sufficiency and has gradually improved household food security throughout this period. India gave an increased and continued policy priority to irrigation through IWRDM. Related issues and agricultural technology in resource allocation, improving the lowest level distribution channels and revamping the rural credit system for groundwater investment were other key factors. As a result, the food production rose from 127 MT in 1979 to 232 MT in 2003, which has subsequently decline to about 212 MT (estimate) in 2004. The second advance estimate of overall foodgrain production during 2004-05 is placed at 206 million tones only. Per caput food availability currently stands at 2400 calories per day but the prevalence of poverty is still high, though the intensive targeted anti-poverty measures reduced the vulnerability to famines and has by and large attained food security in the country.

Mozambique, a food insecure country, after nearly a decade of economic liberalisation promises progress towards sustainable food security alongside the dramatic reduction in food aid; lower and more stable prices for the principal domestically produced staple, white maize; and a food system which now provides consumers with a broader range of choice of low-cost staples (FAO, 1996).

The issues/approaches/policies that can be considered responsible for achieving the near food security in these countries are as follows.

a. Provision of irrigation and high yielding varieties, fertilizers, pesticides
b. Emphasis on population and anti-poverty policies
c. Holistic approach to agriculture
d. Research and dissemination of new technologies
e. Restructuring of the public finance
f. Extensive social safety nets, and
g. Conducive institutional framework

V-D. Role of Research and Development (R&D)

Irrigation is a trillion dollar industry with an annual investment of around 10 billion dollars but invests only around 150 million dollars in R&D (Sanmuganathan, 2000). At the same time, the latter has decreased in not only the developed but the developing countries as well. However, while we seek increased investment in R&D, application of existing engineering and agricultural practices can considerably improve the irrigation and drainage systems assuring food security for many years to come.

Productivity Increase through R&D: R&D plays a crucial role in agricultural development by increasing agricultural production. The acknowledged set of measures to increase productivity of water comprised reduction in conveyance and distribution losses, increase in on-farm efficiency of water application, and crop management practices to maximize production per unit of water.

However, more needs to be done on R&D front for enabling adoption of IWRDM approach, like: ensure access to water, devote attention to labour-intensive practices, and bridge the gap between laboratory/research and field/farmers. Countries will have to call for an open, transparent yet a quick responding regulatory process for new R&D such as say GM food. It is known that agricultural research takes 10 to 20 years for its initiation to implementation in farmers' fields. Therefore research and technology development to contribute to the needed production must start at the earliest.

Agricultural Research Network: Agricultural R&D is conducted throughout the world through a diverse array of organizations and institutions. The global agricultural research system includes the National Agricultural Research systems, besides that by the International Agricultural Research Centres — the CGIAR, consisting of 16 Future Harvest Centers **(Table 12)** that work in more than 100 countries to mobilize cutting-edge effort.

The global level of production of maize, rice and wheat nearly doubled over the period from 1960s to 1994 **(Table 13).** The technological interventions responsible for this yield increase were: irrigation and drainage, improved varieties of seeds, fertilizers, and a range of improved crop and resource management technologies alongwith flood management (FAO, 1996). Science based agricultural technologies, developed through agricultural research, are considered essential for future increase in productivity while maintaining the sustainability of natural resources and environment. Further, to give effect to the agricultural research output, political commitment at all levels is essential.

Table 12: CGIAR - Future Harvest Centers

S.No.	Acronym	Name	Location (Country)
1	CIAT	Centro Internacional de Agricultura Tropical	Colombia
2	CIFOR	Center for International Forestry Research	Indonesia
3	CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo	Mexico
4	CIP	Centro Internacional de la Papa	Peru
5.	ICARDA	International Center for Agricultural Research in the Dry Areas	Syria
6	ICRISAT	International Crops Research Institute for the Semi-Arid Tropics	India
7	IFPRI	International Food Policy Research Institute	USA
8	IITA	International Institute of Tropical Agriculture	Nigeria
9	ILRI	International Livestock Research Institute	Kenya
10	IPGRI	International Plant Genetic Resources Institute	Italy
11	IRRI	International Rice Research Institute	Philippines
12	ISNAR	International Service for National Agricultural Research	The Netherlands
13	IWMI	International Water Management Institute	Sri Lanka
14	WARDA	West Africa Rice Development Association	Ivory Coast
15	ICRAF	World Agroforestry Centre	Kenya
16	WFC	World Fish Center	Malaysia

Table 13: Average aggregate yield (tons/ha) of rice, wheat, and maize, by region, 1960 and 1994

	Rice		Wheat		Maize	
Region	1960	1994	1960	1994	1960	1994
Developing Countries						
Sub-Saharan Africa	0.90	0.93	0.77	1.61	1.10	1.25
Latin America	1.22	1.95	1.06	2.2	1.23	2.31
South Asia	1.03	1.82	0.81	2.17	1.05	1.66
Middle East	1.52	2.37	0.77	1.59	1.09	3.00
North Africa	3.34	4.99	0.77	1.9	1.59	5.05
East Asia	3.08	4.49	2.08	2.73	2.14	3.42
Comparison with						
European Union	3.11	3.73	1.92	5.37	2.69	7.65
United States	2.72	4.67	1.76	2.53	3.43	8.68

Source: FAO (1996)

Green Revolution for Africa: During mid 1960's, South Asia passed through a phase similar to what Africa still seems to be going through. To a remarkable extent all that changed in Asia, with the advent of IWRDM and new high yielding varieties of Wheat and Rice that fuelled the Green Revolution.

But Africa has not succeeded to harness the benefits associated with Green Revolution. One wonders, why? Experts and scientists there need to focus on R&D to identify ways and means to transfer the successful technology of Green Revolution to Africa and Sub-Saharan Africa in particular.

Country Own Funding: Most nations have their own research networks for agricultural development and productivity improvement. However, the worrying part is that the level of funding for such networks is declining in many developing countries. While globally about 2.55 per cent of the GNP was spent on R&D, the share of developing countries was a paltry 0.96 per cent (McCalla 1994). As

developing countries have to come out of the food insecurity status, they must earmark increased funding to at least 1 per cent of GNP for R&D in agriculture/water sectors, be self-reliant and stop looking for outside funding.

International Funding: International development institutions are similarly reducing the share of resources for agriculture and water sectors. In 1992, when the agenda 21 was adopted, these nations were providing on an average 0.35 percent of their GNP for foreign assistance. By 1997, it had dropped to 0.22 percent, though the developed countries committed to increase the ODA contribution to 0.7% of their GNP during WSSD in 2002. Today, only four countries (Sweden, Netherlands, Denmark and Norway) meet the target. Urgent action is called for. Secondly, these governments seem to be changing priorities for funding too fast. One year it is `Water', next year `Agriculture', third year `Rural Water Supply', fourth year say `Poverty Reduction'. Certain stability in policy for R&D funding is required for the recipient Governments to plan R&D suitably.

Role of Non-Monitory Inputs: Irrigation has a land augmenting effect because of the higher yields and larger variety of possible crops. It transforms the rural landscape, radically increases agricultural productivity, and creates income and jobs, provided right concepts of irrigation water management are practiced. This implies a substantial learning process covering every aspect from community organisation to the irrigation management and crop marketing. A farming community that masters irrigated agriculture through training as a non-monetary input has options for achieving full employment and providing sustainable livelihood through food security.

For this purpose, the knowledge base comprising: information on cropping pattern, choice of varieties, crop cultivation practices, fertilizers and manures, number of irrigation applications, quantity at each application, critical growth stages for irrigation, yield response to water and finally pest management etc has to be built up on the basis of local experience and successful innovations. The knowledge base in ultimate sense has to inculcate informed decision making capacity amidst farming communities.

The water productivity can be enhanced by imparting the following concepts to farmers:

(1) training – technical and scientific knowledge,, (2) education -- responsibility, liability, future generation welfare, (3) involvement in project planning and development, (4) management training -- water and conservation law, water policies, (5) crop factors -- cropping pattern, selective crops, timing of irrigation, water efficient and salt tolerant crops, (6) Agro techniques -- crop under water stress without significantly affecting yield and quality, (7) aquaculture -- water for fish along with agriculture (double use).

The land and water user or the farmer is the one and only crucial factor that has to be not the weakest but the strongest link for any technology application, whether it is simple (low-cost) or complicated (high-cost). If ideas and scientific concepts can be conveyed to farmers for adoption of the right technology, great progress towards food security will be possible.

Some key issues in R&D to achieve food sufficiency / security can be as enumerated below:

a. Increase in on-farm efficiency of water application
b. Reduction in conveyance and distribution losses
c. Innovative crop and resources management technologies
d. Exhaustive database for informed decision-making, its availability, accessibility and adoptability.
e. Effective extension / training at grass root level.
f. Labs to land rapid transfer of technology.

V–E. Genetically Modified (GM) Food – Agricultural Biotechnology

Biotechnology utilises living organisms or substances from those organisms to make or modify a product, improve plants and animals, or develop micro organisms for specific uses. In general, crop yields reduce due to insects, pests, diseases, poor quality water or water stress. By using biotechnology, a gene with desired character viz., resistance to pest, can be transferred to the desired crop variety. This improved variety becomes resistant to that particular pest/disease. Growing such bio-tech crop, gives higher yields as losses due to pests reduce, saves expenses on pesticides and prevents water pollution in regenerated waste water or ground water due to reduced application of pesticides. Biotech evidenced by GM foods for instance, has a potential to become a boon to farming communities, though utmost care has to be exercised before releasing new biotech varieties. It can also help designing of crops to suit specific requirements. The process involved seems to be redefined, reliable, repeatable, versatile and incisive.

Globally, about **81 Mha out of 1535 Mha** cropped area (about 5.2%) is covered by GM crops. This crop was grown by 8 million farmers in 17 countries in 2004, the leaders being the US, Argentina, Canada and China. Soybean occupied 48.4 Mha followed by Corn (19.3 Mha) and Canola (3 Mha) in 2004 (Agrifood, 2004). This small area using agricultural biotechnology has brought about a silent revolution and has a potential to serve the food and nutrition needs of the world's poor. Therefore, ways of utilising genetic engineering and biotechnology in a safe and beneficial manner have to be found.

Opportunities in Agri-bio-technology: It has been argued that the revolution in agricultural biotechnology can be harnessed to serve the food and nutrition needs of the world's poor. Safe and beneficial ways of using agricultural

biotechnology have to be found, which could then ensure adequate food production to feed a rapidly growing population all over the world.

In summary, biotechnology has to be scientifically deployed as brought out by scientists, in particular for following reasons.

- The world has to produce more food from the same land, or possibly even lesser land in some regions, while conserving wilderness, the rainforests, and / or other vulnerable lands.
- Post-harvest loss of food has to be reduced by protecting it from various pests.
- The nutritional content of food is to be increased while producing foods containing bio-pharmaceuticals by means of genetic engineering, to target such diseases as diabetes and heart conditions.
- Genetic engineering methods have to be used to reduce dependency on fuel, fertilizers, pesticides or other traditional resources, leading to improvement of environmental quality and reduced cost of production.
- The quality and yield of certain species such as medicinal plants that are particularly important for the human society has to be improved.
- The production of special materials, such as polyhydroxybutyrate, a biodegradable polymer has to be promoted.

Risks Resulting From Agricultural Biotechnology: It has been argued that the agricultural biotechnology to feed the world, is unstable and poses unique hazards to health and biodiversity. The main points of this argument are the following:

- Increased drain on genetic resources from South to North,
- Gradual loss of traditional technology,
- Inherent genetic instability of transgenic crops
- Toxic effects caused by the interaction of transgenic products with the host genome,
- Potential for creating new pathogenic bacteria and viruses
- Spread of transgenes to related weed species, creating herbicide super weeds

Some of the above claims have been proven whereas some others remain unproven and speculative so far. Utmost care has to be exercised before releasing new biotech varieties. Biotechnology essentially holds immense potential and hence ***could Agricultural Biotechnology be used for preventing poor yields of farms of the world that keep poor farmers poor?***

Status of some important GM crops is briefly described below :

Hybrid Rice: Hybrid rice has shown a quantum leap in yield in China. The adoption of this seed technology is progressing in other major rice producing countries such as India, Indonesia and Vietnam. Hybrids in irrigated conditions generally yield 1 tonne per hectare more than the semi-dwarf modern high yielding varieties with the same amount or sometimes even with fewer inputs. The International Rice Research Institute (IRRI) hybrid variety IR 64616H has been recommended for on farm evaluation in the Philippines. At 10.7 tonnes per ha. It has the highest yield ever recorded at the IRRI farm. Hybrid rice use is underway in Colombia, Brazil and Guyana. Rice is the first/ top staple crop of almost half the world population and therefore yield increases with hybrid rice will play a crucial role in achieving food sufficiency / security in developing countries in years to come.

Golden Rice: This genetically modified rice is a vitamin-A enriched rice containing beta - carotene and other carotenoids, invented by Professor Peter Beyer and Professor Potrykus in Germany and is to be made available to the world free of cost. Vitamin A deficiency is responsible for 500,000 cases of irreversible blindness and 1 to 2 million deaths worldwide each year. The initial experiments with golden rice appear to indicate potential for alleviating vitamin A malnutrition. Golden rice is still in the process of development and is not meant to eradicate the problem of vitamin A deficiency overnight, but only to ameliorate it.

Bt Cotton: Bt cotton is a genetically engineered crop. It carries an artificially introduced bacterial gene (Cry1Ac) producing a toxin that helps the plant ward off insect pests. This gene results in higher number of bolls, reduced number of sprays for control of boll worm and high yields. For example, in India 55,000 farmers grew 0.5 million hectares under Bt Cotton out of 9 million hectares under Cotton, with average 30 percent increase in yield and 65-70 percent reduction in use of pesticides. China has 2.1 million hectares under Bt cotton making more than half of China's cotton crop. With normal Cotton production being widely accepted as "no longer economically viable", Bt Cotton seems to be the solution to maintain supply of fibre.

V–F. Trade in Food, Influence of Agriculture Related Issues in WTO

Global trade is a dynamic and highly complex process. It is well established that there are positive linkages between economic growth, openness to trade, local productivity, mechanisation of farming, land holdings, cost of production, subsidies and world prices. Trade impacts positively, a host of economic and social factors like growth rates, income distribution, education, employment, life expectancy, infant mortality and consequently poverty.

Food Trade (Export/Import) is practiced by individual countries depending on sufficiency or deficiency of the agricultural food and its products. Affluent

countries with surplus food grain production, export them to other countries whereas poor countries with deficient production import them.

World cereal production from 1999 to 2004 and net world cereal trade is shown in **Table 2 and 14** (FAO 2004). World cereal production was 2096 million tonnes in 1997-98, which declined to an estimated 2025 million tonnes in 2002-03. World cereal production has been gradually declining over the last six years except a peak in 2001 and 2004. The declining trend is disturbing, since the world population and consumption continues to rise. The FAO's first forecast for 2005, however, shows a reduced cereals production of 1971 million tones.

Comparing the world cereal trade (**Table 14**) the developed countries show a trade (export) surplus of about 12 per cent of their total production, whereas the developing countries show a trade (import) deficit of about 5 per cent of their own production. The situation of least developed countries is serious. They import almost 39 per cent of their own production. The agricultural production in these countries has to increase to keep pace with rising population and food self-sufficiency needs, plus 18% stocks for unforeseen circumstances, unless the land, water, finance for infrastructure, management capacity, knowledge base itself are the constraints.

As countries of the world develop and get industrialized, trade becomes inevitable. Earlier, GATT and now WTO established to facilitate trade among countries. A brief look at agriculture in WTO provides the following insight.

Table 14 : Net world cereal trade surplus in million tonnes (T), or in % of own production (OP)

	1999/00		2000/01		2001/02		2002/03		2003/04*	
	T	OP	T	OP	T	OP	T	OP	T	OP
Asia	-81.1	-7.9	-74.0	-7.4	-76.8	-7.7	-54.7	-5.6	-60.0	-6.0
Africa	-40.7	-36.5	-43.5	-38.7	-44.8	-38.0	-50.2	-43.6	-43.1	-32.8
Americas	82.4	15.7	82.1	15.5	80.7	15.6	59.6	12.6	93.8	16.8
Europe	18.7	4.9	12.5	3.2	17.9	4.2	34.6	8.0	-6.7	-1.9
Oceania	20.7	57.7	20.6	58.4	21.0	52.6	13.4	67.7	18.0	46.2
World	**0.9**	**0**	**-2.4**	**-0.1**	**-1.8**	**-0.1**	**2.8**	**-0.1**	**2.1**	**-0.1**
Developed countries	*116.9*	*13.6*	*103.5*	*12.0*	*106.4*	*12.0*	*98.2*	*11.7*	*91.7*	*10.8*
Emerging countries	*-74.5*	*-6.7*	*-62.4*	*-5.8*	*-62.8*	*-5.7*	*-41.9*	*-3.9*	*-43.8*	*-4.0*
Least developed countries	*-41.5*	*-36.4*	*-43.5*	*-37.0*	*-45.4*	*-38.2*	*-53.5*	*-47.6*	*-45.8*	*-34.6*

*) estimated **Source : Schultz et al. (2005)**

WTO: The General Agreement on Tariffs and Trade (GATT) provided rules for much of the world trade from 1948 to 1994. GATT seemed to be well established but throughout these 47 years, it remained only a provisional agreement and a provisional organisation. Attempts to create an International Trade Organisation (ITO) were aborted in 1948, mainly because the Havana Charter was not ratified.

After 1980 the United States agriculture exports faced a steep decline. Also it became apparent that the decline in the agricultural export was due to protectionist policies of same that countries started supporting an agreement that would enable free trade in agricultural commodities. The GATT provisions for agricultural trade were found weak, and need for a stronger trade regime was keenly felt. Cairns Group of Countries headed by Australia and other important agriculture export countries also found the progress in the GATT negotiations inadequate and unsatisfactory. The final decision on establishment of WTO was facilitated by the agreement between USA and EEC.

The Uruguay Round was launched in 1986 at Punta del Este in Uruguay. This was the longest round of negotiations with duration of seven and a half years. Agriculture was then brought under the purview of GATT for the first time in the Uruguay round (1994). The agreement on agriculture was also finalised there. The agreements were signed in 1994 at Marrakech and WTO was set up in Geneva in January 1995. The outcome of Uruguay negotiations was the Agreement on Agriculture that aimed to discipline trade in agricultural commodities. Commitments under the Agreement on Agriculture relate to market access, domestic support and export subsidies.

Effect of WTO on Agriculture: Agricultural trade is vital to world food security. Without trade, countries would have to rely exclusively on their own production. The developing countries need to acknowledge the implications of current agricultural policy for agricultural development in the context of WTO. The country concerned must identify the areas in which policy needs to be modified and also study the impact of WTO provisions to agricultural policy in future. The interests of small and marginal farmers must be kept in mind to benefit them from provisions in WTO's Agreement on Agriculture. In absence of such provisions the 'haves' have, tended to exploit the 'have nots' through policies that have restricted their trade. Further commitments that may have important implications for agricultural sector relate to Sanitary and Phyto-Sanitary (SPS) measures, Trade Related Intellectual Property Rights (TRIPS), and anti-dumping.

Quantitative Restrictions (QR): The move to remove QRs on importing a large number of agricultural commodities to meet WTO obligations raised apprehensions among developing country farmers that this may lead to a surge in cheap imports and adversely affect the domestic market in general and the farmer producer in particular. If it happens, the prices and sales of domestic products may be affected and the government would need to quantify the magnitude of such imports and evolve means to restrain cheap imports consequently resulting into the removal of QRs to safeguard the interests of the domestic producers. The short-term impact of the removal of QRs may be negative. However, in long run, a positive impact may be seen, as producers and industries in developing countries become more efficient.

Trade Related Intellectual Property Rights (TRIPS): Historically, Intellectual Property Rights (IPR) were given for 'inventions' and patents were never allowed on life forms for ethical reasons. During middle 20th century, a limited form of Plant Variety Protection (PVP) to a breeder of new crop varieties was given. With the hybrid seeds industry (biotechnology driven life sciences industries), they want exclusive rights to their research results. Today, patents on living organisms are considered under agreement on TRIPS. TRIPS falls under WTO and it obliges all parties to make patents available for any invention, whether product or process, in any field of technology without discrimination by the year 2000 for developing countries and 2006 for least developed countries.

The central policy issue in respect of IPRs in agricultural development is to strengthen and ensure their enforcement. The present patenting system needs to be revamped to ensure expeditious and efficient protection to inventors in various fields including agriculture. The developing countries need to take advantage of the provisions under the TRIPS Agreement to protect their genetic resources, products and technologies as well as other interests. The need for developing countries is to investigate if the implementation of the TRIPS Agreement would directly affect farmers and the food security of their countries.

Dumping: Recently the markets in developing countries saw the availability of cheap consumer goods ostensibly dumped by foreign producers. This raised fears that even processes for growth and food products may be dumped in the developing country markets. The onus of proving that dumping has taken place is on the domestic producer of the particular product. Anti-dumping duties can be levied, under WTO, on the countries from where actual imports took place during the course of investigation. The developing countries need to identify ways and means to prevent dumping. There is also a movement for the developing countries to work together to counter the unfair economic and political process control by a few rich countries and to shake off unjust regulations and practices to give developing countries a proper place in the economic globalization process.

Position Of Developing Countries: In view of commitments under Agreements on Agriculture, the developing countries may adopt the following position for negotiations.

- Resist introduction of hidden subsidies.
- Take a proactive – not a passive role.
- Ask for internationally determined norms on sanitary and phyto-sanitary safeguards.
- Insist on closer scrutiny of the non-product specific subsidies in developed countries.
- Ask for better market access for products.
- Insist on giving priority to food sufficiency, as long as 50% or more of workers depend on food production for their livelihood.

In order to firm up their stand, they are increasingly involving all stakeholders at the stage of formulating strategies, develop a sound technical research base, bring about clearer understanding of the pace and pattern of agricultural development of trading partners and develop alliances amongst countries in more or less similar situation.

Virtual Water: Water produces food grains and animal foods. It takes 1 to 3m^3 of water to produce 1 kg of vegetarian food, but 10-to 20m^3 of water to produce 1 kg non-vegetarian food. Such embedded water in producing the food or other products can be termed as `Virtual Water'. Therefore, the concept is that when a country trades such food, it really trades water. Those countries producing surplus food export Virtual Water and those like Saudi Arabia and Kuwait with food deficiency but are economically well off (high GNP) import food / products or Virtual Water. At the same time, the countries like Sub-Saharan African countries having food deficiency and low GNP or those countries having food sufficiency (India and China) with low or lower-middle GNP may not be able to practice Virtual Water Trade. Since food is traded across countries (water goes alongwith it) virtual water trade really makes water a global issue.

Virtual water trade: The concept suggests that a water scarce country should import food thereby preserving the precious scarce water for some other useful purposes. However, the countries concerned should have a capacity to import desired food in required quantity. For example, Jordan is 80 to 90 per cent dependent on Virtual water Import. If the water scarce country is poor, it has to first invest in agricultural sector to enable itself to be self-sufficient.

However, prosperous countries like Japan and South Korea following suit, does not have enough land to produce required food. They therefore, depend on imported food in exchange of export products and achieve food security. Oil exporting West Asian countries, similarly, exports oil products to import food, to make up deficit due to shortage of water.

The relevance of the concept of Virtual Water for countries in the world should be debated by keeping in view the following points: (i) increased dependency on exporting countries; (ii) local agriculture may be damaged; (iii) the exporting country may interfere in the policies of importing countries and (iv) imports may result in severe foreign reserve depletion.

If water is not used for agriculture (food), it could be alternatively used by industry or environmental sector (conservation of bio-diversity). The share of water for optimal use between People sector (Drinking and Industry), Food Production and Nature Sector is best resolved by considering basin as an Unit in any river system. In a few cases there could be no conflicts and it may be just complimentary, as had been the case in some of the results obtained from Country Policy Support Program (CPSP) results in respect of basins in India and

China. CPSP opens a new opportunity to revisit policy options keeping future scenarios (CPSP, 2005).

The food security has been defined in earlier sections as the capability of a country to provide access to adequate food to all its citizens. Populous countries like China, India and Indonesia would like to be self sufficient in their food requirements. Self sufficiency of China and India is in the interest of world food market, which otherwise would significantly distort the demand/supply equation (increase in food prices) for numerous developing and least developed countries.

Many least developing countries lack the ability to produce enough for themselves and hence depend on Food Aid. These countries have to put all their available resources to develop their rainfed/irrigated agriculture first.

The Virtual Water Concept suggests “Countries might be better off using their scarce water resources for economic activity that bring higher economic returns and buy food instead of growing it themselves”. The concerned countries need to debate and answer the following issues:

(i) Are investments in development of infrastructure (irrigation, drainage and flood management) necessary and justified to obtain food self-sufficiency; or could these investments be used for other sectors while importing the required food?
(ii) How reliable are global producers, the international food market and the access to this market?
(iii) To what extent is food security through local production at the cost of environment justifiable? and
(iv) What are the food safety risks as an importer (agro-chemicals and genetically modified food)?

The issue of virtual water is directly related to globalisation and the rules of the globalisation (WTO), which are being defined and re-defined are favourable to practicing the virtual water trade, but the current trade practices are not favourable. Trade arrangements, excess to markets, finance and foreign exchange must all be taken into account. The process of globalisation invites increased dependence amongst countries. This inter-dependence could be stimulant for global cooperation or could be a reason for conflict due to differences amongst countries. The large water exporting countries may influence the policies of recipient countries. Therefore, there is a strong need to develop a set of principles/rules governing virtual water trade otherwise conflict may prevail over cooperation.

Food Aid: The food aid is defined as all actions undertaken to improve the nutritional well being of the distressed populations, who otherwise would not have access to adequate food for reverting to a healthy and active life. The food aid is generally provided under following three situations:

(1) In emergency situation (war and natural disasters),
(2) Provision of food to chronically hungry people who otherwise have no access to this essential means of life,
(3) Food aid as a tool for development with focus on people.

This improves the nutrition of people who can then benefit from health, education, skills and income earning initiatives.

As of early June 2003, some 37 countries around the world faced serious food shortages requiring food aid. Twenty-five of these countries were from Sub-Saharan Africa, 6 from Asia and 6 from Central America and Caribbeans. The effect of droughts last year and the escalation or continuation of conflicts in several countries was responsible for food insecurity in these countries. According to the UN agency, a total food aid requirement for Sub-Saharan region alone is of the order of 4.6 million tonnes, compared with a 2 million tonnes estimate for 2001-2002. International aid will have to continue for sometime while heavy investments are required for infrastructure of water resources together with measures to improve governance and reduce population (**Table 15**).

The policymakers from developing countries may have to address the following three key issues in view of the trade and WTO status, round the world.

(a) Current agricultural policy for agricultural development in the context of WTO
(b) Impact of WTO provisions on agricultural policy in future for a given country
(c) Impact on small and marginal farmers and benefits derived from current developments

VI Progress in Reducing Food Insecurity

The World Food Summit (WFS) guidelines set in 1996 and reinforced by Millennium Summit (MDG) in 2000 suggest to cut the number of under-nourished people to half by 2015.

In a recent FAO meeting of 'Committee on World Food Security' in May 2005 at Rome, it was concluded that the progress made so far is `disappointing'. FAO noted that it is almost certain to miss the target i.e. cutting the number of under-nourished people to half by 2015 (by a wide margin), if the current trends persists.

The FAO estimated that 852 million people worldwide were under-nourished in 2000-02; 815 million in developing countries, 28 million in transition countries and 9 million in industrialized countries. The number of under-nourished people in developing countries decreased during the decade following the World Food Summit baseline period of 1990-1992. However, during the 2nd half of the decade

the number of chronically hungry in developing countries increased at the rate almost 4 million a year, wiping out 2/3rd of the reduction of 27 million achieved during the previous 5 years. This suggests that the Global Food Insecurity still exists and we have a long way to go.

VII ICID Strategy for Food Security

ICID has a network of 104 countries around the world, covering 97 per cent irrigated area, 95 per cent arable/cropped area, 94 per cent population and 89 per cent of geographic area. **(Table 6).**

One of the major concerns of ICID relates to food security. Previous sections have brought out the issues, around which the ICID Strategy for Food Security has to be framed. The basis / criteria are: food self-sufficiency, economic status, status of water resources development against potential, sustainable water and land productivity, equity, efficiency, economy in water use and governance (**Table 15**).

Table 15: ICID Strategies For Global Food Security

Category Of Countries [1]	Food Self Sufficiency	Economic Status (GNI)	Population	Status of WRD	Governance	Strategies
Least Developed Countries	Deficient [2]	*Low*	High	Low	Deficient	Aid, Investment, Develop Water Resources, Improve Efficiency, Population Control
Emerging Developing Countries	Sufficient	Low and Upper Middle	High	Medium	Evolving	Investment, Develop Water Resource, Improve Efficiency, Population Control
Developed Countries	Surplus	High	Low	Adequate	Adequate	Trade – Export

1 Categories of countries arranged from Deficiency to surplus food self sufficiency.

2 Some countries, like oil exporting West Asian countries and Japan may not be food self sufficient but they can practice virtual water – food import, due to their high GNI and still be food secure.

Least Developed countries like many Sub-Saharan countries are food deficit, have low GNP, low water resources development and have relatively deficient governance. Such countries have to depend on aid. Heavy investments for water (irrigation and drainage) and transport infrastructure, water resources development and flood management, and erosion control are required together with steps to improve water use efficiency to achieve food security. Strategies to control population in these countries have to be evolved and implemented; otherwise all efforts towards development will get neutralised.

The emerging developing countries comprise numerous developing countries like India and China, which may be food self-sufficient but not necessarily food secure due to various reasons including: low and middle level GNP, medium

level of water resources development and still evolving governance structure and reforms. Such countries also need increased investment in infrastructure and WRD together with steps to improve efficiency for achieving food security. Strategies to control growth of population have also to be in place.

Oil rich middle eastern countries, may not be producing enough food for themselves but they can afford to import food due to higher level of economic status, surplus earnings from oil and still be food secure. WRD and governance are adequate and population pressure is also relatively low in these countries.

The developed countries like many American and European countries produce surplus food and food security is not a problem due to high GNP, adequate WRD and governance and relatively low population.

VIII Summary

The World, as a whole, has been making steady progress albeit slowly towards improved food security and nutritional status during the past half a century. The progress has been uneven with many countries and population groups remaining unable to access the food produced. Humanity is thus still faced with the stark reality of a chronic under-nutrition affecting some 840 million people, 20 percent of the population of the developing countries, as many as 37 percent in sub-Saharan Africa and still more in several individual countries. The notion that the world would by now be eliminating the scourge of hunger and under-nutrition has so far proven overly optimistic. This seems to be largely because emphasis was shifted for the last decade by some, away from development and improvement of aging infrastructure to only non-structural measures, which takes longer to show results. Both have to continue hand in hand.

World Cereal Production and stocks are declining since 1998 (with exception of 2000-01 and 2003-04), whereas utilization has continued to increase. In order to ensure against the risk associated with decline in the stock of foodgrains globally, a question arises as to how much increase of the optimum level of minimum stock, which is presently about 18 per cent is desirable. One particular suggestion in this regard is to raise the minimum stock level by 5% above the present level of 18%.

As one point agenda, the world food supplies must double during the next two decades to banish hunger and undernourishment from the world. There are three sources of growth for food production. Since food yield response to irrigation is almost double as compared to rain-fed agriculture and consequently human societies will continue to rely on areas under irrigation for food security, the first source of increased food production would be the continued development and expansion of irrigation facilities through WRDM and particularly through IWRDM, which has somewhat slowed down during the last decade. As a matter of fact, the ICID Session at WWF-3 on IWRDM acknowledged that the IWRDM helps in

producing adequate quantity of food and providing sufficiency at national, regional and global level. Presently 277 Mha of land worldwide is irrigated accounting for 18 per cent of total arable and cropped area (1534 Mha), which means that crops are grown on 1258 Mha without a water management system: therefore, there is tremendous scope to increase area under irrigation, which requires building the dams necessary to develop the presently un-harnessed resources, especially in arid-semiarid regions like South Asia and Sub-Saharan Africa where water potential is yet to be fully tapped: if we don't do this, by 2025 one-third of the population of the developing world may still have to face water shortage

The second source is the reduction of the gap between potential yields and the average yields of food crops. This can be accomplished through better and optimum management of nutrients, improved agronomic practices, better management of soil and water resources and by reducing losses caused by diseases, insects, weeds and abiotic stresses. The third source of increase would be through the development of crop varieties with higher yields and yield stability. Plant breeders must use the conventional breeding methods as well as modern tools of biotechnology to develop crop varieties with higher yields and more durable resistance to diseases and insects to reduce crop losses. Thus good crop and water management with new crop varieties and fertilizers in addition to good governance would lead to maximisation of food production, sufficiency and security.

The country case studies suggest the following issues / approaches / policies that could be considered responsible for achieving food security: (1) restructuring of the public finances; (2) conducive institutional framework; (3) research and dissemination of new technologies; (4) emphasis on antipoverty policies; (5) holistic approach to agriculture; (6) provision of irrigation and high yielding varieties, fertilizers and pesticides; and (7) extensive social safety net's etc.

Research and development (R&D) plays a crucial role in agricultural development by increasing agricultural production. If productivity increases are to become instruments of food security, it is necessary to: adopt IWRDM approach, ensure access to water, devote attention to labour-intensive practices, and bridge the gap between laboratory/research and field/farmers. The funding support for agricultural development has been declining. Therefore developed nations will have to be encouraged to increase funding under ODA and the governments in developing countries will have to provide more funds for R&D in order to continue efforts in providing new technology.

Could agricultural biotechnology be used to develop new crop varieties to alleviate food insecurity and to prevent poor yields of farms of the world that keep poor farmers poor? For sure biotechnology is one of the tools to solve problems in agriculture, health and in environment protection. It is a powerful tool for designing crops suited for specific requirements. This revolution

in agricultural biotechnology can be harnessed to serve the food and nutrition needs of the world's poor. However this topic is still somewhat controversial, since it is feared by some that the agricultural biotechnology is unstable and poses hazards to health and biodiversity: thus ways of utilising agricultural biotechnology in a safe and beneficial manner will have to be determined, and this requires enhanced research and care before releasing new biotech varieties. A healthy and nutritionally fed population is indispensable for economic growth and development. Health and nutritional status affect the capacity to learn, which in turn determines productivity and economic growth.

Trade and WTO in view of the implication on agriculture vis-à-vis food security will play a major role in future. The outcome of Uruguay negotiations was the Agreement on Agriculture that aimed to discipline trade in agricultural commodities. Commitments under the Agreement on Agriculture relate to market access, domestic support and export subsidies. Other commitments that may have important implications for agricultural sector relate to sanitary and phyto sanitary (SPS) measures, trade related intellectual property rights (TRIPS), and anti-dumping. In view of commitments under Agreements on Agriculture, the developing countries may take the following course: resist introduction of hidden subsidies; take a proactive – not a passive role; ask for internationally determined norms on sanitary and phytosanitary safeguards; insist on closer scrutiny of the non-product specific subsidies in developed countries; ask for better market access for products; insist on giving priority to food sufficiency, as long as 50% or more of workers depend on food production for their livelihood.

ICID Strategy for Food Security therefore may comprise the following. Those countries (Sub-Saharan Africa) having food deficiency, low GNP, low water resources development, high population and with poor governance will have to depend on aid for sometime to come. Investments in infrastructure and water resources development are required. Countries like India and China, though food self sufficient, are still food insecure due to low-middle GNP, high population and evolving governance. They also need more investments and better governance. Countries with high GNP can import food (Virtual Water Import) and countries with surplus food can export food (Virtual Water Export). Most developing countries and all least developed countries however, may not be able to practice virtual trade due to low GNP.

By the year 2025 per caput food supplies will have increased and the incidence of under-nutrition may have been almost removed from the world. However, parts of South Asia and Latin America and the Caribbean could still remain in a difficult position. Also, a part of the sub-Saharan Africa would probably not be food secure unless concerted action is taken by all concerned on IWRDM.

References

Agrifood. 2004. Global Updates of GM Crops in 2004, Biotech Bulletin No. 12, Kingston, Australia.

Alexandratos N. 2001. World Agriculture : Towards 2010. An FAO Study. FAO and John Wiley & sons, pp 488.

CGIAR, 1990 Technical Advisory Committee, 1990. "A Possible Expansion of the CGIAR" Paper AGR/TAC:IAR/90/24. TAC Secretariat, Food and Agriculture Organization of the United Nations, Rome, Italy.

CPSP. 2005. Draft Report of Country Policy Support Program of ICID, N. Delhi, India.

FAO. 1983. Approach to World Food Security, Economic and Social Development Paper No. 32. FAO, Rome, pp. 19-37.

FAO. 1996. Technical Background Documents, 12-15, Vol. 3. World Food Summit (November 1996), FAO, Rome, Italy.

FAO 2000. The State of Food Insecurity in the World. FAO, Rome.

FAO. 1996. Success Stories in Food Securities, WFS/TECH/11, FAO, Rome, Italy, pp. 36.

FAO. 1996. Role of Research in Global Food Security and Agriculture/Development. WFS/TECH12, FAO, Rome, Italy, pp. 40.

FAO. 2001. Mobilizing Resources to Fight Hunger, Committee on World Food Security, 27th Session, May-June 2001, pp 69.

FAO. 2003. FAO Yearbook : Production, Vol. 57, FAO Statistics Series No. 177, FAO, Rome 2003, pp 259.

FAO. 2004. Agriculture: Towards 2015/30, Technical Interim Report, FAO, Rome.

FAO. 2005. Food Outlook (April Issue). FAO, Rome.

ICID. 2000. ICID Vision and Strategy Document on `Water for Food and Rural Development. 51st ICID-IEC. October 2002. Cape Town, South Africa. Pp 29.

ICID. 2005. ICID Database at www.icid.org

ICID-WWF 2003. ICID-WWF3 Session on “Water for Food and Rural Development : Integrated Water Resources Development and Management (IWRDM) for Ensuring Food Sufficiency and Security”, World Water Forum 3, Kyoto, Japan.

ICOLD-CIGB. 2003. World Register of Dams. International Commission on Large Dams (ICOLD).

“Let it Reign: The new Water Paradigm for Global Food Security” report released by IPFRI, IUCN, IWMI (April 2005)

Keller A., R. Sakthivadivel, D. Seckler. 1998. Water Scarcity and Role of Storage in Development. (Draft Paper). (www.cgiar.org/iwmi/pubs/wwvisn/wwsdehpb.htm). pp. 11.

Krishnaswamy K., R.K. Mallikharjuna and K. Vijayaraghavan. 2002. Nutrition and health aspects related with crop/non-crop foods, relationship between poverty, calorie intake and balanced nutritious diet for productive and full natural life span for people of different regions and countries. National Institute of Nutrion, Hyderabad (India). (Draft Paper). Pp. 34.

McCalla, A.F. 1994. Agriculture and Food Needs to 2025; Why we should be concerned. CGIAR - Sir John Crawford Memorial Lecture, 27 October 1994. Washington. D.C.

Molden, D., U. Amerasinghe, M. Bhattarai, J. Wang and I. Makin. 2001. Food Security - Water for Food, IWMI (Draft Paper).

Sanmuganathan R. 2000. Research and Development in Irrigation and Drainage : A Potential Role for ICID. ICID Golden Jubilee (1999-2000) Presentation.

Schultz B., C.D. Thatte and V.K. Labhsetwar. 2005. Irrigation and Drainage : Important Contribution to Global food Production (Draft Paper).

Schultz B. 2001. Irrigation, Drainage and Flood Protection in a Rapidly Changing World. Irrigation and Drainage, Vol. 30. No. 4.

Shah T., C. Scott, A. Kishore and A. Sharma, 2003, Energy Irrigation Nexus in South Asia. Improving Groundwater Conservation and Power Sector Viability, Research Report No. 70, IWMI, Sri Lanka.

Swaminathan, M.S. 2001. Food Insecurity Atlas of Rural India. M.S. Swaminathan Research Foundation. Chennai. India, pp 162.

Tardieu H. et al. 2003. Socio-Economic Sustainability of Services provided by irrigation, drainage and flood control schemes in water resources sector. ICID Task Force : 3.Draft report presented at WWF 3 at Kyoto, Japan. pp35

World Bank. 2005. World Development Indicator Database. The World Bank, Washington, DC,

World Bank. 2005. Water Security, Growth and Development. The World Bank. Contact : Sjellinck@worldbank.org.

World Trade Organisation, 4th Ministerial Conference held in Doha, Qatar in November 2001: “Doha – Developed Agenda”.

World Water Council. 2004. Synthesis paper on ‘Virtual Water Trade – Conscious Choices’. Based on Virtual Water e-Conference (Sept – Nov 2003) moderated by Paul van Hofwegen (The Netherlands). pp20.