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Managing and Coping with Urban Floods: Lessons from the Kurnool Flood of 2009 in Andhra Pradesh

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ABSTRACT

This paper describes the flooding of Kurnool town in Andhra Pradesh, India, in October 2009 and explains how several factors combined to cause one of the worst floods in 100 years. Several areas were submerged in more than 30 feet water, and it took more than three days for the water to recede completely from the town. Drawing on official information and responses of the affected people, the paper discusses the situation during and after the floods, distribution of the relief material, and the post-flood recovery process. Based on this information, the paper proposes several recommendations that are relevant to the policy framework to handle urban floods in similar situations.

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I

INTRODUCTION

Floods are one of the natural calamities that the societies have to grapple with in different ways depending on the areas of their occurrence - urban, rural, coastal etc. Floods in urban centres, whether in coastal areas or inland locations, affect large populations because of the high density of people in such areas. The utilities of power, transport, water supply and sanitation etc., get severely stressed out in urban areas and create additional problems. This in turn poses serious problems in managing the crisis due to its sheer volume and intensity when compared to that in rural areas. When a flash flood of unprecedented magnitude occurs in an urban area that is not flood-prone, and the situation goes out of control, the affected people suffer untold miseries and the capacity of the administration is stretched to its limits. Kurnool town in Andhra Pradesh (AP), India located on the right bank of Tungabhadra river, a tributary of Krishna river, experienced one of the worst floods in its history between 1-3 October 2009.The rainfall was estimated to be the highest in about 100 years. Several areas were submerged in more than 30 feet water, and it took more than three days for the water to recede completely from the town. The top portion of Srisailam dam across Krishna river downstream of Kurnul, is known to have tilted towards the downstream side by 4 mm on October 3 when an unprecedented inflow of 26 lakh cusecs, described as the "maximum probable flood" in the Krishna basin that occurs once in 10,000 years, flowed into its reservoir. The tilt of the dam is known to have reached 8.8 mm on 8 October 2009 (Malleswara Rao, 2009).

Apart from the loss of property, people faced serious problems clearing the waste, much of which consisted of damaged household items, and accumulated silt. Massive relief operations were launched by civil society organizations and government departments. Surprisingly the heavy flooding occurred during a period when the rainfall was scanty till the end of September 2009 and the district was declared drought-affected.

The present study was undertaken to analyse the causes of the flood, the damage that occurred to Kurnool's water and sanitation infrastructure, and the strategies by which affected people coped with the problems during and immediately after the floods. Based on this information, the study's intent was to develop suitable policy interventions. In addition to drawing on secondary data, we conducted focus group discussions (FGDs)

in three highly affected localities.

The main objectives the study are:

- To analyse the causes and extent of the flooding;
- To estimate the damage caused to the water and sanitation infrastructure and the processes involved in restoring them;
- To examine the coping mechanisms adopted by the affected people especially the low-income and the poor people to the problems of water and sanitation; and
- Come up with suitable policy interventions for managing and coping up with floods in urban areas.

To begin with, an attempt has been made to analyse the urban sprawl during 1999 to 2009 and landuse/land cover of Kurnool town for 2009 based on satellite images. Data on rainfall and water levels in important dams in the Krishna basin during 28 September - 3 October 2009 have been collected from the bulletins issued by the Central Water Commission (CWC), Lower Krishna Basin, Hyderabad. As per the officials of the Kurnool Municipal Corporation (KMC), the maximum flood level reached on 2 October was 284 mts above mean sea level (MSL). The IRS-P6-LISS-IV and Cartosat-1 satellite data sets were utilized to prepare the latest digital base map. To map the various categories of submergence levels, the topographical contour map has been overlaid on the base map and identified the area of inundation.

Information on damage to the water and sanitation infrastructure, and their restoration, was collected from the KMC. Three FGDs were conducted in three severely affected localities (i.e. one in each) to ascertain the experiences of the flood-affected people in coping with the problem of water and sanitation services, the nature of relief provided by the government and non-governmental agencies, and the process of adjustment.

In section 2 we present briefly the demographic growth and land use changes in Kurnool town in the last decade. Section 3 describes the Kurnool flood - causes of flooding, rainfall, water levels in dams in Krishna basin and levels of submergence. Official responses to the flood are presented in section 4. Information from the FGDs is presented in section 5 and policy recommendations are provided in the last section.

Urban floods and climate change

Studies reveal that, due to climate change, there is a more than 90 percent probability of heavier precipitation events in the 21st century-with an increase both in frequency and in the proportion of heavy falls in total rainfall. These flooding events cause

considerable hardship for urban residents, particularly the poor. People in low-income countries are four times as likely as those in high-income countries to die in a natural disaster (IFRRCS, 2009). The vulnerability of individuals is determined, among other things, by the availability of resources and, crucially, by the entitlement of individuals and groups to call on these resources (Adger et al, 2003). Floods are by far the most frequent and devastating natural disasters in Asia. In the 30 years between 1973 and 2002, Asia had a 40 percent share of all flood disasters in the world followed by America (25percent), Africa (17 percent), Europe (14 percent) and Oceania (4 percent). Available data indicate that the flood frequency is increasing in all Asian countries, and this has been attributed mainly to climate change, and to land use changes and surface degradation (Dutta and Herath, undated). These were also identified as the main reasons for urban flooding in Africa. In much of the tropics, rainstorms tend to be highly localized, often covering less than 10 sq.km, more intense and of short duration (Douglas et al, 2008).

In India a substantial increase in extreme precipitation (as in Mumbai in 2005 and the Gujarat flood events of 2005 and 2006) is expected over a large area of the west coast and central parts. This will require a significant revision of urban planning practices to integrate flood and climate change mitigation and adaptation measures (Revi, 2005). Urban flooding events have been increasing in frequency and intensity in Indian cities in recent years (Chigurupati, 2008).

II

KURNOOL

Kurnool was the first capital city of Andhra state during 1953-56 after the Telugu-speaking districts of Rayalaseema and Coastal Andhra were separated from the erstwhile Madras Presidency in 1953, before the formation of Andhra Pradesh (AP) state in 1956. It is currently the headquarters of Kurnool district in the Rayalaseema region of AP. The principal rivers flowing in the district are the Tungabhadra (and its tributary, Hundri) and the Kunderu. It may be noted that Kurnool district does not fall in the flood-prone areas in AP. The district falls under scarce rainfall zone (500-750 mm). The normal rainfall in the district is 670 mm out of which 68 percent is received from the south-west monsoon and 22 percent from the north-east monsoon. Out of 54 Mandals in the district, 48 were declared as drought affected during 2009-10. As per the 2001 census the town had 3.42 lakh population spread over 50 election wards. The town has been recording a modest growth in population. The estimate for 2009 puts the town's population at 4.67 lakh (Table 1).

Table 1: Population and Growth Rate of Kurnool: 1961-2001

Year	Population	Growth rate
1961	100815	--
1971	136710	35.6
1981	206362	50.9
1991	233717	13.3
2001	342973	46.7
2009 (Estimate)	466142	--

Note: Population estimate for 2009 is done based on the annual compound growth rate of 3.91 during 1991-01.

Source: Kurnool Municipal Corporation (KMC), Kurnool.

About one-third of the population is living in slums. The average density of population in the town is 11887 per sq.km (as per 2009 estimate). However, the density is very high in a number of wards. Most of the wards are very small in size with less than one square kilometer (Table 2). The high-density wards are located in the area between Tungabhadra and Hundri rivers which is also traditionally known as the old town. It is this high-density area between these two rivers that was highly submerged in the flood of 2009.

Table 2: Area, Population and Density of Kurnool (Ward-wise): 2001

Ward No.	Population 2001	Pop.Estimate 2009	Area Sq. Km	Density 2009
1	6561	8917	0.17	52000
2	6845	9303	0.18	51002
3	6942	9435	0.04	231059
4	7204	9791	0.29	34153
5	6594	8962	0.11	83807
6	6901	9379	0.09	106353
7	7185	9765	0.11	90883
8	7229	9825	0.19	52853
9	6216	8448	0.17	50888
10	6297	8558	0.10	87740
11	7382	10033	0.11	95475
12	6711	9121	0.09	97430
13	6497	8830	0.18	49886
14	6560	8916	0.08	108099
15	6725	9140	0.18	49737
16	6696	9101	0.13	69525

17	7228	9824	0.29	34441
18	7639	10382	0.18	56970
19	6924	9411	1.48	6366
20	6808	9253	2.10	4411
21	6351	8632	5.34	1618
22	6164	8378	3.17	2640
23	6207	8436	0.46	18234
24	7022	9544	0.09	101159
25	6862	9326	0.25	37390
26	6844	9302	0.21	44393
27	7363	10007	0.89	11227
28	7226	9821	0.80	12281
29	7060	9595	0.99	9702
30	7187	9768	0.62	15849
31	7229	9825	0.35	28418
32	7041	9570	1.43	6710
33	7268	9878	3.37	2931
34	7406	10066	0.41	24812
35	7306	9930	4.88	2033
36	6489	8819	3.01	2927
37	7195	9779	1.06	9205
38	6206	8435	0.78	10750
39	6177	8395	0.42	20113
40	6720	9133	0.38	24184
41	6181	8401	0.52	16197
42	6331	8605	0.53	16151
43	6934	9424	0.50	18833
44	7355	9996	0.47	21447
45	6585	8950	0.83	10743
46	7496	10188	0.40	25421
47	6610	8984	0.29	31037
48	7109	9662	0.21	46552
49	6909	9390	0.17	53988
50	6996	9508	0.13	71038
Total	**342973**	**466142**	**39.21**	**11887**

Note: 1. Area of the wards is worked out based on the ward boundaries. As per our calculation, the area of the KMC works out to 39.21 sq.km which is based on the map provided to us by the KMC. This is less than the official area of the KMC (49.73 sq.km).

2. The annual compound growth rate of 3.91 recorded by the town during 1991-01 has been applied to all the wards to project their populations for 2009.

Source: 1. Based on the ward-wise population for 2001 provided by the KMC.

Land use/land cover changes

An attempt was made to prepare a multi-date land use/land cover maps of Kurnool urban area from multi-sensor satellite data and to monitor changes in the land use/land cover categories using digital remote sensing techniques. For this purpose the IRS-P6, LISS-4 MX of April 2009 and merged data of IRS-ID, LISS III + Pan of April 1999 have been used. The land cover/land use thematic maps have been prepared using the Survey of India digital analogue topographic sheets and the remote sensing satellite imageries. Changes in the built-up area during 1999-2009 and the various land use categories in 2009 are presented in Table 3 and Table 4 respectively.

Table 3: Change in the built-up area during 1999-2009

Built-up area	Area in Hectares	Area in Sq.Km
Built-Up area in 1999	1958	19.58
Increase in the Built-Up area from 1999 to 2009	467	4.67
Area under plotting	424	4.24
Total	2849	28.49
Area of the town based on the map	3921	39.21
Area of the town as per KMC	4973	49.73

Table 4: Land use/land cover categories-2009

Sl. No.	Landuse Type	Area in Sq.Km	Area in Hectares	Percent to total
1	Agriculture	12.45	1245.14	31.71
2	Commercial	0.65	65.39	1.67
3	Industrial	1.66	165.70	4.22
4	Mixed Built-Up	1.03	102.89	2.62
5	Open Plots	3.97	397.27	10.12
6	Parks & Play Grounds	0.36	36.30	0.92
7	Public Utility	0.13	13.18	0.34
8	Public/Semi-Public	1.30	130.23	3.32
9	Residential-Dense	6.75	674.91	17.19
10	Residential-Sparse	8.27	827.41	21.07
11	River	1.49	149.12	3.80
12	Transport & Communication	0.14	14.31	0.36
13	Vacant	1.05	105.29	2.68
	Total	39.27	3927.15	100.00

The land use/land cover figures indicate a large proportion of the area (38.26 per cent) under residential categories (dense and sparse). The area under agriculture is 31.71 per cent which is mostly in the outskirts. The commercial area is less than two per cent. Residential areas in the densely built zones and along the main streets have mixed use character and are commercially very prominent especially in the old town. The town is woefully short of parks and play grounds with less than two per cent of the area under this category. The area under transport and communication is also quite less (less than one per cent).

III

THE KURNOOL FLOOD

The heavy rains that caused the October 2009 floods in the catchment area of the Krishna river basin resulted in heavy inflows into the three rivers which merge into each other in and outside Kurnool town. The Hundri river and its tributary, Vakkileru, pass through and merge in the town; while the Hundri and the Tungabhadra join together on the outskirts of the town and flow as the Tungabhadra till it joins Krishna river further downstream (Figure 1). The large storage area that is created by the Srisailam reservoir downstream is known to have created a backwater effect and made it difficult for a free flow of water from these rivers. The Srisailam Dam withstood the heaviest inflows of about 25 lakh C/s (cusecs - cubic feet flow per second) since its construction in 1981.

According to officials of the Kurnool Municipal Corporation (KMC), maximum flood level was reached at 284 metres above mean sea level (MSL) on 2 October. On the contour map of the town, the contour identified for the bank of the Tungabhadra river is 271 metres. Therefore, the area between the contours 271-284 metres has been marked as the submerged/inundated area. This submerged area has been divided into three categories: high, moderate, and low. The area of each submergence category has been calculated by superimposing the ward boundaries onto the submerged zones. The submerged areas were converted into polygons and the areas calculated by using the Geographical Information System (Arc GIS).

Heavy rains and water levels in dams

The heavy rains that started on 28 September 2009 in the Krishna river basin intensified from the next day onwards. The rainfall on 30 September was 1378 mm, it peaked on 1 October with 1885 mm, and dropped to 1086 mm on 2 October. Some of the rain

Fig. 1: Location of Kurnool and the Srisailam Dam

gauge stations might have already got submerged or non-functioning on 1 October, hence reported 'not available' for rainfall on 2 October (Table 5). In the catchment of Hundri river, a heavy rainfall of about 300 mm is known to have occurred in a short span of three hours between 10.00-13.00 hours on 2 October. This river, passing through the heart of the town, received a flow of 2.0 lakh C/s against its carrying capacity of 0.5 lakh C/s that day. The Tungabhadra river, the same day, received about 9.0 lakh C/s of floodwater against its capacity of 4.0 lakh C/s (Raju, 2010). A number of tanks were breached, and the Sunkesula Barrage across Tungabhadra, upstream from Kurnool, was washed away before noon (supposed to have occurred during 09.00-10.00 hours).

The revised bulletin of the Central Water Commission (CWC) indicated an inflow of 17.66 lakh C/s from the earlier 15.89 lakh C/s between 6 PM on 2 October to 6.00 AM on 3 October whereas the actual inflows were 22.37 lakh C/s recorded at various rain gauge stations. Together with the flows from local catchment areas (not recorded in rain gauge stations) the actual inflows into the Srisailam reservoir totaled about 25.50 lakh C/s which exceeded the anticipated inflows (Srinivas Rao, 2010). All these factors compounded the situation with too much water entering into the river system and causing enormous flooding in the town.

The water levels in different reservoirs in Krishna basin indicate that those in Karnataka state were full by 28 September (Table 6). Of the three dams in Karnataka, the Tungabhadra dam is located on Tungabhadra river while the other two, Alamatti and Narayanpur, are situated across Krishna. Of the three dams across the Krishna river in AP, two dams - P.D. Jurala and Srisailam - were nearly full by 28 September. The P.D. Jurala dam is located above Alampur. The Tungabhadra river joins the Krishna river near Alampur and flows down as a single river (the Krishna) into the Nallamala forests (Eastern Ghats) where Srisailam dam is located, about 60 km downstream of Kurnool. The Nagarjunasagar dam is located further downstream from Srisailam. Srisailam reservoir is also an extended storage reservoir for Nagarjunasagar; while the former is used for conservation, the latter is used for moderation (Subba Rao, 2010). The entire runoff from the rainfall from Karnataka has to flow downstream into AP, first into Srisailam (through Tungabhadra and Krishna rivers) and then into Nagarjunasagar dam, later into Prakasam Barrage near Vijayawada, and finally into the Bay of Bengal.

The Nagarjunasagar was nearly half empty at the time, with its water level at 536 feet and a storage of 209 TMC (thousand million cubic feet) as against the full reservoir level (FRL) of 590 feet and a total storage capacity of 408 TMC. The difference of about 57 feet in live storage in Nagarjunasagar (between the FRL and actual water level) seems to work out to about 50 percent of its storage capacity. The temple town of Mantralayam on the right bank of Tungabhadra, about 95 km upstream of Kurnool, received the highest rainfall on 1 October and was completely submerged and devastated on 2 October. Apart from the heavy rainfall in the Krishna basin, one of the issues raised as responsible for the flooding of Kurnool town was high water level (to near its full reservoir level) in the Srisailam reservoir has created a backwater effect up to Kurnool town. While the flooding of Kurnool town could not have been avoided, it is felt that the submergence levels would have been much less and water would have receded from the town probably within a day or so instead of more than three days.

Table 5: Rainfall at Different Places in the Krishna River Basin during 28 September to 3 October 2009

Sl. No.	Rain gauge Station	State	Rainfall in mm					
			28th Sep	29th Sep	30th Sep	1st Oct	2nd Oct	3rd Oct
1	Kurundwad	Karnataka	20.0	24.0	62.0	42.0	18.6	58.0
2	Gokak	"	NA	10.0	16.0	0.0	90.0	60.0
3	Almatti Dam	"	9.5	29.6	114.2	107.6	88.4	68.7
4	Narayanpur	"	3.2	29.6	43.0	104.2	180.2	44.0
5	Cholachguda	"	5.2	14.0	52.8	66.4	86.8	17.2
6	Takli	"	30.0	16.0	69.6	49.4	50.0	30.8
7	Wadakbal	"	7.0	19.2	43.0	70.0	42.2	18.0
8	Deongan Br.	"	14.0	128.4	68.6	124.8	24.4	54.8
9	Yadgir	"	1.0	23.0	40.0	80.6	57.6	86.0
10	Huvinhedgi	"	0.0	6.1	35.8	38.2	50.0	6.0
11	Deosugur	"	0.0	19.6	37.4	22.2	NA	NA
12	Shimoga	"	0.0	33.0	2.0	23.2	4.4	13.4
13	Honnali	"	4.6	35.0	10.4	17.2	7.2	15.8
14	Harlahalli	"	0.0	39.8	18.2	36.4	28.0	11.0
15	Marol	"	0.0	10.6	33.4	40.0	53.2	24.6
16	Tungabhadra	"	0.0	24.8	47.6	92.2	87.5	NA
17	Jurala	Andhra Pradesh	1.3	31.0	77.0	120.0	67.8	103.0
18	Oollenur	"	43.6	9.2	71.2	106.2	NA	0.0
19	T.Ramapuram	"	4.4	7.8	80.4	120.4	NA	NA
20	Mantralayam	"	4.0	7.3	45.4	172.0	NA	NA
21	K.Agraharam	"	0.0	37.2	49.6	NA	10.0	0.0
22	Srisailam	"	2.6	30.1	37.0	111.9	NA	20.8
23	Nagarjunasagar Dam	"	0.0	31.2	51.4	64.6	NA	11.6
24	Wadenapalli	"	0.0	11.2	32.0	97.6	49.6	2.4
25	Madhira	"	0.0	24.6	109.4	53.0	21.2	3.6
26	Paleru Bridge	"	0.0	29.2	58.4	47.2	18.4	1.4
27	Polampalli	"	0.0	36.4	50.6	39.6	34.6	2.4
28	Prakasam Barrage	"	0.0	7.0	22.0	38.0	16.0	4.5
	Total		**150.4**	**724.9**	**1378.4**	**1884.9**	**1086.1**	**658.0**

Source: Central Water Commission, Lower Krishna Division, Hyderabad.

Note: The towns with raingauge stations for NA (Not Available) marked for 2nd and 3rd October were already submerged or badly affected.

Table 6: Water Levels in different Reservoirs in Krishna River basin in Karnataka and Andhra Pradesh during 28 September to 3 October 2009

Dam/Reservoir and Date	Full Reservoir Level (FRL in (Feet)	Water Level at 8:00 hrs (Feet)	Percent Live Storage w.r.t FRL
28 Septempber 2009			
Almatti (K)	1705	1704.72	99.98
Narayanpur (K)	1615	1614.34	99.96
Tungabhadra (K)	1633	1633.00	100.00
P.D.Jurala (AP)	1045	1042.32	99.74
Srisailam (AP)	885	883.69	99.85
Nagarjunasagar (AP)	590	533.10	90.36
29 September 2009			
Almatti (K)	1705	1704.72	99.98
Narayanpur (K)	1615	1614.53	99.97
Tungabhadra (K)	1633	1633.00	100.00
P.D.Jurala (AP)	1045	1042.32	99.74
Srisailam (AP)	885	884.19	99.91
Nagarjunasagar (AP)	590	534.60	90.61
30 September 2009			
Almatti (K)	1705	1704.72	99.98
Narayanpur (K)	1615	1614.73	99.98
Tungabhadra (K)	1633	1632.93	100.00
P.D.Jurala (AP)	1045	1042.49	99.76
Srisailam (AP)	885	884.35	99.93
Nagarjunasagar (AP)	590	536.30	90.90
1 October 2009			
Almatti (K)	1705	1704.59	99.98
Narayanpur (K)	1615	1612.70	99.86
Tungabhadra (K)	1633	1632.97	100.00
P.D.Jurala (AP)	1045	1042.49	99.76
Srisailam (AP)	885	884.60	99.95
Nagarjunasagar (AP)	590	542.00	91.86
2 October 2009			
Almatti (K)	1705	1703.90	99.94

Narayanpur (K)	1615	1609.06	99.63
Tungabhadra (K)	1633	1632.70	99.98
P.D.Jurala (AP)	1045	1040.52	99.57
Srisailam (AP)	885	881.56	99.61
Nagarjunasagar (AP)	590	566.80	96.07
3 Ocober 2009			
Almatti (K)	1705	1701.77	99.81
Narayanpur (K)	1615	1609.84	99.68
Tungabhadra (K)	1633	1632.66	99.98
P.D.Jurala (AP)	1045	1041.99	99.71
Srisailam (AP)	885	894.69	101.09
Nagarjunasagar (AP)	590	578.00	97.97
4 October 2009			
Almatti (K)	1705	1702.10	99.83
Narayanpur (K)	1615	1607.61	99.54
Tungabhadra (K)	1633	1632.16	99.95
P.D.Jurala (AP)	1045	1038.88	99.41
Srisailam (AP)	885	895.11	101.14
Nagarjunasagar (AP)	590	584.50	99.07

Source: Bulletins of the Central Water Commission (CWC), Lower Krishna Division, Hyderabad addressed to Chief Engineer, Krishna Godavari Basin, Hyderabad and others during those days.

Note: 1.While the CWC bulletin mentions the storage level in Srisailam reservoir as 881.56 at 080 hrs on 2 October, it was a little lower than 883.40 ft. upto 2.00 PM on that day (Srinivas Rao, 2010).

Water level at Srisailam reservoir and the backwater effect

The maintenance of the water level at 883.69 feet (about 270 metres) (as against the FRL of 885 feet) at Srisailam Dam is known to have created a backwater effect up to Kurnool town even as large inflows were coming into the reservoir. This situation is known to have aggravated the flooding of the town. The unprecedented water level of 896.5 feet (about 273.4 metres), 11 feet above FRL, at Srisailam Dam was reached on 3 October, and came down to normal level only after six days - by the evening of 9 October.

It should have been possible to start emptying the Srisailam reservoir into the Nagarjunasagar by the morning of 30 September. Instead, the release of water from

Srisailam was very slow and initially less than the quantum of inflows resulting in maintaining the near-full level (Srinivas Rao, 2010). Rejecting this argument, one senior engineer opines that Kurnool got inundated when the water level at Srisailam Dam was 883.90 ft. The water level started receding in the town when water level at Srisailam Dam was crossing FRL limits. The flooding of Kurnool was, therefore, due to the inadequate carrying capacity of Tungabhadra and Hundri rivers. There was a rare phenomenon of synchronization of peak inflows into Srisailam reservoir from the three sources of Jurala (12.50 lakh C/s), Sunkesula (5.25 lakh C/s) and intermediate catchment (2.25 lakh C/s) on 2 October 2009 (Subba Rao, 2010). By showing the contour levels of the flood and water levels in Srisailam reservoir, another senior engineer argues that the backwater effect was also responsible for flooding of Kurnool and, because of this, water took about three days for receding whereas it took only one day in 2007 for the flood to recede, which was caused by Hundri river (Raju, 2010).

Photo 1: People being recued (Photo courtesy: Sakshi, *Telugu Daily* Kurnool, 2 October 2009)

Photo 2: Srisailam reservoir in the peak flood
(Source: *The Hindu*, Hyderabad, 21 October 2009)

Maintaining high water level in Srisailam, even after the forecast of heavy rains, raised a controversy because the Nagarjunasagar at the downstream was half-empty. With heavy rains occurring in the Krishna basin from 29 September onwards and all the reservoirs from Srisailam upwards being full, it was possible for emptying the Srisailam reservoir at least from the morning of 30 September. This would have facilitated easy flow of the flood water into the Srisailam reservoir from the overflowing Tungabhadra and Krishna rivers. Instead, the release of water from Srisailam was very slow and gradual and initially less than the quantum of inflows resulting in maintaining the near-full level of the reservoir. For instance, at 19.00 Hrs on 30 September 2009 the inflows and outflows were 2.062 lakh C/s and 1.821 lakh C/s respectively; and at 12-00 Noon on 1 October the inflows and outflows were 9.46 lakh C/s and 9.055 lakh C/s respectively, and the water level was 883.50 ft (Srinivas Rao, 2010). Even at that stage the outflows were less than the inflows. There has never been a clear and convincing explanation by the authorities regarding non-release of water from Srisailam reservoir in anticipation of heavy inflows[1].

[1] While the opposition political parties attributed this to the negligence of the engineers managing the Srisailam Dam and demanded stern action on those responsible for the flooding of Kurnool, the officials now and then spoke about the bulletins from the CWC not being clear enough to warn the impending disaster. One view is also that the floods occurred exactly one month after the death of the then chief minister, Y.S. Rajasekhar Reddy, and there was total political uncertainty in AP, which also indicates the unpreparedness of the district administration to face the flood.

The flooding of Nandyal town and a large number of villages along the course of Kunderu river in Kurnool district and the neighbouring Kadapa district in the Pennar river basin is directly related to the water level rising above FRL at Srisailam Dam. Nandyal has about 1.5 lakh population and is located 65 km away from Kurnool. The backwaters of the reservoir have inundated the Pothireddypadu head regulator which resulted in heavy inflows into the Kunderu river causing floods and loss of property along its course. Thousands of hectares of crops were submerged in Kurnool and Kadapa districts till the water entered Pennar river. This has happened on 3 October and afterwards even as the rainfall had stopped and the flood levels were receding in Kurnool town. This is an instance of vast areas getting inundated in a river basin due to heavy rains and water (mis)management in the neighbouring basin.

Levels of submergence

The total submerged area between the contours 271-284 metres works out to 11.56 sq. km or about 30 per cent of the area of the town (Table 7 and Figure 2). The 'high submergence' area at a depth of at least 13 mts (42.5 ft) accounted for 8.6 per cent of the area (3.36 sq. km), and was located in the low lying areas sandwiched between Tungabhadra and Hundri rivers. The 'moderate submergence' area between contours 279-284 metres with a depth of 6 mts (19.5 ft) represented a larger area of 5.36 sq. km or 13.7 per cent. A 'low submergence' area between the contours of 283-284 metres with a depth of 2 mts (6.5 ft) accounted for 2.84 sq. km or 7.2 per cent of the area. The actual depths of submergence on the ground were slightly less than indicated above because of the built-up nature of the urban territory.

Table 7: Submergence Levels (above MSL)

Submergence Category	Submergence Levels (contour levels in metres)	Depth of Inundation (in metres/feet)	Area under each category (sq.km)	Percent to total area
High	271 to 284	13/42.5	3.36	8.6
Moderate	279 to 284	6/19.5	5.36	13.7
Low	283 to 284	2/6.5	2.84	7.2
Total			**11.56**	**29.5**

Note: Total area is taken as 39.21 sq.km based on the map provided by the KMC.

Twenty-one wards were completely submerged, affecting about 42 percent of the population, or close to 2 lakh people (Table 8). That these wards constitute only 4.59 sq. km (11.71 percent) of the area indicates the very high population density in the affected areas. These are also the areas where submergence level was the highest and

water took more time to recede. In another 10 wards the submergence was 50-99 percent affecting 14.1 percent more population. Together, these 31 wards accounted for 25.86 percent of the town's area and 56.1 percent of population (about 2.6 lakhs) and were badly affected by the flood.

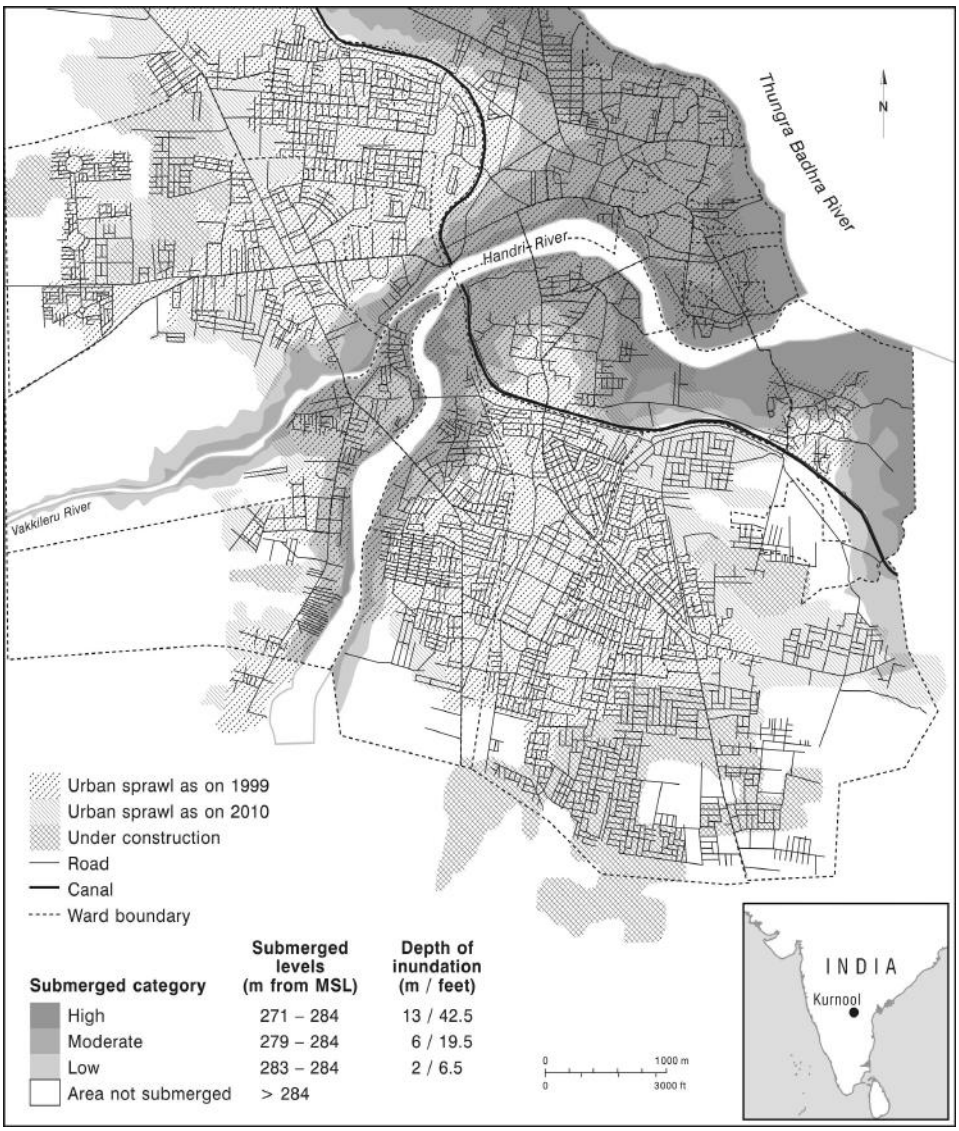

Fig 2: Levels of Submergence

Table 8: Area and Population affected by Submergence

Percent of Submergence	Total Wards	Area affected		Population Affected	
		Sq.km	Percent	Number	Percent
100	21	4.59	11.71	195465	42.0
75 - 100	3	2.01	5.13	23260	5.0
50 - 75	7	3.54	9.0	42488	9.1
25- 50	1	0.16	0.41	4451	1.0
Less than 25	10	2.39	6.09	9063	1.9
Not submerged (Population not affected)	8	8.81	22.47	71101	15.3
Total	50	39.21	100.00	466142	100.00

Note: The number of people affected in the partly affected wards is estimated based on the percent of the ward's areas that is affected (as worked out based on Arc GIS). That is, if 50 percent of a ward is submerged, half of its population is considered flood-affected.
Source: Based on the analysis of submergence levels on the map.

IV

OFFICIAL RESPONSES

The guidelines of the Revenue (Disaster Management) Department, Government of AP issued in 2009, provide details of the Standard Operation Procedure (SOP) for management of relief and rescue operations in times of cyclones, floods and heavy rains. The SOP is supposed to be operationalised 48 hours before a cyclone, flood, heavy rain etc., as soon as the warnings are received from the relevant organizations at the state and central level. The SOP refers to keeping the official machinery ready before 48 hours and 24 hours of the impending disaster. It also refers to paying some compensation after the calamity is over.

The guidelines refer to setting up of a state control room at the state headquarters (i.e. Hyderabad) with clearly defined roles for different officers. Annexure-3 of the SOP, entitled 'Important Instructions to District Collectors' clearly mentions the arrangements to be made before 48 hours and 24 hours. These include opening a district control room, keeping the cyclone shelters ready to shelter the victims with hygienic food and drinking water, providing for emergency supply of drinking water, stocking of adequate quantities of drugs, arranging search and rescue teams for relief operations and maintaining of hygiene at relief camps. On monetary relief, the SOP specifies the amounts

to be paid to individuals (based on injury or death) and to households based on the extent of damage to houses. It also talks about compensation for clothing and utensils for the families whose houses are washed away or fully damaged.

At the state level, the management of floods, cyclones, heavy rains is under the over all guidance and control of the Commissioner, Disaster Management & Ex-officio Principal Secretary to the Government. At the district level, the Collector is expected to be pro-active, leading and supervising the entire operations. The experience in Kurnool reveals that the SOP was not followed in full and the administration was not prepared to handle the heavy flood and evacuate people in a short time. For example, the batteries of cell phones of several senior officers in Kurnool were exhausted due to their continuous use from 1st October itself. When the calamity struck on 2nd October, many of them were left with non-functional cell phones which could not be recharged due to power cuts which affected the non-submerged areas also.

One of the reasons for low level of preparedness may be that Kurnool does not fall in the flood and cyclone-prone areas in A.P and a flood of this intensity was not expected. There are, for instance, no purpose-built relief camps in the area. Another reason could be political, as discussed earlier, relating to the death of the then chief minister one month before this flood. The response of the official machinery was more evident in the post-flood reconstruction process, especially in the massive clean-up operation and restoration of water and sanitation services.

The clean up

Removal of silt and debris was a major challenge faced by the authorities. Most of the household items, foodgrains and other consumables stored in houses and warehouses were reduced to waste. In a massive operation, the government mobilized hundreds of officers, workers and machines from 35 urban local bodies in AP to clean up the town. Over the course of the next one month, 9568 vehicles and 56305 workers (both cumulative) were deployed in the clean-up operation. About 1.13 lakh tons of garbage and debris was reported to have been lifted and removed. To prevent any outbreak of diseases, about 500 tons of bleaching powder was sprinkled during that period (KMC, 2009). Water contamination was prevented by regular mixing of chlorine at several points in the distribution system and constant monitoring of its levels for several days. Chlorine tablets were also distributed on a large scale to the people at relief camps and residences for mixing with water in the containers. Thus there was no outbreak of water-borne disease in the flood-affected areas.

Photo 3: Waste getting cleared (Photo: Author, 14 October 2009)

Water, sanitation and public health

The two main sources of water supply to Kurnool town are Tungabhadra river and the Kurnool-Cuddapah (K.C) Canal. The present supply is about 45.45 million litres per day which works out to about 113 litres per capita per day. There are 31134 house service connections,1810 public stand posts, and 1290 hand pumps (of which 61 are reported to be dry) in the town. The water is supplied daily for 2-3 hours in about 65 percent of the area and on alternate days in the rest of the town. The pumping stations suffered damage to their high capacity pump sets and electric transformers due to submergence. The infiltration wells also suffered damage. While garbage was being lifted from streets and drains, about 200 metres of water distribution pipelines and 300 house service connections were damaged. Hand pumps (numbering 270) were also damaged due to submergence. The KMC claims that most of the damaged water supply systems were repaired and restored within a few days (KMC, 2010). Be that as it may, in the 2 to 3 weeks after the flood, water supply needs had to be supplemented through tankers supplied by the KMC (including those obtained from other local bodies) and private agencies. Drinking water needs were met largely by the water sachets distributed by a number of private agencies at the relief camps and to the households in different localities.

Kurnool town doesn't have a centralized sewage system and a sewage treatment plant. It is largely organized into septic tanks, and hence silt did not block the entire system.

According to the KMC, between 21 October and 5 November, 339 septic tanks were identified as overflowing and were cleaned. One may have to take these claims with certain reservations given the experience of civil society groups who had to exert pressure on the KMC to get the septic tanks of schools cleaned, as exemplified by the instance of the Government Girls Urdu High School[3].

Health services

The role of the government with regard to maintaining public health was mostly focused on preventing the spread of epidemic diseases by cleaning up the streets, spraying bleaching powder, fogging against mosquitoes, maintaining water quality by chlorination etc. Fogging was done even in the late evenings. 'That is why we were saved from public health-related diseases', was the unanimous opinion of the participants in all the FGDs.

Over the traumatic post-flood period, for about a month, the government made its medical emergency services available to provide free treatment for health problems. Mobile health care units (ambulances marked with the number 104) made periodic visits to different areas for primary care. The government also made emergency ambulances (identified by the number 108 and run in partnership with private sector) available to provide regular health services to affected areas. Some private and charitable hospitals also provided free medical camps. The same services were made available at the buildings serving as relief camps, but for the most part people stayed in these places only at night.

Distribution of relief materials

Civil society organizations rushed in massive relief but its distribution was a major problem. The relief that poured in immediately was small in quantities, was disorganized and the people who brought it were also in a hurry to distribute it and leave. It was a stampede-like situation every time a relief van arrived at a designated place in a colony where people were already waiting. More organized efforts had been put in place only after several days of the calamity. The effort in particular by a Telugu television news channel, TV-9, was more organised, and that by Telugu Desam Party (TDP) also came in for appreciation.

V

FOCUS GROUP DISCUSSIONS

Finding effective ways to improve responses to a disaster will become easier with a good understanding of the situation from the perspective of the affected people. To obtain the experiences of the affected people during this calamity, focus group discussions were conducted in February 2010 separately in three localities: one each in Budhavarpet, Madam's Satram, and Roza Veedhi. These localities are geographically spread out in the old town and were all badly affected in the flood. In each of the focus groups there were about 15-20 persons, mostly women of different age-groups. The number of participants was deliberately limited so that a meaningful interaction would be possible. In each of the neighbourhoods, a local social activist engaged by the research team first discussed about the research study with a local women's leader and obtained her cooperation. These leaders were not affiliated to any political party. They were either social activists or community leaders. People from each locality were gathered at a designated place (a community building in one instance and residences in the other two). No specific criteria were followed in identifying the participants - selection was left to the local leader. Word was put out, and people gathered from the immediate neighbourhood of the place of the meeting. The majority of inhabitants in the three localities are dalits (Budhavarpet), Muslims and socially weaker sections of population (Madam's Satram and Roza Veedhi). The participants narrated their experiences in a free and frank manner and went beyond the planned scope of the discussion, pouring out their emotions and grievances while recollecting their harrowing experiences. Their narrations are summed up in the following sections.

Immediate crisis and the rescue operations

The local people were highly appreciative of the role of police in issuing warnings and helping in evacuation. But many felt that the response was far from adequate. "Government has to inform us properly beforehand", recalled a woman at Madam's Satram. "We were not informed. I got a phone call from Veligonda (neighbouring town). Some of us who had cell phones were saved". Many of the affected people were unwilling to vacate their homes and move to relief centres for fear of thefts. In the crisis, young men were invaluable in assisting people to cross buildings and flooded streets with the help of sticks. They also helped senior citizens and children to reach safer places and relief camps. In Madam's Satram area, floodwater entered all houses by 10.00 A.M. on 2 October, the day of maximum flood. There was no time to take their belongings. People spent about 48 hours on top of the buildings. To prevent short

circuits, the authorities had discontinued the power supply. People had to look out for safe places in total darkness.

"Walking on and along the walls we reached the road on Friday night (2 October). Some of us went to the Collector's bungalow, some to the Church and some others went to their relatives' houses. Some thousands of people were there on roads for three days. So many belongings have been washed away in the flood; we didn't feel like having our food even," recollected a woman, while the other participants concurred with her. Rumours of further inundation, to the extent of washing away of the entire town on 3 October, created a sense of panic and the way the people ran for their lives is something the participants don't want to recollect. Months later, the memories of helplessness and of running for safety continued to haunt them. The private boatmen had demanded exorbitant amounts (in cash or kind i.e. gold ornaments) for rescuing people. "They were demanding Rs 5000/-. I only had Rs 10/- at that time", recollects a sobbing woman. The fact that income levels played such a key role in this situation left a bad taste in people's minds. It also highlighted the failure of the government to rein on the boatmen.

"On Thursday (1 October) night we went to the terrace," narrated a woman in Madam Satram. "For 48 hours we stayed there. It was even slightly rainy. We were about 50 people and remained there without food and water. Children were weeping. We stayed there under umbrellas in the rain". "In our group there was a woman who delivered a child a week before," another woman from Roza Veedhi recalled. "We were helplessly sitting even then. And there was another lady who had been operated on just a few days before. What else could we do? Later we carried her in a chair to the relief camp. Alas! In that process she was dropped in the water. Anyway, she is fine now!"

The "relief camps"

There were no formally designated relief camps in the area, but people made use of any public buildings or spaces that offered themselves, including the railway station, a school, a mosque, and the Collector's bungalow, an office complex with a large open space. These buildings were not designed to accommodate such large numbers of people, and lacked basic facilities. They were called relief camps simply because they were the places that people were able to reach in that desperate situation and take shelter - although the shelter was far from adequate. All these buildings were located at about two kilometers from the inundated areas. There were no special arrangements to transport people. It was a 'run for your life' situation. On those two days of 2-3 October people could think of nothing beyond saving themselves from the disaster.

Distribution of relief

Participants were highly appreciative of the relief rushed in by civil society organizations, finding their responses to be more effective than that of the government. The initial chaos was troubling many, however. Outsiders, bringing in relief in vans, did not know who the really affected people were. A large number of people from non-affected areas would also wait in the crowd and snatch the relief supplies. Households without able-bodied male members and those in the narrow interior lanes were at a disadvantage. Middle class families, many of whom became paupers overnight, found it highly difficult and degrading to rush and push for the relief materials. They suffered silently and cursed their fate. "We could not get into that crowd and jostle for the relief. Both physically and psychologically it was difficult. We are not used to that. It was like begging, even worse than that", said a middle class woman in Budhavarpet[2].

The most effective distribution method was generally felt to be that adopted by a Telugu news channel (TV-9), which distributed coupons to every house even if the inmates were not present. The affected people could go to a designated place with the coupons and collect the relief material. Nobody was left out. The TDP also organized massive relief in a similar way but without distributing coupons, and here again people living in interior of the narrow lanes or those who were not present at the time of distribution were left out.

Water and sanitation at relief camps

The government machinery was not prepared to provide water and sanitation facilities at the buildings used as relief camps. While drinking water was provided in the form of water sachets, sanitation was a major problem. People somehow bore with the inevitable situation. Some typical comments included the following: "In the Church's compound there were toilets but there was also foul smell all around;" "In Balabharathi School we carried water and used the toilets. Because the area was less muddy, somehow we managed to go with the help of a stick;" and "We went out in to the fields for sanitary purposes. Some were forced simply to squat wherever they could".

Those who were perched on top of the buildings for more than 24 hours had also the worst kind of memories, especially ladies. "Some of us controlled ourselves by God's grace. We were about 50 people on the terrace. There was some space on the terrace. We used that space as a toilet," recollected another woman from Roza Veedhi.

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[2] This was in conversation with the research team members in a street in Budhavarpet before the focus group discussions. The participants in these discussions broadly agreed with this predicament of the middle class people who were otherwise reasonably well off.

The clean up

The clean up after the water receded was a major challenge. Although government was very much involved in the more general clean up, people had to cope with cleaning out their houses. "When we came back to our homes," said one woman, "all our clothes and other household items were full of mud. Up to two feet of silt was spread in the houses. Many of our belongings were either washed away or stolen by thieves. In the process of cleaning we were affected by skin infections. Doctors conducted health camps for about 10 days. They supplied us with tablets for cleansing drinking water, against allergy and body pains. Government gave us tablets for mixing in the tap water." People cleaned their houses in the daytime and went back to either relief camps or relatives' places at night. This went on for about 20-30 days.

Many people left their small children at relatives' places either in the same town or in the neighbouring villages and towns during the clean-up process. For about a month the affected areas smelled foul, with tons of garbage, damp mattresses, soaked grain bags thrown on the roads. People claimed they would not wish this experience to happen even to their enemies. No support was available for the cleaning process. Some people came from rural areas and charged Rs 5000/- per house for cleaning. Even after twenty days, when the cleaning process was still not completed, some people paid Rs. 1200-1800 to have the job finished up. Some have also paid to get their clogged toilets/pipes cleaned. "Government did not help us in this regard. Even after 3 months the condition of the toilets has not improved. They helped us only in pumping out water. The mud from the pipes was removed by private contractors who charged us Rs. 1500-2000," said several women at Roza Veedhi.

Water supply and sanitation during rebuilding stage

Although the KMC repaired much of the damage to the local water system, people who consumed municipal water experienced discomfort and later shifted to packaged water. "The tap water in the beginning was red in color, looked like muddy water, and it made us sick to our stomachs", said a woman at Budhavarpet. Sometimes people had to purchase water packets. Boys played a key role in collecting water packets for their families. Clean water for other purposes was hard to come by, and many of the affected people said they didn't bathe for about 10 days. The local legislator (MLA) supplied a liquid called 'hypo' which could be sprinkled around to cope with the foul smell. Some liquid was also supplied for easy cleaning of the toilets.

In the initial days after the flood, when the toilets were silted up and not in usable condition, it was challenging for people to attend to their needs. Some women acknowledged that they used old cloths, donated as part of relief, for defecation inside

the house. "Then we threw them into the garbage outside", said a middle-aged woman, clearly embarrassed by the admission. Several other women nodded silently. Although the municipality was involved in the cleaning and repair of many sanitary facilities in the weeks after the flood, household and community toilets in localities inhabited by low-income people and those of lower castes evidently received low priority. According to participants in discussions, the community toilets in Budhavarpet (a low caste neighbourhood) continued to be unusable even months after the floods. Out of 16 units only three could be used several months later. About one thousand families, mostly dalits, depend on these toilets. They are now forced to use the open spaces of the nearby canal and the graveyard for defecation.

Solidarity

The traumatic times brought out the best in people during the floods. There was considerable mutual support and aid. The affected people have felt that nature had eliminated the differences between people, even if only temporarily. However, there was also cause for hurt feelings in some situations. Specifically, in the post-flood recovery process, some people who came from outside were interested in offering help only to people from their own castes or groups, and this caused ill feeling. This opinion was commonly expressed in all the focus groups. The same was clearly true in terms of the inequitable municipal responses, as noted with regard to community toilets in Budhavarpet. The lack of interest and compassion was sorely felt by many. The participants in the focus groups made it clear that they were thankful to the research team for the opportunity to be heard. This is how they expressed it: "Nobody visited us to share our experiences during floods or later. Today we feel a sense of relief and happiness that we could talk to other persons who were not affected by the crisis. We will never forget your patient hearing of all of us".

VI

CONCLUSIONS AND RECOMMENDATIONS

Based on the experience, as reported both by the authorities and by the affected people in focus groups on the Kurnool flood, the study brings out some findings and recommendations that can form part of a policy framework to cope with this kind of calamity in an urban area.

1. It is crucial to disseminate prior information and warnings on the likely scope of flooding, based on the amount of rainfall and other factors. The public should receive credible warnings. Often people find it hard to imagine how serious a threat can be. People's representatives and civil society organizations should be taken into confidence by the local administration and credible information should be passed on to people through them.

2. Providing sufficient security to the vacated areas is of utmost importance to convince people to vacate their houses and move to the relief camps. Without this security, they are likely to be afraid of losing their valuables due to thefts when the entire area is evacuated. It should be possible to identify certain strategically located buildings where security posts can be set up, with prior understanding of the owners. Such security posts should be provided with an electric generator for power supply (since power supply is disconnected in such situations) and also a public address system for disseminating correct information to the public. This will greatly help in building confidence and avoid rumours.

3. In the early stage of floods when the power supply is discontinued, the affected families cannot get updated information through television channels (wherever they exist). Mobile phones provided the main source of communication from friends and relatives as happened in Kurnool. One of the suggestions that came up during those difficult days in Kurnool was to keep adequate number of stand-by generators ready at least 48 hours in advance for power supply at relief camps, and at the monitoring centres. Cell phone recharging facilities should be arranged at these places so that neither officers nor affected people are left without communication devices at crucial times.

4. The Kurnool experience shows that even in areas that are not normally considered to be at risk from disasters, it is necessary that some form of preparation for housing people and dealing with their basic needs is essential in emergency situations.

5. The role of media and civil society has become crucial in informing the people in rescue and relief operations and post-flood recovery process. The flow of aid has been instant and massive from the public. The administration must put in place, in advance of the calamity, a coordinating mechanism with the media and civil society groups for assisting in and managing the rescue and relief operations.

6. The experience shows how the lack of coordination affected distribution of the relief material which resulted in some people, including the unaffected ones, cornering more than others. Distribution of tokens to each house in advance has worked more effectively and equitably in Kurnool.

7. The distribution of chlorine tablets to the affected people for mixing with water at their houses and chlorination in the water distribution system and continuous monitoring of water quality at different points for at least 2-3 weeks helped in preventing water-borne diseases.

   In the post-flood situation, provision of a certain minimum quantity of drinking water to each household should get highest priority. Availability of bottled/packaged water provides a huge opportunity to meet such needs. The token system can also be adopted for distribution of drinking water on a per capita basis.

8. Government's assistance, which should at the very least not be applied on a preferential basis, should encompass a broader framework for restoring the livelihoods and compensating for loss of income, rather than mechanically fixing a certain amount based on the damage to the house, as stipulated by the standard operating procedure. Even when the houses are not damaged, submergence of the house and the loss of household items acquired over years can push the affected people into poverty for a long time. Non-salaried people like small business people and daily wage earners forego several days of work in the post-flood period.

   Allowances for house cleaning and basic sustenance for disaster affected people should be considered as integral to policy responses. The basic sustenance allowance could be equivalent to the prevailing daily wage and be paid until normalcy prevails in the affected areas. The school children who lose their books should get assistance for purchase of books and their fees could be waived. The specific modalities for these kinds of responses should be worked out with the involvement of local communities.

9. From the humanitarian point of view, it is of utmost importance that the affected people during the calamity, and even more so, in the post-flood recovery process, be treated with fairness and empathy. Making them feel that they are cared for and involving them in the local reconstruction process will go a long way in assuaging their feelings and helping them to recover from the traumatic experiences.

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