



Summer 2008

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### Recommended Citation

Govindasamy Agoramoorthy, Sunita Chaudhary & Minna J. Hsu, *The Check-Dam Route to Mitigate India's Water Shortages*, 48 NAT. RES. J. 565 (2008).

Available at: <https://digitalrepository.unm.edu/nrj/vol48/iss3/3>

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# The Check-Dam Route to Mitigate India's Water Shortages

## ABSTRACT

*An interstate water conflict is emerging in southern India's Cauvery River delta. Despite an estimated per capita annual average freshwater availability of 87,015 cubic feet per person, many of India's nearly one billion people suffer occasional water shortages due to uneven availability. Precipitation is concentrated mainly during the monsoon season. Although some areas of India receive heavy rainfall during the summer monsoon, most of the water cannot be harvested for later use due to inadequate storage facilities. In this paper, we present data about how check dams constructed across India's rivers can mitigate future conflicts involving irrigation water shortages in rural areas.*

## INTRODUCTION

Water is one of the most important commodities of the twenty-first century.<sup>1</sup> There is a conflict between the burgeoning human population and the planet's unchanging supply of freshwater, and this conflict worsens every year.<sup>2</sup> This creates a challenge in meeting the water and food needs of the burgeoning human population while leaving enough for nature's needs.<sup>3</sup>

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1. See generally HAR DARSHAN KUMAR, WATER WOES: CONSERVING AND MANAGING OUR FUTURE LIFELINE 2 (2006) (discussing global water scarcity).

2. *Id.* at 228–63 (explaining the looming water crisis in the world).

3. *Id.* at 275–85 (discussing water-harvesting structures, and the fact that if water-harvesting structures are implemented efficiently, problems related to flooding and water shortages can be tackled in the future).

In India, rivers are considered to be sacred. For example, the *Puranas* (Hindu holy texts) portray that a person can gain salvation by bathing in the Ganges and the same goal can be achieved merely by catching sight of the Narmada.<sup>4</sup> This river was considered holy even in British India—the crime of attempted suicide was overlooked if the offense was committed in the Narmada.<sup>5</sup>

Although India's rivers are sacred, the survival of many of these sacred rivers is at stake now due to aggressive developmental activities that lead to pollution and degradation.<sup>6</sup> For example, big dams built upriver on the Cauvery in the southwestern Indian state of Karnataka caused an insufficient flow of water to the neighboring state of Tamil Nadu, resulting in droughts of calamitous proportions in 2003.<sup>7</sup>

India could avert such conflicts by increasing irrigation water availability. India is currently facing serious irrigation water problems due to dwindling groundwater reserves,<sup>8</sup> making dams essential. However, a comprehensive and integrated approach to water-resources management can protect the integrity and function of river basin ecosystems and aquifers. This is essential because rivers and the freshwater that they harbor play an immense role in human life. There are two types of dams that may be used in India, large dams and check dams. Large dams include arch dams, buttress dams, embankment dams, and gravity dams, and have the potential to prevent flooding, irrigate farms, and generate electricity.<sup>9</sup> In contrast, check dams are small barriers using stones, cement, and concrete built across the direction of water flow on a shallow river or stream to harvest rain water. They retain excess flow during rains in small catchment areas behind the dam, and the stored water is mainly used for irrigation.<sup>10</sup> Check dams are usually supported by electrically-powered pumps that lift water from the low-lying check dam up to nearby farmlands.<sup>11</sup> This is called

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4. JACQUES LESLIE, *DEEP WATER: THE EPIC STRUGGLE OVER DAMS, DISPLACED PEOPLE, AND THE ENVIRONMENT* 42 (2005).

5. *Id.* at 43.

6. Nita Bhalla, *India's Rivers Dying Due to Sewage Say Activists*, REUTERS, June 14, 2007, available at <http://www.reuters.com/article/latestCrisis/idUSDEL92270>.

7. T.S. Subramanian, *Drought in the Delta*, THE HINDU, Feb. 14, 2003, available at <http://www.thehindu.com/fline/fl2003/stories/20030214001904400.htm>.

8. Daniel Pepper, *India's Water Shortage*, CNN MONEY, Jan. 29, 2008, available at, [http://money.cnn.com/2008/01/24/news/international/India\\_water\\_shortage.fortune/index.htm](http://money.cnn.com/2008/01/24/news/international/India_water_shortage.fortune/index.htm).

9. WGBH Educational Foundation, *Building Big: Dam Basics*, <http://www.pbs.org/wgbh/buildingbig/dam/basics.html> (last visited Nov. 1, 2008).

10. Developing Alternatives, *Check Dams and Irrigation*, <http://www.dainet.org/livelihoods/checkdams2.htm> (last visited Nov. 1, 2008).

11. N.M. Sadguru Water and Development Foundation Lift Irrigation, <http://www.nmsadguru.org/ComuunityWaterResourceDevelopment.html> (last visited Nov. 1, 2008).

"lift irrigation"; it makes irrigating easier. Both check dams and lift-irrigation systems are managed by the local farming community.<sup>12</sup>

While big dams may be essential for India, harvesting rain water using thousands of smaller check dams is also necessary to combat irrigation water shortages in the future. Water harvesting using smaller dams has the potential to transform infertile drylands to productive agricultural lands, revive rivers during the dry season, recharge groundwater, sustain ecology, and ultimately alleviate poverty among rural communities in India. Even silt is not a problem since opening the gates washes away any accumulated sediment.<sup>13</sup> Check dams constructed near forest areas provide water during the dry season to large numbers of wildlife.<sup>14</sup> Usually only the last flow of water from the monsoon is harvested.

Check dams are built using ancient techniques. India's first check dam, the Grand Anicut ("*Kallanai*" in the Tamil language), was built by an ancient Chola king named Karikalan in the Cauvery River delta in Tamil Nadu during the second century A.D.; it is the world's oldest water-diversion structure still in use.<sup>15</sup> This design was later adopted by the legendary British irrigation engineer Arthur Cotton, who built various irrigation structures across India in the nineteenth century.<sup>16</sup>

Check dams are eco-friendly because they do not submerge nearby farms and property, and they also help to recharge groundwater in aquifers and nearby wells.<sup>17</sup> Check dams built in southern India are known to reduce high levels of fluoride (to less than 1.5 parts per million) in groundwater, reducing human health hazards.<sup>18</sup> In this paper, we have highlighted how the ancient technique of eco-friendly rain water harvesting benefits people by expanding irrigation and agricultural activities in the water-scarce regions of western India.

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12. SANJIV J. PHANSALKAR & SHILP VERMA, MAINSTREAMING THE MARGINS. WATER-CENTRIC LIVELIHOOD STRATEGIES FOR REVITALIZING TRIBAL AGRICULTURE IN CENTRAL INDIA 77-121 (2005) (see generally for lift-irrigation schemes in tribal areas of India).

13. Govindasamy Agoramoorthy, *Quest for Water in Tribal Drylands to Quell Poverty*, SADGURU FOUNDATION ANNUAL REPORT, 7-9 (2007) (on file with the *Natural Resources Journal*) (see generally for role of check dams in forest areas of India).

14. *Id.*

15. Govindasamy Agoramoorthy, *India's Second Green Revolution Needs to Transform the Drylands*, 92 CURRENT SCI. 157, 157 (2007), available at <http://www.ias.ac.in/currsci/jan252007/157.pdf> (see generally for details on Grand Anicut of India).

16. *Id.*

17. *Id.*

18. S.V. Bhagavan & V. Raghu, *Utility of check dams in dilution of fluoride concentration in ground water and the resultant analysis of blood serum and urine of villagers, Anantapur District, Andhra Pradesh, India*, 27 ENVTL. GEOCHEMISTRY & HEALTH 97-108 (2005) (see generally for the use of check dams in reducing fluoride poisoning in groundwater wells).

## I. BACKGROUND OF DRYLANDS IN WESTERN INDIA

We conducted a study of three districts—Dahod (in the north-western Indian state of Gujarat), Jhalawar, and Banswara (both of which are in the state of Rajasthan, to the northeast of Gujarat)—each with check dams constructed between 2001 and 2006 by a Gujarat, India-based nonprofit agency, the Sadguru Foundation (“Sadguru”).<sup>19</sup> Dahod District covers an area of 3,642 km<sup>2</sup> with a population of 1,636,433.<sup>20</sup> Jhalawar District has an area of 6,928 km<sup>2</sup> and supports a population of 1,180,323 with the vast majority (86 percent) living in rural areas.<sup>21</sup> Jhalawar is among the poorest districts in Rajasthan and the World Bank has initiated a poverty eradication project there.<sup>22</sup> The district has 1,468 villages and the region receives an average annual rainfall of 960 millimeters.<sup>23</sup> The Banswara District has an area of 5,037 km<sup>2</sup> (1.47 percent of Rajasthan) and it supports a population of 1,501,589 with a literacy rate of 45 percent.<sup>24</sup> The district is also among the least developed in Rajasthan. It is situated in the Mahi River basin; it receives an annual rainfall of 920 mm.<sup>25</sup>

A team of civil engineers, including one of this article’s co-authors (Sunita Chaudhary), reviewed topographic maps and satellite images of rivers to assess the water-harvesting potential in these selected field sites before finalizing the construction sites for check dams in the drylands of

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19. See generally Govindasamy Agoramoorthy, *Reducing Water Conflict in Cauvery River Delta*, 92 CURRENT SCI. 1198, 1198–99 (2007) available at <http://www.ias.ac.in/currsci/may102007/1198a.pdf> (discussing Sadguru Foundation’s construction of check dams in western India).

20. INDIA OFFICE OF THE REGISTRAR GEN. & CENSUS COMM’R, CENSUS OF INDIA 2001, BASIC DATA SHEET, DISTRICT DOHAD 1 (2001), available at [http://www.censusindia.gov.in/Dist\\_File/datasheet-2418.pdf](http://www.censusindia.gov.in/Dist_File/datasheet-2418.pdf) (showing population information for Dahod District; Indainetzone, Dahod District, Gujarat, [http://www.indianetzone.com/7/dahod\\_district\\_gujarat.htm](http://www.indianetzone.com/7/dahod_district_gujarat.htm) (last visited Nov. 1, 2008) (showing geographical information for Dahod District)).

21. INDIA OFFICE OF THE REGISTRAR GEN. & CENSUS COMM’R, CENSUS OF INDIA 2001, BASIC DATA SHEET, DISTRICT JHALAWAR 1 (2001) <http://www.jhalawar.nic.in/jhalawar.htm> (last visited Nov. 1, 2008) (showing geographical information for Jhalawar District).

22. Indian Farm Forestry Dev. Cooperative Ltd., *District Poverty Initiative Project*, <http://www.iffdc.org/project-dpip.htm> (last visited Nov. 1, 2008).

23. Jhalawar, <http://www.jhalawarzp.org/Introduction.asp> (last visited Nov. 1, 2008).

24. INDIA OFFICE OF THE REGISTRAR GEN. & CENSUS COMM’R, CENSUS OF INDIA 2001, BASIC DATA SHEET, DISTRICT BANSWARA 1 (2001), <http://www.rajasthan.gov.in/rajgovt/Districtprofile/banswara.html> (last visited Nov. 1, 2008) (showing geographical information for Banswara District).

25. Banswara District Map, <http://www.mapsofindia.com/maps/rajasthan/districts/banswara.htm> (last visited Nov. 1, 2008).

western India.<sup>26</sup> The engineers then prepared field activity charts on the patterns of forest types and river drainage networks.<sup>27</sup> During this study, we collected data on the demand for check dams, as well as other factors including, environmental protection and sustainability, social justification in terms of community benefit for sustainable development, migration patterns, education, family structure, and employment opportunities. We calculated the capacity for water storage in check dams by using the formula  $L \times B \times H / 2$  (where  $L$ =length of dam,  $B$ =length of backwater, and  $H$ =height of dam,) following water-resources technical procedures.<sup>28</sup> We visited the check dams located in western India between July 2006 and June 2007, and recorded information on the dams and their benefits to nearby residents and the environment.<sup>29</sup> We compiled data related to rivers, dam measurements, storage of water in the dams, and groundwater recharge. We also reviewed the increase of groundwater levels in village wells after the construction of check dams.<sup>30</sup> A total of 306 check dams and over 600 water-resource development projects were implemented by the Sadguru Foundation between 1974 and 2006; data on 100 of those check dams constructed between 2001 and 2006 were included in our analysis (Table 1).<sup>31</sup> We looked at local employment for dam construction, and the impact of check dams on local ecology and society.<sup>32</sup> We also reviewed the National Crime Records Bureau (Government of India) data on suicides committed by local farmers between 1997 and 2005.<sup>33</sup>

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26. See generally HARNATH JAGAWAT, *TRANSFORMING THE DRY LANDS: THE SADGURU STORY OF WESTERN INDIA* 39–59 (2005) (detailing check-dam constructions and implementations by Sadguru Foundation).

27. See generally RAJ VIR SINGH, *WATERSHED PLANNING AND MANAGEMENT* 30–54 (2003) (explaining the methodology on delineation of watersheds and geometric/spatial characteristics of watersheds).

28. See generally H.L. BOGGSET AL., *U.S. DEP'T OF THE INTERIOR, BUREAU OF RECLAMATION, DESIGN OF SMALL DAMS: A WATER RESOURCES TECHNICAL PUBLICATION* 315–434 (3rd ed. 1987) (explaining a methodology to calculate water storage and water spillways in dams).

29. Agoramoorthy, *supra* note 15 (discussing the impact of check dams constructed in western India by the Sadguru Foundation to improve irrigation and agriculture).

30. U.S. ENVTL. PROT. AGENCY, U.S. GEOLOGICAL SURVEY, *GROUND WATER SAMPLING GUIDELINES FOR SUPERFUND AND RCRA PROJECT MANAGERS*, available at <http://www.epa.gov/region09/qa/pdfs/finalgroundwatersamplingguidelines.pdf>

31. SAS INSTITUTE INC., *SAS/ETS SOFTWARE: CHANGES AND ENHANCEMENTS*, RELEASE 8.2 53–97 (2001), available at [http://support.sas.com/rnd/app/da/new/802ce/ets/ets\\_ce.pdf](http://support.sas.com/rnd/app/da/new/802ce/ets/ets_ce.pdf). All statistical analyses were conducted using Statistical Analysis System (SAS) software. All mean values are presented as  $\pm 1$  standard deviation. A linear regression analysis was used to estimate the cost in US\$ according to the length of check dams. *Id.*

32. JAGAWAT, *supra* note 26, at 31.

33. NATIONAL CRIME RECORDS BUREAU, MINISTRY OF HOME AFFAIRS, GOVERNMENT OF INDIA *ACCIDENTAL DEATH AND SUICIDE IN INDIA*, <http://mynation.wordpress.com/2008/02/11/ncrb2006> (last visited Nov. 1, 2008).

Table 1: Eco-friendly check dams (built from 2001 through 2006 by Sadguru Foundation) enhance local ecology and the livelihoods of people in India's semi-arid regions.

Name of State	Name of District	Name of River	No. of check dams	Mean length (meters) of check dam	Mean height (meters) of check dam	Area benefited by irrigation after check dam (acre)	No. of beneficiaries/ household	No. of local workers hired for dam work	No. of local workers hired for dam work (female)	Cost of dam in US\$ (1000)
Gujarat	Dahod	Bhe	3	53.7	3.05	589	188	6611.5	6361.5	124.3
Gujarat	Dahod	Kali-II	1	57.9	3.10	154	19	2900	2108	33.9
Gujarat	Dahod	Khajuria	1	58.7	2.90	118	50	0	0	44.875
Gujarat	Dahod	Khan	1	66.0	3.40	200	56	4055	2589	44.175
Gujarat	Dahod	Nalshwar Nadi	1	46.3	2.00	161	51	0	0	0
Gujarat	Dahod	Panam	1	102.3	3.05	300	125	0	0	0
Gujarat	Dahod	Redhani Nadi	1	55.8	4.00	120	36	0	0	0
Gujarat	Dahod	Rivulet	13	32.6	1.87	434.2	257	8468	9809	174.875
Gujarat	Dahod	Sukhi	2	69.0	2.75	309	55	5944	5648	74.575
Gujarat	Dahod	Ujpl	1	79.0	2.00	170	62	0	0	64.45
Gujarat	Dahod	Walai	1	34.4	2.95	94	19	1222	1076.5	21.05
Gujarat	Dahod	Walwa	1	46.7	3.60	70	40	0	0	33.625
Gujarat	Dahod	Wankdi	2	59.8	3.00	282	69	7747	3590.5	65.25
Gujarat	Dahod	Welwa	1	60.0	3.10	158	41	2645.8	2164.3	35.175
Gujarat	Panch Mahal	Rivulet	2	31.3	3.28	170	45	5213	3212	51.7
M.P.	Dhar	Rivulet	1	51.4	2.25	20	10	1961.5	1219	23.7
M.P.	Jhabua	Rivulet	2	48.3	2.26	35	24	3048	3025.5	44.3
M.P.	Ratlam	Jammar River	1	92.5	2.98	100	50	3362.5	3608.5	53.875
M.P.	Ratlam	Rivulet	2	56.7	2.83	90	34	3247.5	4306	67.675
Rajasthan	Banswara	Bunand	1	100.2	2.15	200	118	1448	1594	0
Rajasthan	Banswara	Haren River	1	107.0	5.50	503	73	4104	3976.3	116.05

(Table 1 continues)

Table 1 (continued)

Name of State	Name of District	Name of River	No. of check dams	Mean length (meters) of check dam	Mean height (meters) of check dam	Area benefited by irrigation after check dam (acre)	No. of beneficiaries/ household	No. of local workers hired for dam work (male)	No. of local workers hired for dam work (female)	Cost of dam in US\$ (1000)
Rajasthan	Banswara	Hiren	1	137.9	1.00	200	100	3376	3063.5	56.175
Rajasthan	Banswara	Jiradhara	1	44.6	2.50	100	45	1417	728	21.55
Rajasthan	Banswara	Negdi	1	38.8	3.20	32	20	1693.5	1928.5	31.925
Rajasthan	Banswara	Pundiya	4	93.3	2.74	260	100	6946.8	10179	167.375
Rajasthan	Banswara	Ranek	1	37.4	1.56	20	8	1427	950	20.325
Rajasthan	Banswara	Rivulet	20	43.5	2.60	869	319	26977	21892	483.8
Rajasthan	Banswara	Telni	4	69.3	2.70	238	97	7651.8	7022	187.325
Rajasthan	Banswara	Wakdi	3	68.7	3.33	277	79	6869.5	4739	123.15
Rajasthan	Chittorgarh	Rivulet	1	51.7	2.50	46	19	1174.5	1768.5	25.55
Rajasthan	Chittorgarh	Warda	1	82.4	3.37	105	50	1494.5	1686.6	0
Rajasthan	Dahod	Rivulet	1	52.5	4.50	70	25	2192.5	2228.5	540.175
Rajasthan	Dahod	Wakdi River	1	53.6	2.07	75	30	2139	2065.5	34.225
Rajasthan	Dungarpur	Mahi	1	367.0	7.25	7000	3000	0	0	1180
Rajasthan	Jhalawar	Ahu	8	164.3	3.14	2970	763	13100	11871	639.625
Rajasthan	Jhalawar	Chambel	1	233.0	3.11	800	80	6553.5	10951	186
Rajasthan	Jhalawar	Chhoti Kalisind	3	225.7	2.81	2400	620	4394.5	4667	667.175
Rajasthan	Jhalawar	Kanthari Nadi	1	125.8	3.33	100	48	0	0	0
Rajasthan	Jhalawar	Kilol	1	73.9	2.69	75	21	0	0	0
Rajasthan	Jhalawar	Kshipra	4	166.6	4.59	4025	266	27364	41143	787.5
Rajasthan	Jhalawar	Rivulet	2	51.9	3.54	200	23	1924	2741	66.475
TOTAL			100			24139	7135	178673	183911	6291.9



## II. DAMS AND THE CAUVERY RIVER CONFLICT

By building dams, reservoirs, and diversion canals, humans have drastically changed the very nature of rivers, including the quantity and timing of flows. Prior to 1900, only 40 reservoirs had a storage volume of more than 25 billion gallons. Today, about 3,000 reservoirs exist that collectively contain over 1,500 cubic miles of water—large enough to flood 120-million acres of land.<sup>34</sup> Governments around the world have spent US\$2 trillion on large dams—the “equivalent of the entire 2003 U.S. government budget.”<sup>35</sup>

According to the watershed industry standard, any dam structure higher than 15 meters is considered a “large dam”; when it exceeds 150 meters, it is considered a “major dam” or “mega-dam.”<sup>36</sup> Check dams are usually less than 15-meters high and the largest check dam built by a nonprofit agency in India with government support currently stands in Rajasthan at 7.25 meters in height (Figure 1).<sup>37</sup>

The battle over mega-dams is at the center of conflicts throughout the world involving water scarcity, environmental degradation, biodiversity loss, globalization, social justice, survival of indigenous peoples, and the growing gap between the rich and poor. Global water use has tripled since the 1950s, and for decades policymakers and politicians have met this rising demand by building larger dams. India is the most prolific dam builder in the world today with 4,300 large dams; it ranks third behind China and the United States for completed large dams.<sup>38</sup>

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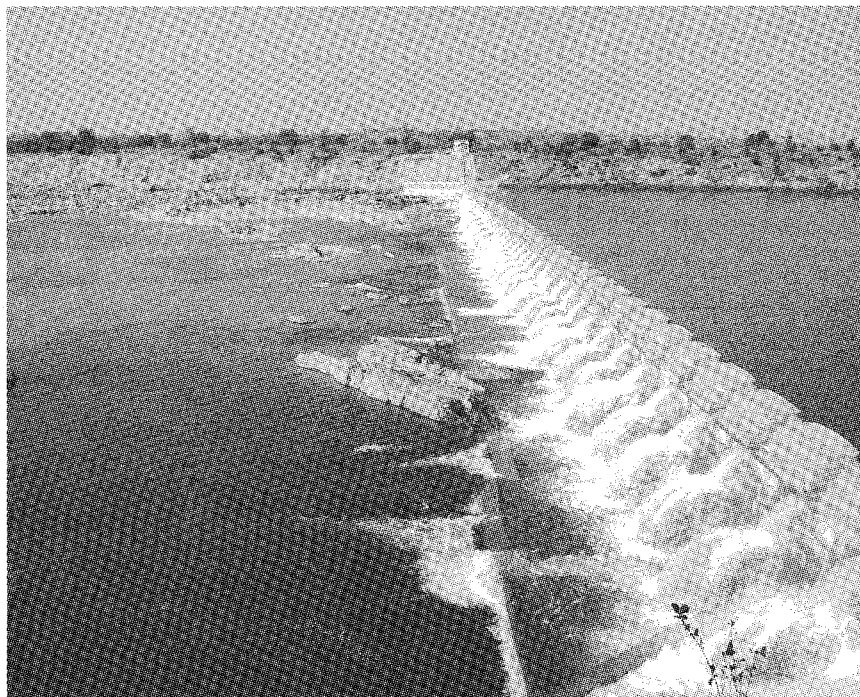
34. KUMAR, *supra* note 1, at 1–34 (discussing the water-storing capabilities of large dams).

35. LESLIE, *supra* note 4, at 4–5 (providing an example of how man claims his conquest of nature by discussing the technological advancement of Hoover Dam in the United States).

36. IUCN.org, eAtlas Technical Notes, [http://www.iucn.org/about/work/programmes/water/wp\\_resources/wp\\_resources\\_eatlas/wp\\_resources\\_eatlas\\_technical.cfm](http://www.iucn.org/about/work/programmes/water/wp_resources/wp_resources_eatlas/wp_resources_eatlas_technical.cfm) (last visited Nov. 1, 2008).

37. Agoramoorthy, *supra* note 13, at 7 (containing a photograph of the largest check dam in India, built by the Sadguru Foundation).

38. India International Rivers, <http://internationalrivers.org/en/south-asia/india> (last visited Nov. 1, 2008).



**Figure 1.** India's largest check dam was built by the Sadguru Foundation on the Mahi River at Baneswardham in Rajasthan. It stores a maximum of 350 million cubic feet of water, allowing farmers to continue irrigation during the dry season. (Photo: G. Agoramoorthy)

India's large dams have destroyed natural ecosystems and displaced millions of people.<sup>39</sup> Its Sardar Sarovar dam in the Narmada valley became the world's most contentious because of its significant displacement of people. In December 2006, the height of the Sardar Sarovar was raised to 122 meters to allow it to hold more water.<sup>40</sup> As a result,

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39. See generally ENAKSHI GANGULY THUKRAL, *BIG DAMS: DISPLACED PEOPLE* 7-27 (1992) (discussing the battle over dams involving environmental destruction, social injustice and relocation of many indigenous peoples, including case studies of the Hirakud Dam in Orissa, the Nagarjunasagar Dam in Andhra Pradesh, the Sardar Sarovar Dam in Gujarat, and the Pong Dam in Himachal Pradesh).

40. Press Release, International Rivers, Protesters Assemble to Oppose Sardar Sarovar Dam (Jan. 1, 2007), <http://internationalrivers.org/en/south-asia/india/narmada-river/protesters-assemble-oppose-sardar-sarovar-dam> (last visited Nov. 1, 2008).

320,000 people were displaced.<sup>41</sup> Most of the affected were poor, indigenous communities.<sup>42</sup> The Narmada Bachao Andolan, a prominent anti-dam non-governmental organization (NGO), has been a strong advocate for the affected; it has initiated more than 7,000 legal cases against the government to protect for the rights of those displaced when Sardar Sarovar's capacity was increased.<sup>43</sup>

India's most recent water conflict over large dams involves the holy river Cauvery, traditionally known as "Daksina Ganga" (Sanskrit meaning "Ganges of the South").<sup>44</sup> The Cauvery is Tamil Nadu's lifeline; it irrigates vast areas in the delta region and four million farmers are entirely dependent on it.<sup>45</sup> Sharing of Cauvery water has been an issue of contention between the states of Karnataka, Tamil Nadu, Kerala, and Pondicherry.<sup>46</sup> The Cauvery Water Disputes Tribunal was specifically set up in June 1990 to deal with this issue (Figure 2).<sup>47</sup> The tribunal gave its verdict on the sharing of river water among the four riparian states in February 2007. It granted Tamil Nadu the right to receive 419 billion cubic feet as compared to the state's demand of 562 billion cubic feet, and granted Karnataka 270 billion cubic feet as compared to its demand of 465 billion cubic feet. The tribunal's ruling instantly satisfied Tamil Nadu but agitated Karnataka since both have long been in competition over the rivers dwindling water supply.<sup>48</sup> Despite the tribunal's recommendation to create a Cauvery Management Board to implement its final award, political leaders in Karnataka are still reluctant to adhere to the judicial verdict.<sup>49</sup>

There is no need for the downstream farmers of the Cauvery delta in Tamil Nadu to fight over water with Karnataka. Instead, the immediate construction of a series of check dams in Cauvery, and its tributaries throughout the delta, to harvest the monsoon flow would solve any problems. The check dams would retain excess water flow during monsoon rains in a small catchment area behind the structure. The water entrapped

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41. *Id.*

42. *Id.*

43. *Id.*

44. See generally Agoramoorthy, *supra* note 19 (discussing the Cauvery River).

45. *Id.*

46. *Id.*

47. T.S. Subramanian, *Muted Elation*, FRONTLINE, Feb. 10, 2007, at 10 (discussing the long history of water conflicts involving the Cauvery River in southern India and the volatile political and sociological consequences of the river-water conflict).

48. *Cauvery Delta Farmers Welcome Verdict*, THE HINDU GROUP, Feb. 5, 2008, <http://www.blonnet.com/2007/02/06/stories/2007020601551200.htm> (last visited Nov. 1 2008).

49. B.S. Ramesh, *Karnataka Formulating Response to Cauvery Tribunal Notice*, THE HINDU, <http://www.hinduonnet.com/2004/04/24/stories/2004042403311500.htm> (last visited Nov. 1, 2008) (providing a map of the Cauvery River in southern India and discussing the Cauvery Water Disputes Tribunal award on water distribution to southern Indian states).

by the dam (surface/subsurface) is primarily intended for irrigation usage during the monsoon and later during the dry season, but can also be used for livestock and other domestic needs.

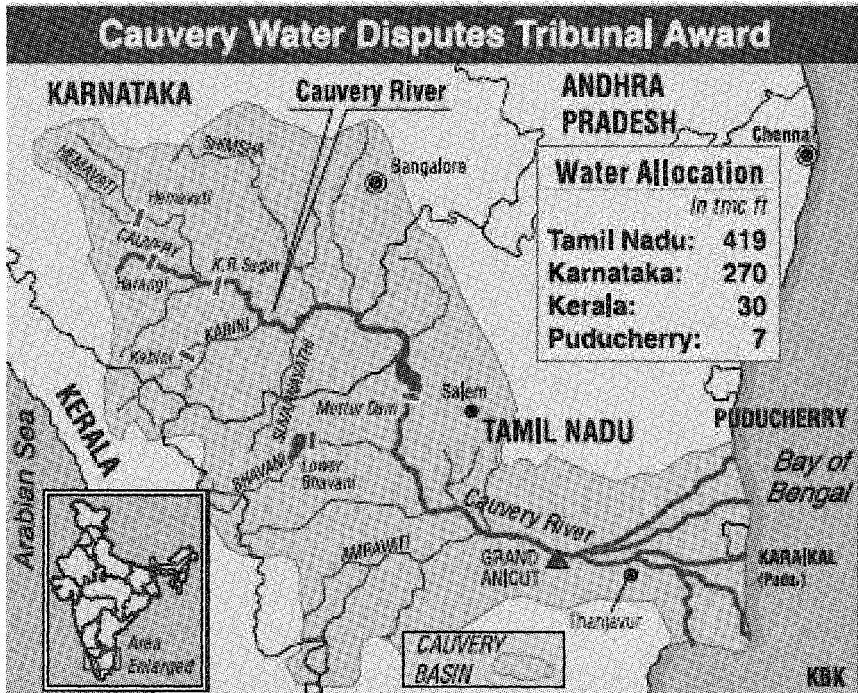


Figure 2. Cauvery River Water allocation. (Courtesy: Frontline Magazine)

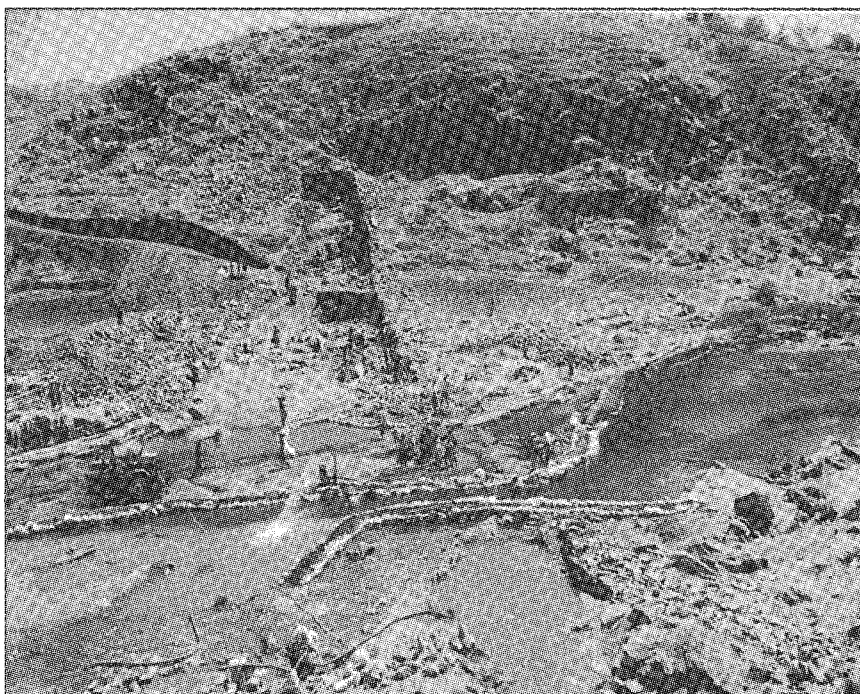
### III. CHECK DAMS REVIVE RIVERS AND RECHARGE GROUNDWATER

The Sadguru Foundation has transformed the drylands across western India with its 306 check dams.<sup>50</sup> Sadguru was established in 1974; it is India's premier NGO and is known globally for its expertise in natural resources management.<sup>51</sup> Sadguru promotes sustainable and equitable rural development through community-based, eco-friendly, natural resources

50. See generally JAGAWAT, *supra* note 26, at 39–58 (discussing check dams implemented by Sadguru Foundation between 1974 and 2004). Sadguru is based in Gujarat state. The word “Sadguru” means “true teacher” in Sanskrit.

51. *Id.*

development projects in western India.<sup>52</sup> Sadguru's check dam and lift-irrigation programs have converted 259,696 acres of drylands in western India to productive agricultural land, ultimately benefiting 196,181 families and 1,155,418 people in rural villages.<sup>53</sup> These people lived in absolute poverty prior to the intervention, but now enjoy an economically enhanced life mainly due to the fact that check dams and lift-irrigation schemes provided opportunities for farmers to grow more than one crop per year, increasing their agricultural productivity, self-sufficiency in food, and income.<sup>54</sup>



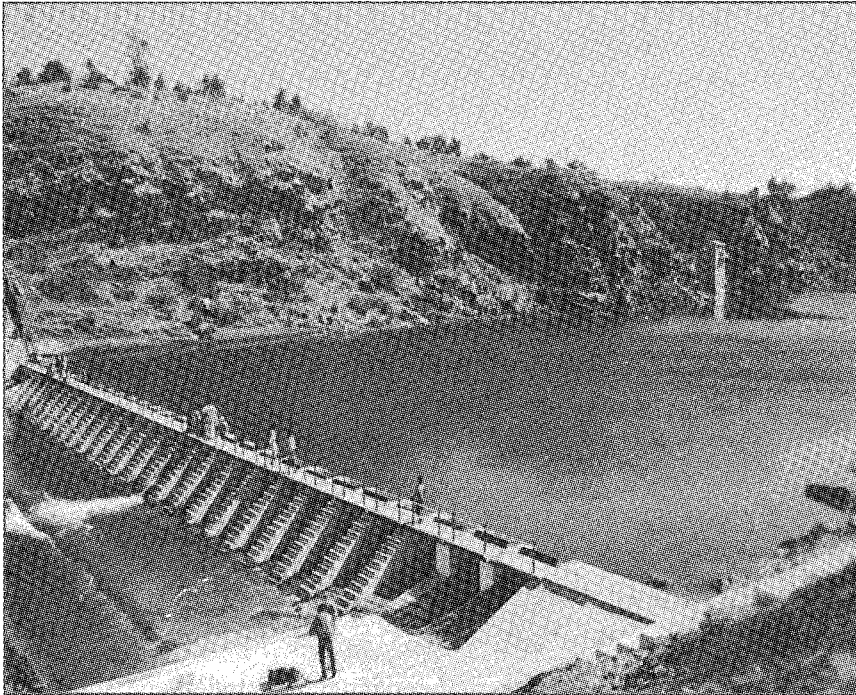
**Figure 3.** In January 2002, before the check dam was built in the village of Antersuba (Dahod District, Gujarat), the river bed was dry. (Photo courtesy: Sadguru Foundation)

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52. *Id.*

53. *Id.* at 59–75. (discussing land-based income generating activities in rural villages of India where people generate income mainly from various sustainable agriculture activities).

54. *Id.*



**Figure 4.** After construction, in May 2002, the check dam was full of water and farmers were able to irrigate their land. (Photo courtesy: Sadguru Foundation)

The average height of the check dams constructed by Sadguru was  $2.85 \pm 0.96$  meters (m) (range: 0.75–7.25 m;  $n=99$ ; see Table 1) and the average length of the check dams was  $79.07 \pm 62.24$  m (range: 12–367 m;  $n=99$ ; see Table 1). The average check-dam capacity was  $11.55 \pm 39.33$  million cubic feet (range: 0.1–350 million cu. ft.;  $n=100$ ). The average cost for building the check dams was estimated at  $\text{US}\$72,320.69 \pm 143,897.70$  (range:  $\text{US}\$125,000$ – $1,180,000$ ;  $n=87$ ; see Table 1). The average number of household beneficiaries included  $71.35 \pm 300.15$  (range: 2,000–3,000 households;  $n=100$ ; see Table 1), with each household supporting an average of six family members. These families used to grow one rain-fed crop each year and frequent droughts often forced them out of their villages to search for jobs in nearby towns.<sup>55</sup> Ever since check dams were constructed, local people stopped migrating to nearby towns and cities for work. They were able to

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55. JAGAWAT, *supra* note 26, at 59–75.

stay on their farmlands due to the availability of water to grow more food/cash crops (agriculture, horticulture, floriculture, and social forestry) after the establishment of check dams. In the absence of check dams, there was no way for farmers to get water for irrigation, therefore they previously relied on rain-fed agriculture depending on the often erratic rainfall in the drylands of western India.<sup>56</sup>

Not only does the existence of check dams help people, but actually building the check dams helps the local economy. During the time of the Sadguru check-dam construction, local villagers were employed and employment averaged  $2152.68 \pm 1577.79$  for males and  $2215.79 \pm 2350.87$  for females. The area that benefited from irrigation after the construction of check dams was  $241.39 \pm 735.71$  acre (range: 3,000–7,000 acres;  $n=100$ ; see Table 1).

The length of the Sadguru check dams significantly affected the cost of construction ( $F_{1,85}=114.13$ ,  $p<0.01$ ,  $R^2=0.57$  with an estimated cost of regression =  $-\text{US}\$59,949.00 + 1788.97 \times \text{length of check dam}$ ). The longer check dams were costlier to construct due to materials, machineries, and manpower usage. The major funding for the construction of check dams came mainly from the government, with matching funds from business corporations and the local NGO (Sadguru Foundation) as a catalyst in the process to implement the check dams in rural areas to relieve poverty. To assist rural communities in India, NGOs could initiate sustainable rural development projects with the partnership of government and business corporations following the model of the Sadguru Foundation.<sup>57</sup> In 2007, the Chief Minister of Rajasthan inaugurated a large check dam (length: 367 meters; height: 7.25 meters) built with a cost of 4.72 crore India rupees (US\$1.18 million) and praised Sadguru Foundation for its contribution to India's rural development, poverty alleviation, and natural resources management (see Figure 1).<sup>58</sup> It is India's largest check dam constructed by a nonprofit agency with government support, and it is located on the Mahi River where the government had built the bigger Mahi-Bajaj Sagar dam upstream.<sup>59</sup> Building similar check dams near big dams to reduce future water conflicts could be done on other rivers, including the Cauvery.<sup>60</sup>

All check dams have demonstrated an ability to store water during each year's dry season; Figures 3 and 4 depict the potential for small dams to store water in the drylands of western India. The stored water in check dams was directly used by farmers to irrigate crops during the annual dry

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56. *Id.*

57. *Id.*

58. Agoramoorthy, *supra* note 13, at 7 (containing a photograph of the largest check dam built in India by the Sadguru Foundation).

59. *Id.*

60. *Id.* at 9.

season. Further, water seepage beneath the dams recharged groundwater levels in nearby village wells.<sup>61</sup> For example, in 2002, in a small village in Gujarat called Rozam, eight small check dams increased the local groundwater level in 50 open wells from 0.60 meters to 9.0 meters.<sup>62</sup> The "average water table went up by 2.57 meters in 2002 and 2.10 meters in 2003" in the open wells, and the well-water yield also increased, from 0.64 liters per second (lps) to 1.50 lps.<sup>63</sup> Overall, the groundwater recharge "increased the surface water availability by 8.24 mc ft [million cubic feet] from July to December each year and 16.00 mc ft of groundwater recharge, which is available round the year since 2002."<sup>64</sup> Before the establishment of check dams, the total area where different crops were cultivated encompassed only 76 acres, but afterwards, the area under cultivation doubled, increasing the water table and water recharging potentials in village wells.<sup>65</sup> Moreover, the total area under cultivation—with crops such as wheat, maize, gram, and pulses—during the post-monsoon season (October to February) increased by 88.4 percent in 2003 and 129.24 percent in 2004 leading to self-sufficiency in food production in Rozam.<sup>66</sup>

The construction of check dams is demand-driven and undertaken only after a local community justifies the need for them to boost agriculture, revive rivers, and to protect local ecology.<sup>67</sup> Villagers who would benefit from check dams are involved from the beginning via irrigation cooperatives; ultimately management is transferred to the villagers, and they are responsible for 100 percent of any charges for requested services. This participatory demand-driven approach ensures that people obtain the level of services they desire; it also ensures that they can afford to pay for the services. Furthermore, full-cost recovery of operation, maintenance, and replacement costs ensures the financial viability and future sustainability of water-harvesting structures. India's government-built big dams are properly planned and maintained. In contrast, across India, thousands of smaller check dams and lift-irrigation systems constructed by government

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61. RAKESH PANDEY ET AL., INFLUENCE OF SURFACE WATER HARVESTING ON GROUND WATER REGIME—A CASE STUDY OF VILLAGE ROZAM, 30TH WEDC INTERNATIONAL CONFERENCE, VIENTIANE, LAOPDR (2004), available at <http://wedc.lboro.ac.uk/conferences/pdfs/30/Pandey.pdf>.

62. *Id.*

63. *Id.* at 445.

64. *Id.* at 445.

65. *Id.* at 444–45.

66. PANDEY ET AL., *supra* note 61, at 444.

67. Harnath Jagawat, *Revival of Rivers* (6th ed. 2007), [www.nmsadguru.org/Article\\_RivivalOfRivers.htm](http://www.nmsadguru.org/Article_RivivalOfRivers.htm) (last visited Nov. 1, 2008).



agencies (through private contractors) have failed in recent years, due to lack of monitoring, community involvement, and flawed construction.<sup>68</sup>

#### IV. CHECK DAMS AND SUSTAINABLE DEVELOPMENT

India has experienced rapid economic development in recent decades, often leading to environmental disasters. Groundwater, which is crucial for rural agriculture, has been severely depleted. The cultivable land remains static at 120 million hectares and relies mainly on monsoon water. India requires 210 million tons of grain to feed its people, but produced only 200 million tons in 2007.<sup>69</sup>

When the Green Revolution—armed with high-yield seeds, canal irrigation, and chemical fertilizers—swept Asia during the mid-1960s, it was hailed as the solution to world hunger.<sup>70</sup> “Green Revolution” is a term generally applied to successful agricultural experiments conducted between the 1940s and 1960s in many developing countries to increase grain production.<sup>71</sup> It was first introduced in 1968 by the former U.S. Agency for International Development (USAID) director, William Gaud, who said, “the developments in the field of agriculture contain the makings of a new revolution. It is not a violent ‘Red Revolution’ like that of the Soviets, nor is it a ‘White Revolution’ like that of the Shah of Iran. I call it the ‘Green Revolution.’”<sup>72</sup> However, India’s Green Revolution has gone brown during the last few decades due to the creation of agrarian class differentiation, environmental disasters, stagnating yields, water deficiency, and declining soil quality.<sup>73</sup>

According to the National Commission for Enterprises in the Unorganized Sector (an advisory body set up by the government of India to improve productivity of enterprises to create employment opportunities

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68. KANHAIYA CHOUDHRY ET AL., A STUDY OF GOVERNMENT-INSTALLED LIFT IRRIGATION SCHEMES IN DISTRICT JHABUA, MADHYA PRADESH, (Jan. 24, 2003) available at [http://www.iwmi.cgiar.org/iwmi-tata\\_html/PM2003/PPT/CInI/Jhabua.ppt](http://www.iwmi.cgiar.org/iwmi-tata_html/PM2003/PPT/CInI/Jhabua.ppt).

69. See generally Raj Chengappa & Ramsesh Vinayak, *Grain Drain*, INDIA TODAY, Jun. 11, 2007, at 3, available at <http://indiatoday.com/itoday/20070611/cover1.html&SET=T> (evaluating the current agriculture crisis in India since food was not sufficiently produced to meet the local demand forcing the government to import grains in 2007).

70. SABY GANGULY, FROM THE BENGAL FAMINE TO THE GREEN REVOLUTION, [www.indiaonestop.com/Greenrevolution.htm](http://www.indiaonestop.com/Greenrevolution.htm) (last visited Nov. 1, 2008).

71. *Id.*

72. William S. Gaud, Administrator, Agency for Int’l Dev., Dep’t of State, *The Green Revolution: Accomplishments and Apprehensions* (Mar. 8, 1968), in AGBIOWORLD, <http://www.agbioworld.org/biotech-info/topics/borlaug/borlaug-green.html> (last visited Nov. 1, 2008).

73. See generally N.D. Sharma, *Do You Believe in a Second Green Revolution?* 92 CURRENT SCI. 1032, 1032-33 (2007) (discussing Green Revolution problems that resulted in environmental degradation in India).

on a sustainable basis in rural areas) 836 million people (77 percent) live on less than half a dollar a day.<sup>74</sup> To make things worse, since 2002, one farmer has committed suicide every 30 minutes.<sup>75</sup> India's rural farmers can no longer compete with cheap cotton imported from the United States, where the farmers are provided with government subsidies.<sup>76</sup> The poor farmers' deaths can be linked to India's negligence in addressing rural poverty and the shortcomings of the globalization agenda. While cheering India's unprecedented economic growth (over 8.5 percent since 2000), the looming agriculture distress and increasing water shortages in remote villages goes unnoticed. The majority (68 percent) of India's workforces rely on farming despite the fact that the agriculture contribution to gross domestic product (GDP) has diminished from 38 percent in 1975 to 19 percent in 2007.<sup>77</sup> Under these circumstances, is there any way of achieving sustainable development in rural India?

Major factors that determine the extent of global demand on bio-capacity include: (1) population, (2) consumption of goods/services per person, (3) resource-use intensity, (4) bio-productive areas, and (5) bio-productivity per hectare.<sup>78</sup> India has no choice but to eliminate excessive demands from these five factors. One crucial means for eliminating excessive demand on bio-productive areas is the eco-friendly transformation of the vast barren drylands in western India.

The major downside of India's water-conservation strategy is the historic neglect of watershed areas in remote drylands that have been inhabited by tribal communities for centuries.<sup>79</sup> An area roughly 1,500 kilometers by 500 kilometers that stretches across central India, starting from Dungarpur in the west to Dumka in the east, provides good prospects for future sustainable agriculture development.<sup>80</sup> India's *adivasi* (meaning "original" people; they are also known as "tribal" people) communities are the poorest since they predominantly inhabit the harsh drylands and have less access to public services in health, education, and commerce.<sup>81</sup> Within

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74. *Nearly 80 Percent of India Lives on Half Dollar a Day*, REUTERS, Aug. 10, 2007, available at <http://www.reuters.com/article/latestCrisis>.

75. NATIONAL CRIME RECORDS BUREAU, *supra* note 33.

76. Gumisai Mutume, *Mounting Opposition to Northern Farm Subsidies*, 17 AFRICA RECOVERY 1 (2003), available at [www.un.org/ecosocdev/geninfo/afrec/vol17no1/17agri4.htm](http://www.un.org/ecosocdev/geninfo/afrec/vol17no1/17agri4.htm).

77. Chengappa & Vinayak, *supra* note 68.

78. WORLD WILDLIFE FUND, INTERNATIONAL, LIVING PLANET REPORT 2006, available at [http://assets.panda.org/downloads/living\\_planet\\_report.pdf](http://assets.panda.org/downloads/living_planet_report.pdf).

79. See generally Govindasamy Agoramoorthy, *Can India Meet the Increasing Food Demand by 2020?* 40 FUTURES 503 (2008), available at <http://galenet.galegroup.com/servlet/BCRC?srchtp=adv&c=1&ste=31&tbst=tsVS&tab=2&aca=nwmg&bConts=2&RNN=A180277936&docNum=A180277936&locID=albu78484> (discussing check dams constructed in western India by the Sadguru Foundation).

80. *Id.*

81. *Id.*

the rankings of the traditional Indian caste system, tribal people occupy the lowest position.<sup>82</sup> The Indian constitution of 1950 singled them out for preferential treatment, in a kind of permanent policy of affirmative action, but development plans implemented by the government have not succeeded in improving their livelihood.<sup>83</sup> Most of India's 70 million tribal people are illiterate and have a shorter life expectancy than other castes in India.<sup>84</sup> Of the millions of people displaced by India's large dams, nearly half are tribal, even though they comprise less than a tenth of the overall population.<sup>85</sup> Foremost among the many challenges facing tribal people in the drylands are the typically marginal environmental conditions for agriculture found there; low or erratic rainfall and an unreliable water supply add to the problem.<sup>86</sup> Since India is one of 25 hotspots among the highly endangered eco-regions of the world, these remote tribal dryland areas must be focused on if India is to achieve agriculture sustainability without negative ecological consequences.<sup>87</sup>

## V. CONCLUSION

Mega-dam building is a controversial venture in any country since it involves displacing people and destroying nature. Rajiv Gandhi, the Prime Minister of India from 1984 to 1989, was skeptical of mega-dams and commented over two decades ago, "We can safely say that almost no benefit has come to the people from big surface irrigation projects.... For 16 years, we have poured out money. The people have got nothing back, no irrigation, no water, no increase in production, no help in their daily life."<sup>88</sup> Unlike big dams, check dams neither displace people nor destroy nature. Therefore it is crucial for the government of India to embark on a serious mission to build numerous check dams across rivers to supplement and support large dams in partnership with NGOs and business corporations.

As part of the river valley system, smaller dams can hold sufficient water during the dry season, and building of such check dams should start at the source of the river or rivulet and proceed downstream, forming a series. This approach will result in a cascade of smaller reservoirs large

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82. *Id.*

83. *Id.*

84. Agoramoorthy, *supra* note 79.

85. Angana Chatterji & Robert Jensen, *Large Dams in India - Temples or Burial Grounds?* (2004), <http://www.countercurrents.org/en-jensen220904.htm> (last visited Nov. 1, 2008).

86. See generally Agoramoorthy, *supra* note 19 (describing the marginal conditions of India's drylands).

87. See generally Govindasamy Agoramoorthy & Minna J. Hsu, *Biodiversity Surveys are Crucial for India*, 82 CURRENT SCI. 244 (2002) (providing details on India's biodiversity hotspots).

88. *Id.*

enough to distribute water equally among villages that rarely, if ever, see water during the dry season. Check dams would also recharge groundwater, supplying local wells. Thus the role of check dams highlighted here is simple, natural, and cost-effective. If a check-dam strategy is implemented across the vast drylands of India and elsewhere in the developing world, it could not only help minimize future water conflicts, but also increase agricultural output, guarantee rural food security, enhance groundwater resources, and potentially reduce poverty.