**ARTICLES**

# Check Dam Projects and Farm Productivity: Comparison of Economic Benefits in Selected Districts of Gujarat

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ABSTRACT

Among the minor irrigation schemes, checkdams have received considerable importance for harvesting the rain water and utilising it for raising the farm productivity and farm income. The study compares the economic benefits due to checkdams in the selected districts of Gujarat. After comparing the post-development phase with the pre-development phase, the study finds positive impact of checkdams on cropping area, productivity, income, employment and wage rate. However, these returns vary among the selected districts on account of variation in topographic characteristics and status of socio-economic factors. In order to efficiently utilise the harvested rain water and maximise the gains, the study suggests for adopting the integrated approach in which the check dam projects should be supplemented with the overall development of the village. This would act as a nuclei for the development of neighbouring villages.

Keywords:  Checkdams, Agricultural productivity, Agricultural income, Employment, Economic
                  rate of return, Benefit-cost ratio.

JEL: D61, J43, Q11, Q15

I

INTRODUCTION

Among the artificial rain water harvesting mechanisms, check dams have received considerable importance in India as well as the other countries. Check dams are small barriers built across the direction of water flow such as channel, stream, nala, etc., to capture the monsoon flows which otherwise merges with the seas. The collected rain water may be stored, utilised in different ways or directly used for recharge purposes. It thus decreases the demand for water from wells and enables ground water levels to be sustained rather than be depleted. Particularly, at places, where there are few rain events, check dams have crucial importance to address the problem of water scarcity. There are numerous additional advantages of the dam structure like those affecting the flood-load deposit during *kharif*, decreasing the erosive force of water and increasing the contact time of water with land surface (Murty, 1994). Such outcomes ultimately results into recharging of underground water, thus extending and maximising the time available to make use of monsoon rain for irrigation purpose.

India has predominance of agriculture and irrigation has high dependence on ground water resources. Ground water accounts for about 62 per cent of the irrigated area (Government of India, 2010). Due to fluctuating climatic conditions on the one side, and increasing demand for ground water on the other on account of industrialisation and water-intense life styles, the available volume of water for irrigation has decreased. Excessive withdrawal of ground water leads to intrusion of sea water, particularly in the coastal areas (Tularam and Krishna, 2009 and Alfarrah and Walraevens, 2018). As a consequence, rural economy faces many problems like low farm income, unemployment, distress migration resulting into widening of rural-urban gap and less contribution to the nation's growth. Conserving the rain water through check dams is thus important for raising the farm productivity and to tackle the problem of rural poverty.

Looking into the low cost and immediate benefits from the water harvesting structures, check dams are strongly promoted in India by the Central Government, State Governments and many non-governmental organisations (both local and international), by providing different kinds of financial, institutional and technical support. Since 1995-96, NABARD, through its Rural Infrastructure Development Fund (RIDF), has been supporting the State Governments for completion of the ongoing irrigation and other rural development projects under its various tranches. Upto 20 tranches, out of total sanction of 289994 irrigation projects, 281538 are the minor irrigation projects. In Gujarat, out of 29294 RIDF sanctioned projects, minor irrigation accounts for 29261 projects which includes 29135 check dams. The check dams in Gujarat are constructed with public-private partnership under the Water Conservation Scheme called 'Sardar Patel Participatory Water Conservation Scheme' by Government of Gujarat. The pattern of sharing is 80:20 for the entire state (80 per cent Government and 20 per cent beneficiary share). These check dams are demand-driven. The farmers (beneficiaries) belonging to a checkdam are those who own agricultural farms on either side of the stream/river. These farmers (upto 11 in number) formed informal/unregistered groups for construction and management of checkdams with one farmer as the head (convenor) who is responsible for organising all activities related to the checkdams.

The existing studies on irrigation development claims important role of check dams in reviving the rural economy. The studies both at national and international levels have estimated several tangible and intangible benefits of these eco-friendly structures (Balooni *et al*., 2008; Khlifi *et al*., 2010; Samantara *et al*., 2006; Khosla, 1999; Bhamoriya and Mathew, 2014; Mudrakantha, 2003; Palanisami *et al*., 2006; Gale *et al*., 2006; Sangwan, 2001 among others). This includes multiple cropping, diversified cropping, plantation of vegetables and fruit trees, increased yield, better prices, increase in farm employment, increase in livestock productivity due to better foddering as well as recharging of ground water, availability of drinking water, and finally better living conditions in the rural areas.

The present study measures the change in farm productivity due to above mentioned check dam projects and compares the economic benefits in four districts of Gujarat, namely, Rajkot, Sabarkantha, Dang and Dahod. The selected districts belong to different agro-climatic zones and thus have different geographical and climatic features. Accordingly, there are regional variations in the availability of irrigation water. Among the selected districts, Dang belongs to South Gujarat which has a sub-humid climate and perennial rivers, but the ground water potential due to underlying hard rocks is poor. Sabarkantha, which is a part of North Gujarat has very few seasonal rivers. It has semi-arid climatic conditions but the underlying alluvial aquifers have good water storage potential. Rajkot belong to Saurashtra region which has a hard rock geology and poor ground water potential. The climate is semi-arid to arid. Dahod is a part of Eastern Hilly Region and belongs to Aravalli and associated rocks and Deccan trap formations.

Apart from the climatic factors, the developmental factors are also very unevenly spread in the state, particularly in the rural areas. These factors include road connectivity, market availability, communication facility, electricity supply, banking facility, access to information, etc. These factors are important for transportation of inputs and agricultural produce, knowing the price trends in the market, gaining knowledge about climatic conditions and the improved techniques of cultivation and access to credit facility. In essence, the developmental factors enable the farmers to utilise the harvested rain water in an efficient manner. The improper development of these factors increases the cost of production and thus creates a depressing environment for the farmers to practice agriculture in their own farms.

The check dams considered for the study are mainly meant for the irrigation purpose either directly (lifting water through electricity/diesel operated pumps from low lying checkdams upto nearby farmlands) or indirectly through recharged wells (due to percolation of water) in the surrounding or both. The long length of stored water for a longer period of time provides assured irrigation facility for a longer part of the year which in turn prolong the crop growing season. It also provide opportunities for the farmers to grow more than one crop per year, increase their agricultural productivity and self-sufficiency in food and income. The check dams also have a positive externality as the farmers living outside the command area are also benefitted due to rise in water table in their wells.

This study focuses on the check dams that are constructed in Gujarat under RIDF tranche XVI of NABARD. Taking into account the direct beneficiaries of the said checkdams, the impact of the checkdams is measured in terms of change in agricultural returns. The variations in returns from agriculture after the construction of check dams is explained with the help of dimensions of check dams and local level developmental factors. The study gives an important insight to the policy makers in making the maximum use of harvested rain water through check dams in the direction of raising farm income.

The paper is structured as follows. Section II discusses the methodology adopted for the study. Section III presents the profile of the selected villages. Section IV examines the rainfall pattern in the selected districts. Section V compares the irrigation water availability in the pre and post development situation. Section VI determines the change in irrigated area, cropping pattern, productivity and agricultural income in the selected districts as a result of check dam projects. Section VII measures the change in employment and wages for both the recurring and non-recurring types of employment. Section VIII determines the overall gains from the check dam projects in the selected districts. Section IX checks the economic viability of the check dams. Section X estimates the factors responsible for variations in agricultural returns in the selected districts, and the final section concludes the study.

II

METHODOLOGY

As per the official records from Secretariat, Government of Gujarat and NABARD Regional Office, Ahmedabad, in RIDF tranche XVI, a total 4334 check dams were constructed spread over 22 districts of Gujarat. The project commenced on 1st April 2010 and was completed on 31st March, 2013. Considering a brief period of stabilisation of the benefits, calendar year 2015 was taken as the reference year of the study. All the benefits and cost of investment were collected for the reference year. Investment cost of the project collected at historical prices was updated to reference year price using wholesale price index for comparison. For comparing the pre-and post-development situation, year 2009-10 is taken as pre-development agricultural year and 2014-15 as post-development agricultural year, considering that the checkdams starts giving the results from the immediate monsoon. Since the success of checkdams depends upon the rainfall pattern, this implies that the district which received more rainfall during the study period should be more benefitted due to checkdam and hence has high probability of being over-represented in the results. To normalise the situation, the benefits due to checkdams were assigned weights according to their deviation from the average rainfall, i.e., the checkdams in the district having highly positive deviation in rainfall received less weight and vice versa (Annexure A3).

The information for pre-development and post-development situation is collected with the help of field survey, that was conducted during May to August 2015. Multistage sampling technique is adopted as follows:

(a) *Selection of Districts*

Gujarat is broadly divided into five agro climatic zones. North-west arid zone contains Kachchh district which faces highly adverse climatic conditions. This district has received the highest number of check dams. However, this district has not

experienced rainfall after the construction of check dams and hence benefits could not be estimated. As a result, Kachchh has not been able to become the part of this study. From the remaining four agro climatic zones, namely South Gujarat, North Gujarat, Saurashtra and Middle Gujarat, one district per zone was selected taking into account the number of check dams constructed, i.e., the district with highest number of check dams in the respective agricultural zone was selected for the study. Therefore, in all, four districts, namely, Rajkot, Sabarkantha, Dang and Dahod were selected.

(b) *Selection of Blocks*

Since the spread of check dams within the district is highly uneven, it was decided to select those blocks which have large number of check dams. After arranging the blocks in descending order of the number of check dams in the selected districts, eight blocks were selected.

(c) *Selection of Check Dam Projects*

Five per cent of the check dams constructed in the selected blocks were considered for the study. Thus in all, 40 check dams were sampled by using stratified random sampling method. All the checkdams are of equal height (2 meters), but the length varies from 10 meters to 55 meters. It was decided to include check dams of all sizes in the study.  This helped us in finding the relationship between size of the check dams and the benefits obtained.

(d) *Selection of Respondents*

From each check dam, five beneficiary farmers were selected for survey. Therefore, in all, 200 beneficiaries were surveyed. These beneficiaries have their agricultural farms on either side of the stream/river on which the checkdam is built. Thus all the farmers have equal opportunities to utilise the harvested rain water. All the beneficiary farmers were given equal probability of being selected irrespective of their land sizes. Thus the selected beneficiaries were a mix of marginal, small and large farmers.[1] The sample detail is shown in Table 1. The data were collected by using pre-tested structured interview schedules.

In order to capture the economic benefits, pre- and post-development situations were compared. The economic benefits are determined in terms of: (a) Incremental gains from agricultural activity; (b) Employment and income generation from agriculture and (c) Value addition to GDP from agriculture.

Incremental gain was arrived as the difference between net income in the post development agricultural year (2014-15) and net income in the pre development agricultural year (2009-10).

TABLE 1. SAMPLE DETAIL AND VILLAGES COVERED

| Agro-climatic zone | Selection of district | Sampled check dams | Distribution of sample in blocks | | No. of beneficiaries surveyed | Villages covered |
|---|---|---|---|---|---|---|
| | | | Block name | No. of checkdams surveyed | | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Saurashtra | Rajkot | 16 | Rajkot | 8 | 40 | Jaliya, Vadali, |
| | | | Jasdon | 8 | 40 | Mota Matra, Virnagar |
| North Gujarat | Sabarkantha | 15 | Bayad | 6 | 30 | Amargadh, Ambliyara, Ramas, Talod |
| | | | Vadali | 5 | 25 | Bhajpura, Himatpur |
| | | | Prantij | 4 | 20 | Katwad |
| South Gujarat | Dang | 5 | Ahwa | 5 | 25 | Ambapada, Gaykhas, Supdahad, Chikhali |
| Middle Gujarat | Dahod | 4 | D'Baria | 2 | 10 | Satkunda, Ankali |
| | | | Limkheda | 2 | 10 | Rai |
| Total | 4 districts | 40 | 8 Blocks | 40 | 200 | 18 |

The sample size is 5 per cent of the total check dams constructed in the selected blocks. It comprises 1 per cent of the total checkdams constructed under RIDF XVI.

The checkdams undertaken in this study are a part of the social infrastructure development programme constructed by the State Government with the support from NABARD's RIDF, and are meant for benefitting the farmers/society. The beneficiaries have not directly borne the cost of investment. For assessing the benefits of such projects, measuring the economic viability is of paramount importance. Thus, it is appropriate to calculate the economic rate of return (ERR) rather than financial rate of return (FRR). FRR is calculated when projects are set up by individuals or private enterprises with profit motive. ERR is important for integrating the profitability of projects with the macro objectives of the national planning (Shrivastava, 1999). The use of ERR for the projects undertaken by government for society's development has been advocated by many studies (Florio *et al*., 2018, Hagen *et al*., 2012; Zeidan and Resende, 2010 among others). Gray and Srinidhi (2013) and Chaturvedi (2004) have calculated ERR for economic valuation of watershed development projects in different states of India. Joshi *et al*. (2005) have used it for similar study in Sri Lanka. Samantara *et al*. (2003) has used ERR for impact evaluation of RIDF investment in order to check the economic viability of benefits in terms of transportation, via rural roads and bridges. Sangwan (2010) has applied ERR technique for economic evaluation of infrastructure for agricultural development.

Social discount rate should equal the government's borrowing rate on long term securities because these securities are essentially riskless (Shrivastava, 1999). In the present study, social discount rate is determined from the rate at which the NABARD gives RIDF loans to the state governments. After 2003, the rate of interest of RIDF loans disbursed by NABARD have been linked to RBI's bank rate. However, it has varied from 0.5 per cent above the bank rate to 1.5 per cent below the bank rate (*Annual Report*, NABARD, various years). After the initiation of the project in 2010,

the bank rate itself has varied from 6 per cent in 2010-11 to 9 per cent during 2012-13. Currently, the bank rate is 6.5 per cent. Accordingly, a uniform discount rate is calculated by averaging method (which is equal to 7.76 per cent).

In order to ensure the reliability of the results, sensitivity of the benefit-cost ratio and ERR is examined to changes in key variables: (i) a 10 per cent increase in cost, (ii) a 10 per cent decrease in benefits, and (iii) a 1 per cent increase in discount rate. Since the project involves a one time investment which has already been incurred, change in maintenance cost is taken into consideration.

The results are obtained only for the agricultural activity. The other activity particularly dairy, depends upon the growth of agricultural activity and thus has an indirect relationship with the project. The benefits involved are those which are accrued to the society in the income stream of work. Thus all the quantifiable benefits were included and all the intangible benefits were not included.

Some assumptions made before analysing the economic rate of return and the viability of the project as listed below:

- Total cost includes the investment cost and the maintenance cost.
- Benefits accrued in the reference year of the study have been stabilised. During the first year after completion of the project, 100 per cent of the net income of the reference year is accrued.
- Labour cost is 40 per cent of the total cost (as recommended by the World Bank).The economic cost[2] of labour is obtained by using standard conversion factor (multiplying the cost by a factor of $0.8^3$).
- Economic life of the project is 15 years (as per DPR).
- Operation and maintenance (O &M) work will be taken in the 7th and 14th year of the project (as per DPR). O & M cost is 0.05 per cent of the capital cost.
- Incremental benefit to incremental cost is taken into account, i.e., the effect of sunk cost of investment in the analysis is neutral.
- The analysis is based on zero year concept that the investment completes in zero year and benefit accrues from first year onwards.

In order to explain the variations in ERR from different check dams, regression analysis is carried. ERR of the sampled check dams is considered as the dependent variable. The regression is carried in two ways. Firstly, ERR is regressed on length of the checkdam (LEN_CD) and its storage capacity (STOR_CD). Secondly, the model is augmented by including some more explanatory variables like percentage increase in cropping intensity (CRP_INT), percentage increase in agricultural yield (AG_YLD), literacy rate (LITR), access to credit facility (CREDIT), electricity supply for agricultural use (ELECTRIC), connectivity and information access (CON_INFO) and market availability (MARKET). The model specification is as follows:

$$ERR = \beta_0 + \beta_1 LEN\_CD + \beta_2 STOR\_CD + e_i$$

$$ERR = \beta_0 + \beta_1 LEN\_CD + \beta_2 STOR\_CD + \beta_3 CRP\_INT + \beta_4 AG\_YLD + \beta_5 LITR$$
$$+ \beta_6 CREDIT + \beta_7 ELECTRIC + \beta_8 CON\_INFO + \beta_9 MARKET + e_i$$

The dependent variable ERR on check dam is calculated considering the normal rainfall year. The districts having excess and scanty rainfall during the study period are normalised by appropriate weights. Among the explanatory variables, length of the surveyed checkdams is measured in meters, storage capacity of the checkdams is in Mcft, cropping intensity is the ratio of effective crop area harvested to the physical area (cropping intensity = (gross cropped area/net sown area) x100), agricultural yield refers to total agricultural output per hectare of land area (quintals/ hectare) and literacy rate is the per cent of literate population in total population. Credit facility, electricity supply for agricultural use, connectivity and information access and market availability are dummy variables. If the farmers have access to these services, then the variable is assigned number 1, otherwise zero. Credit facility includes the banks as well as agricultural credit societies. Connectivity and information access includes availability of post office, telephone connections, newspapers and magazines. These facilities increase social connectivity as well as creates general awareness about the market, climatic conditions, improved methods of agricultural practice, etc. All the selected explanatory variables are hypothesised to have positive signs. Since all the farmers have their agricultural farms on either side of the stream or river on which the selected checkdam is constructed, the geophysical differences would not show any variation. All the selected farmers get equal opportunity to benefit from check dam. Hence distance of the agricultural farm from the selected checkdams was dropped. Road connectivity was also dropped as all the villages are connected with road and thus did not show variation in the dependent variable.

III

PROFILE OF THE SELECTED VILLAGES

The profile of the selected villages is presented in Table 2. Population density varies from 3036 in Ankali village of Dahod district to 69 in Vadali village of Rajkot district. The villages in Dang have concentration of tribal population. Literacy rate is poor in the villages of Dang and Dahod as compared to villages of Rajkot and Sabarkantha. Work participation rate is comparatively high in Dang. Agriculture appears to be rainfed in the villages of Dang and Satkunda and Ankali in Dahod. Irrigation is totally dependent upon ground water resources in the villages of Sabarkantha (except Amargadh and Ramas) and Rajkot (except Mota Motra) and Rai in Dahod. All the villages are connected with road.  The distance of the nearest town varies from 10 km in Ankali to 48 km in Gaykhas. Regarding the other amenities, villages in Dang and also Katwad  in Sabarkantha and Mota Matra in Rajkot do not have bank/agricultural credit societies. The villages of Dang along with Amargadh, Ankali and Rai lack telephone connections. Ambapada, Gaykhas  and Chikhali in

TABLE 2. PROFILE OF THE SELECTED VILLAGES

| District (1) | Village (2) | Popu. density (people per sq km land area) (3) | Social backward-ness (in per cent) (4) | Literacy rate (in per cent) (5) | Work parti. rate (in per cent) (6) | Per cent of area irri. by under-ground water (7) | Electricity for agri. use (8) | Road connectivity (9) | Distance from nearest town (in kms) (10) | No. of telephone connections (11) | No.of banks/agri. credit society (12) | Distance from agricultural market (13) | News paper (14) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rajkot | Jaliya | 71.79 | 16.35 | 60.16 | 54 | 100 | Y | Y | 25 | 20 | 1 | 10+ km | Y |
| | Vadali | 69.13 | 8.47 | 52.1 | 46 | 100 | Y | Y | 24 | 15 | 1 | 10+ km | N |
| | Mota Matra | 147.20 | 2.71 | 5369 | 56 | 90.09 | Y | Y | 40 | 1 | 0 | 5-10 km | Y |
| | Virnagar | 196.95 | 8.11 | 70.02 | 36 | 100 | Y | Y | 12 | 51 | 3 | 10+ km | Y |
| Sabarkantha | Amargadh | 555.98 | 0 | 66.48 | 45 | 12 | Y | Y | 39 | 0 | 1 | 5-10 km | Y |
| | Ambliyara | 237.31 | 12.75 | 64.2 | 41 | 100 | Y | Y | 25 | 50 | 3 | 10+ km | Y |
| | Ramas | 327.30 | 7.59 | 68.66 | 44 | 31.94 | Y | Y | 40 | 12 | 2 | 10+ km | Y |
| | Talod | 293.87 | 14.3 | 59.9 | 56 | 100 | Y | Y | 38 | 4 | 1 | 5-10 km | Y |
| | Katwad | 640.79 | 1.72 | 65.5 | 54 | 100 | Y | Y | 15 | 20 | 0 | < 5 km | N |
| | Bhajpura | 257.55 | 26.79 | 71.54 | 59 | 100 | Y | Y | 12 | 33 | 2 | 10+ km | Y |
| | Himatpur | 238.92 | 1.61 | 66.4 | 51 | 100 | Y | Y | 45 | 1 | 1 | <5 km | Y |
| The Dangs | Ambapada | 244.79 | 100 | 59.26 | 63 | 0 | Y | Y | 17 | 0 | 0 | 10+ km | N |
| | Gaykhas | 190.43 | 98.66 | 58.56 | 46 | 0 | N | Y | 48 | 0 | 0 | 10+ km | N |
| | Supdahad | 269.67 | 100 | 59.85 | 63 | 0 | N | Y | 44 | 0 | 0 | 10+ km | Y |
| | Chikhali | 210.70 | 99.09 | 57.12 | 56 | 0 | N | Y | 20 | 0 | 0 | 10+ km | N |
| Dohad | Satkunda | 595.56 | 29.88 | 61.92 | 53 | 0 | N | Y | 18 | 10 | 0 | 10+ km | Y |
| | Ankali | 3036.53 | 23.56 | 43.65 | 51 | 0 | N | Y | 10 | 0 | 1 | 5-10 km | Y |
| | Rai | 504.80 | 35.01 | 4741 | 55 | 100 | Y | Y | 45 | 0 | 2 | 10+ km | Y |

*Source*: District Census Handbook, Census of India, 2011.
*Note*: Y = available, N = Not available.

Dang, Katwad in Sabarkantha and Vadali in Rajkot do not even have the newspaper facility for general awareness. The lack of one or the other facility should have an effect on the farm productivity even if irrigation water is made available through checkdams.

IV

RAINFALL PATTEN IN THE SELECTED DISTRICTS

The rainfall pattern in the selected districts of Gujarat for a period of 20 years is reported in Table 3. The rainfall is highly erratic and unpredictable. On the one side, Dang receives good rainfall averaging around 2300 mm and has experienced more than the average rainfall for 7 years. On the other side, the average rainfall is scarce in Rajkot with an average of 676 mm. In Rajkot and Sabarkantha, rainfall was more than the average for 10 years while in Dahod and Dang, it is for 9 years. During the study period 2009 to 2015, the number of years having above the average rainfall in Sabarkantha, Rajkot, Dahod and Dang is 5, 3, 3, 1 respectively.

TABLE 3. RAINFALL PATTERN IN SELECTED DISTRICTS (1996 TO 2015)

| Year | Rajkot | Sabarkantha | Dang | Dahod |
|------|--------|-------------|------|-------|
| (1) | (2) | (3) | (4) | (5) |
| 1996 | 755 | 721 | 2877 | - |
| 1997 | 760 | 1017 | 2896 | - |
| 1998 | 609 | 1102 | 3770 | 800 |
| 1999 | 311 | 437 | 3111 | 352 |
| 2000 | 345 | 425 | 1636 | 303 |
| 2001 | 429 | 593 | 2200 | 530 |
| 2002 | 373 | 431 | 2442 | 750 |
| 2003 | 740 | 846 | 2129 | 916 |
| 2004 | 558 | 732 | 1640 | 1039 |
| 2005 | 729 | 1037 | 3802 | 565 |
| 2006 | 843 | 1721 | 2626 | 1204 |
| 2007 | 1047 | 1294 | 1860 | 872 |
| 2008 | 788 | 646 | 2469 | 590 |
| 2009 | 541 | 660 | 1616 | 439 |
| 2010 | 1248 | 898 | 1890 | 586 |
| 2011 | 853 | 978 | 1635 | 690 |
| 2012 | 348 | 792 | 1603 | 739 |
| 2013 | 1116 | 1142 | 2397 | 851 |
| 2014 | 515 | 921 | 1706 | 614 |
| 2015 | 606 | 909 | 1368 | 446 |
| Average rainfall (1996-2015) | 675.7 | 865.1 | 2283.65 | 682.56 |

*Socio – Economic Review*, Gujarat state, various issues, Directorate of Economics and Statistics, Government of Gujarat, Gandhinagar.

Further, rainfall pattern is examined for the *rabi* and *kharif* seasons for the period 2009 to 2015 (Table 4). Most of the rainfall is received from the south-west monsoon between June to September. The entire rain falls within a period of 2 months in a year (IMD, 2016). The rainy days vary from 28 in Rajkot to 80 in Dang. Sometimes 40-50

per cent rain falls only in 7-8 day.[4] High intensity of rainfall of short duration, resulting from cloud bursts often create excessive run-off. It does not provide enough time for water to percolate. The rest of the year is absolutely dry that gives rise to a drought like situation. In the absence of water harvesting structures, the agriculture is entirely based upon single cropping pattern.

TABLE 4. SEASON-WISE RAINFALL PATTERN IN THE SELECTED DISTRICTS (2009 TO 2015)

| Season (1) | 2009 (2) | 2010 (3) | 2011 (4) | 2012 (5) | 2013 (6) | 2014 (7) | 2015 (8) | Average number of rainy days (9) |
|---|---|---|---|---|---|---|---|---|
| **Rajkot** | | | | | | | | |
| *Kharif* | 538.9 | 1169 | 797.2 | 338.6 | 982.8 | 485 | 577.5 | 28 |
| *Rabi* | 1.9 | 79 | 21.5 | 1.7 | 37.2 | 14.8 | 2.4 | |
| **Sabarkantha** | | | | | | | | |
| *Kharif* | 656.8 | 869.8 | 945.35 | 791.9 | 1026.6 | 913.7 | 727.5 | 35 |
| *Rabi* | 3.7 | 27.9 | 31.5 | 0 | 84.6 | 2.2 | 0 | |
| **Dang** | | | | | | | | |
| *Kharif* | 1307 | 1703 | 1181.48 | 1406.9 | 1591.6 | 1125.5 | 1036.2 | 80 |
| *Rabi* | 225 | 184 | 52.3 | 43.3 | 47.1 | 65.5 | 64 | |
| **Dahod** | | | | | | | | |
| *Kharif* | 401.2 | 578 | 663.8 | 729.1 | 746.8 | 537.7 | 426.8 | 33 |
| *Rabi* | 38 | 8.1 | 15.6 | 2.6 | 52.5 | 5.4 | 1.1 | |

*Sources*: (1) http://hydro.imd.gov.in/hydrometweb/(S(trjulcna5jb0me55lhspe545))/landing.aspx, (2) http://hydro.imd.gov.in/hydrometweb/(S(trjulcna5jb0me55lhspe545))/DistrictRaifall.aspx, (3) http://www.gujaratstat.com/meteorological-data/22/rainfall/238/stats.aspx, (4) www.gsdma.org/rainfalldata-2?Type =2.

V

IRRIGATION WATER AVAILABILITY IN THE PRE AND POST DEVELOPMENT SITUATION

The construction of check dams has changed the scenario of availability of irrigation water. It is observed from Table 5 that the depth of water table has decreased in all the selected blocks in the post project situation as compared to pre-project situation. In Jasdan block of Rajkot, before checkdam, the depth of underground water ranged from 150-450 ft. It has now decreased to the range of 100-250 ft. In Rajkot block, the water table has decreased from 80-90 ft to 40-50 ft. In Sabarkantha, on account of comparatively high amount of rainfall during the study period, remarkable change is observed in all the blocks. The underground water level which was 150-600 ft. in Vadali has increased to 100-250 ft. and in Bayad, it has reached 15-150 ft. In Dahod, during the pre-development situation, the water level was down to 150-200 ft. in D'Baria. Now the water is available at 10-25 ft. In Limkheda, much change in not observed as there is rock 50 ft beneath the earth surface. So underground water is not accessible after 50 ft. In Dang, despite very high average rainfall, not much change is observed in the underground recharge. This district has rocky terrains due to which water do not percolate into the surface of the earth.

TABLE 5. DEPTH OF WATER TABLET IN THE COMMAND AREA
(PRE AND POST DEVELOPMENT SITUATION)

| District | Block | Depth of Water (in ft) | |
|---|---|---|---|
| | | Pre Project | Post Project |
| (1) | (2) | (3) | (4) |
| Rajkot | Rajkot | 80-90 | 40-50 |
| | Jasdan | 150-450 | 100-250 |
| Sabarkantha | Bayad | 30-250 | 15-150 |
| | Vadali | 150-600 | 35-200 |
| | Prantiz | 80-500 | 60-400 |
| Dang | Ahwa | 130-400 | 90-350 |
| Dahod | D' Baria | 150-200 | 10-25 |
| | Limkheda | 30-50 | 20-25 |

*Source*: Based on field survey.

Further, the duration of availability of water for irrigation is compared for the pre-project and post-project situation. As shown in Table 6, before the construction of check dams, majority of the talukas were having the availability of irrigation water for 3-4 months, implying that the agriculture was almost rainfed. After the construction of checkdam, irrigation water is available for 8-10 months in Bayad and Vadali blocks of Sabarkantha, 7-8 months in blocks of Rajkot, 6-8 months in Prantiz block of Sabarkantha district and D'Baria and Limkheda blocks of Dahod district, and 6-7 months in Dang district. This implies that the construction of checkdams has increased the possibility of cultivation of more than one crop in a year.

TABLE 6. DURATION OF AVAILABILITY OF WATER FOR IRRIGATION DURING THE YEAR (PRE AND POST DEVELOPMENT SITUATION)

| District | Block | Availability of irrigation water (in months) | |
|---|---|---|---|
| | | Pre-project | Post-project |
| (1) | (2) | (3) | (4) |
| Rajkot | Rajkot | 4-5 | 7-8 |
| | Jasdan | 3-4 | 7-8 |
| Sabarkantha | Bayad | 4-5 | 8-10 |
| | Vadali | 3-4 | 8-10 |
| | Prantiz | 4-5 | 6-8 |
| Dang | Ahwa | 3-4 | 6-7 |
| Dahod | D'Baria | 3-4 | 6-8 |
| | Limkheda | 3-4 | 6-8 |

*Source*: Based on field survey.

VI

PRE AND POST DEVELOPMENT COMPARISONS OF IRRIGATED AREA, CROPPING PATTERN,
PRODUCTIVITY AND AGRICULTURAL INCOME

6.1 *Change in Irrigated Area*

Prior to the construction of checkdams, nearly 76 per cent of the operational holdings were unirrigated (Table 7). In the post development period, the irrigated area has increased to 46 per cent of the total area. In Dahod, the irrigated area has

more than doubled, from 24 per cent during the pre-development period to 59 per cent in the post-development period. It has increased by 18 per cent in Sabarkantha. In Dang, though the irrigated area has increased by more than three times, from 8 per cent to 24 per cent, it is still very low. This is on account of lack of electricity for agriculture use to lift water from the check dam to the agricultural farm (as reported by the beneficiaries). The unirrigated area is also high in Rajkot even after the construction of checkdams. Farmers in Rajkot were found to have least interest in practicing agriculture, and therefore, there is high tendency of migration to Rajkot city. This is reflected in terms of non-cooperation among the farmers in the construction of checkdams.

TABLE 7. IRRIGATED AND UNIRRIGATED AREA OF SAMPLED BENEFICIARIES
IN SELECTED DISTRICTS

(*ha*)

| Districts | Pre-development | | | Post development | | |
|---|---|---|---|---|---|---|
| | Irrigated | Unirrigated | Total | Irrigated | Unirrigated | Total |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Rajkot | 54.98 | 290.21 | 345.19 | 134.61 | 210.58 | 345.19 |
| | (15.92) | (84.07) | (100.0) | (38.99) | (61.02) | (100.0) |
| Sabarkantha | 90.41 | 134.46 | 224.87 | 132.29 | 96.49 | 228.78 |
| | (40.21) | (59.79) | (100.0) | (57.82) | (42.18) | (100.0) |
| Dang | 5.06 | 61.05 | 66.11 | 16.32 | 49.79 | 66.11 |
| | (7.65) | (92.35) | (100.0) | (24.69) | (75.31) | (100.0) |
| Dahod | 16.6 | 52.73 | 69.33 | 40.68 | 28.65 | 69.33 |
| | (23.94) | (76.06) | (100.0) | (58.68) | (41.32) | (100.0) |
| Total | 167.05 | 538.45 | 705.50 | 323.90 | 385.51 | 709.41 |
| | (23.68) | (76.32) | (100.0) | (45.66) Irr | (54.34) | (100.0) |

*Source*: Field survey.

## 6.2 *Change in Cropping Pattern*

Owing to construction of check dams, the gross cropped area in Rajkot has increased by 44 per cent (Table 8(A)). The area under irrigation for almost all the crops has increased. The area under *kharif* crops has increased by 10 hectares on account of increase in area under groundnut. The area under *rabi* crop has more than doubled. During *rabi* season, an additional 70, 69 and 45 hectares of land is brought under cultivation of wheat, cotton and groundnut respectively. Among the *zaid* crops, 4.7 hectares of land is cultivated. The cropping intensity has increased from 133 to 186. As a whole, the cropping pattern has shifted towards the high value crops particularly groundnut and cotton.

In Sabarkantha, the gross cropped area has increased by 57 per cent (Table 8(B)). This is mainly attributed to the cultivation during *rabi* and zaid season. The land under *kharif* crop has marginally increased during the post project situation. The impact of checkdams is mainly visible in the increase in the area under vegetables and fruits in the selected villages. The area under vegetables and fruits has increased from 16 hectares to 59 hectares. The area under maize has significantly decreased by

TABLE 8(A). AREA UNDER DIFFERENT CROPS OF SAMPLED BENEFICIARIES IN RAJKOT

(*ha*)

| Name of crops/ Seasons | Pre development | | | Post Development | | |
|---|---|---|---|---|---|---|
| | Irrigated | Unirrigated | Total | Irrigated | Unirrigated | Total |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| *Kharif* | | | | | | |
| Jowar | 1.8 | 4.1 | 5.9 | 0.0 | 0.0 | 0.0 |
| Bajara | 2.3 | 6.0 | 8.3 | 7.0 | 1.3 | 8.2 |
| Maize | 0.0 | 0.1 | 0.1 | 1.4 | 0.5 | 1.9 |
| Moong | 0.2 | 0.1 | 0.3 | 2.2 | 0.4 | 2.6 |
| Tuar | 0.1 | 0.5 | 0.6 | 1.3 | 0.4 | 1.7 |
| Urad | 0.0 | 2.6 | 2.6 | 2.2 | 0.4 | 2.7 |
| Groundnut | 26.3 | 195.6 | 221.9 | 126.4 | 106.3 | 232.3 |
| Sesamum | 0.3 | 3.3 | 3.6 | 2.1 | 2.1 | 4.3 |
| Soyabean | 0.0 | 0.8 | 0.9 | 1.4 | 0.4 | 1.8 |
| Cotton | 19.4 | 57.5 | 77.0 | 48.7 | 29.0 | 78.4 |
| Vegetables and Fruits | 1.8 | 2.1 | 3.9 | 2.4 | 1.1 | 3.5 |
| Fodder | 2.0 | 2.8 | 4.8 | 3.5 | 2.3 | 5.7 |
| Others | 1.5 | 3.8 | 5.3 | 1.5 | 0.6 | 2.1 |
| *Kharif* total | 55.7 | 279.3 | 335.2 | 200.1 | 145.0 | 345.2 |
| *Rabi* | | | | | | |
| Bajra | 0.6 | 3.2 | 3.8 | 1.8 | 1.4 | 3.2 |
| Maize | 0.0 | 1.6 | 1.6 | 1.6 | 0.0 | 1.6 |
| Wheat | 18.9 | 9.7 | 28.7 | 97.3 | 1.3 | 98.6 |
| Moong | 0.9 | 1.7 | 2.6 | 0.9 | 0.9 | 1.8 |
| Urad | 0.9 | 1.5 | 2.3 | 1.0 | 0.6 | 1.6 |
| Gram | 0.2 | 2.3 | 2.5 | 0.6 | 0.4 | 1.0 |
| Cumin | 10.3 | 15.5 | 25.8 | 19.7 | 6.3 | 26.0 |
| Groundnut | 6.1 | 7.4 | 13.5 | 41.1 | 17.2 | 58.3 |
| Sesamum | 0.5 | 1.0 | 1.4 | 1.0 | 0.5 | 1.5 |
| Rapeseed and Mustard | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 | 0.3 |
| Cotton | 8.7 | 10.4 | 19.1 | 52.4 | 36.0 | 88.3 |
| Vegetables and Fruits | 1.0 | 8.1 | 9.1 | 6.3 | 3.2 | 9.5 |
| *Rabi* Total | 48.2 | 62.4 | 110.5 | 224.0 | 67.8 | 291.7 |
| *Zaid* | | | | | | |
| Bajara | 0.0 | 0.0 | 0.0 | 1.2 | 0.1 | 1.3 |
| Moong | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.5 |
| Urad | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.4 |
| Groundnut | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.4 |
| Sesamum | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.4 |
| Vegetables and Fruits | 0.2 | 0.3 | 0.5 | 1.3 | 0.5 | 1.8 |
| Zaid Total | 0.2 | 0.3 | 0.5 | 3.3 | 1.4 | 4.7 |
| GCA | 104.1 | 342.0 | 446.2 | 427.4 | 214.2 | 641.6 |
| Cropping Intensity | 186.9 | 122.4 | 133.1 | 213.6 | 147.8 | 185.9 |

*Source*: Field survey.

TABLE 8(B). AREA UNDER DIFFERENT CROPS OF SAMPLED BENEFICIARIES IN SABARKANTHA

(*ha*)

| Name of crops/ Seasons | Pre development | | | Post development | | |
|---|---|---|---|---|---|---|
| | Irrigated | Unirrigated | Total | Irrigated | Unirrigated | Total |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| *Kharif* | | | | | | |
| Paddy | 3.8 | 6.5 | 10.4 | 3.3 | 0.7 | 4.0 |
| Jowar | 1.7 | 1.4 | 3.1 | 6.0 | 0.9 | 6.9 |
| Bajra | 4.2 | 14.6 | 18.8 | 2.4 | 12.6 | 15.0 |
| Maize | 2.5 | 28.8 | 31.3 | 5.9 | 1.5 | 7.4 |
| Moong | 1.7 | 0.4 | 2.1 | 2.9 | 0.4 | 3.3 |
| Moth | 0.5 | 0.1 | 0.6 | 1.1 | 0.8 | 1.9 |

*Contd.*

TABLE 8(B). CONCLD.

(*ha*)

| Name of crops/ Seasons | Pre development | | | Post development | | |
|---|---|---|---|---|---|---|
| | Irrigated | Unirrigated | Total | Irrigated | Unirrigated | Total |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Tuar | 3.1 | 3.1 | 6.2 | 4.6 | 0.6 | 5.2 |
| Urad | 1.2 | 0.3 | 1.6 | 1.8 | 0.1 | 1.9 |
| Castorseed | 16.1 | 10.3 | 26.4 | 25.9 | 2.3 | 28.2 |
| Groundnut | 2.3 | 3.5 | 5.8 | 6.5 | 0.2 | 6.7 |
| Sesamum (Til) | 1.3 | 0.6 | 2.0 | 1.8 | 0.6 | 2.4 |
| Soyabean | 0.8 | 2.0 | 2.7 | 0.5 | 0.2 | 0.7 |
| Cotton | 26.9 | 42.1 | 69.0 | 56.5 | 1.3 | 57.8 |
| Guar seed | 2.7 | 4.1 | 6.7 | 5.7 | 2.0 | 7.7 |
| Vegetables and Fruits | 12.4 | 3.3 | 15.7 | 56.7 | 2.4 | 59.1 |
| Fodder | 2.7 | 5.2 | 7.8 | 2.1 | 8.2 | 10.3 |
| Others | 6.4 | 5.7 | 12.1 | 7.2 | 2.7 | 9.9 |
| *Kharif* Total | 90.4 | 131.8 | 222.3 | 190.9 | 37.5 | 228.4 |
| *Rabi* | | | | | | |
| Maize | 0.0 | 0.0 | 0.0 | 2.6 | 0.9 | 3.5 |
| Wheat | 24.6 | 4.4 | 28.9 | 115.6 | 0.0 | 115.6 |
| Gram | 0.0 | 2.7 | 2.8 | 4.0 | 1.0 | 5.0 |
| Cumin | 0.8 | 0.8 | 1.5 | 1.8 | 0.4 | 2.2 |
| Fennel | 2.2 | 0.2 | 2.4 | 2.8 | 0.7 | 3.5 |
| Rapeseed and Mustard | 2.7 | 0.6 | 3.3 | 4.3 | 1.7 | 5.9 |
| Tobacco | 0.1 | 0.0 | 0.1 | 5.1 | 0.0 | 5.1 |
| Guar seed | 0.0 | 0.0 | 0.0 | 2.9 | 1.0 | 4.0 |
| Isabgul | 0.0 | 0.0 | 0.0 | 1.7 | 0.0 | 1.7 |
| Vegetables and Fruits | 3.3 | 1.9 | 5.2 | 25.3 | 8.4 | 33.7 |
| Fodder | 1.1 | 3.6 | 4.6 | 5.8 | 0.9 | 6.7 |
| *Rabi* Total | 34.8 | 14.1 | 48.9 | 171.8 | 15.0 | 186.8 |
| Summer / Zaid | | | | | | |
| Bajra | 5.7 | 8.7 | 14.4 | 5.2 | 12.2 | 17.4 |
| Maize | 0.0 | 0.0 | 0.0 | 1.7 | 0.5 | 2.2 |
| Moong | 0.0 | 0.0 | 0.0 | 4.1 | 1.0 | 5.1 |
| Urad | 0.0 | 0.0 | 0.0 | 0.6 | 0.7 | 1.3 |
| Groundnut | 0.6 | 1.5 | 2.1 | 2.6 | 1.0 | 3.6 |
| Sesamum | 0.0 | 1.6 | 1.6 | 1.0 | 0.2 | 1.2 |
| Guar seed | 0.0 | 0.0 | 0.0 | 1.4 | 0.5 | 1.8 |
| Vegetables and Fruits | 0.0 | 0.0 | 0.0 | 3.1 | 2.2 | 5.3 |
| Total | 6.3 | 11.7 | 18.0 | 19.6 | 18.3 | 37.9 |
| GCA | 131.5 | 157.6 | 289.1 | 382.3 | 70.8 | 453.1 |
| Cropping Intensity | 145.5 | 119.5 | 130.1 | 200.3 | 188.7 | 198.4 |

*Source*: Field survey.

24 hectares. The area under *rabi* cultivation has almost quadrupled. The *rabi* crop is dominated by traditional crop as wheat alone occupies around 62 per cent of the cropped area. Prior to construction of check dam, area under wheat cultivation was 59 per cent. The area under all the other crops has also shown an increase. Vegetables and fruits remarkably shared 18 per cent of the cropped area which was only 0.03 per cent prior to construction of checkdam. The area under zaid crops was almost nil (except bajara, sesamum and groundnut) prior to construction of check dam. In the post development situation, the selected beneficiaries have started taking multiple crops. Many crops like maize, moong, urad, guar, and vegetable and fruits have joined the cropping scenario in summer season. These crops occupy nearly 41 per

cent of the area cultivated during summer season. The total cropped area during the summer season has increased by 20 hectare.

In Dang, the impact of check dam is found to be relatively weak. Table 8(C) show that during the *kharif* season, the area under irrigation has increased only by 18 per cent (from 8.6 per cent of total area under *kharif* crops to 26.4 per cent). The total area under *rabi* and zaid crops has increased only by 5.6 and 6.6 hectares respectively. The unirrigated land still comprises a major share of the total cropped area. It is 73, 40 and 87 per cent during *kharif*, *rabi* and zaid season. Among all the *kharif* crops, nagli and paddy dominates and they together occupy more than 60 per cent of the total area under *kharif* cultivation. They are followed by varai which occupies 14 per cent of the cropped area. Other crops individually occupy less than 5 per cent of the cropped area. It was found during field survey that majority of the cropping in the district is for self consumption. The impact on gross cropped area and cropping intensity is found to be less as compared to other selected districts. The gross cropped area has increased by 17 per cent and the cropping intensity by 6.6 per cent only.

TABLE 8(C). AREA UNDER DIFFERENT CROPS OF SAMPLED BENEFICIARIES IN DANG

(*ha*)

| Name of crops/ Seasons | Pre development | | | Post development | | |
|---|---|---|---|---|---|---|
| | Irrigated | Unirrigated | Total | Irrigated | Unirrigated | Total |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| *Kharif* | | | | | | |
| Paddy | 0.0 | 18.9 | 18.9 | 0.0 | 19.5 | 19.5 |
| Maize | 0.0 | 3.1 | 3.1 | 1.7 | 1.6 | 3.3 |
| Nagli | 2.2 | 18.8 | 21.0 | 4.4 | 16.2 | 20.6 |
| Niger seed (Kharsani) | 0.0 | 2.5 | 2.5 | 0.6 | 0.9 | 1.5 |
| Varai | 0.9 | 3.3 | 4.2 | 2.9 | 6.2 | 9.1 |
| Moong | 0.0 | 0.1 | 0.1 | 0.8 | 0.0 | 0.8 |
| Tuar | 0.2 | 1.7 | 1.9 | 1.0 | 0.6 | 1.6 |
| Urad | 0.7 | 1.5 | 2.2 | 2.1 | 0.9 | 3.0 |
| Groundnut | 0.5 | 3.1 | 3.6 | 2.3 | 1.1 | 3.4 |
| Vegetables and Fruits | 0.6 | 0.0 | 0.6 | 1.5 | 0.1 | 1.6 |
| Fodder | 0.0 | 1.0 | 1.0 | 0.0 | 1.0 | 1.0 |
| *Kharif* Total | 5.1 | 54.0 | 59.1 | 17.3 | 48.1 | 65.4 |
| *Rabi* | | | | | | |
| Jowar | 0.5 | 3.4 | 3.9 | 1.0 | 3.5 | 4.5 |
| Wheat | 4.2 | 0.0 | 4.2 | 7.0 | 0.0 | 7.0 |
| Gram | 1.1 | 1.2 | 2.3 | 1.4 | 2.2 | 3.6 |
| Vegetables and Fruits | 0.1 | 0.2 | 0.2 | 0.5 | 0.9 | 1.4 |
| *Rabi* Total | 5.9 | 4.8 | 10.6 | 9.9 | 6.6 | 16.5 |
| Zaid/ Summer | | | | | | |
| Moong | 0.0 | 0.8 | 0.8 | 0.1 | 0.5 | 0.5 |
| Urad | 0.0 | 0.0 | 0.0 | 0.1 | 0.4 | 0.5 |
| Groundnut | 0.3 | 0.8 | 1.0 | 0.1 | 0.5 | 0.6 |
| Zaid Total | 0.3 | 1.6 | 1.8 | 0.2 | 1.4 | 1.6 |
| GCA | 11.3 | 60.4 | 71.5 | 27.4 | 56.1 | 83.5 |
| Cropping Intensity | 220.8 | 111.8 | 121.0 | 158.4 | 116.6 | 127.7 |

*Source*: Field survey.

In Dahod, before the construction of check dams, the selected beneficiary farmers were taking only *kharif* crop. The checkdams have enabled them to cultivate the *rabi* crop. Owing to this, as shown in Table 8(D), the gross cropped area has increased from 117 hectare to 163 hectare. The area under cultivation among the sampled beneficiaries is found to be greater than the total operational holding. During the field survey, it was observed that due to easy availability of water, the farmers are cultivating on the unregistered land (in some cases adjoining to their farm) and even in the kotar (in the path of water flow). Though the area under *kharif* crop has increased by only 3 hectares but the area under irrigation has more than doubled. Some shift in the cropping pattern has also occurred. The area under paddy has increased by 8 hectare (11 per cent), tuar by 10 hectare (13 per cent) and urad by 2 hectare (2.7 per cent) at the cost of the area under maize which has decreased by 41 per cent. The total cropped area under *rabi* crop has remarkably increased by 38 hectare (46 per cent). The irrigated area has increased from 27 per cent of total cropped area to 55 per cent. Maize, the least important crop among *rabi* before the construction of check dam has become the dominating crop after the completion of checkdam project. The area under maize has increased from 3 hectare to 21 hectare and occupies 45 per cent of the area under *rabi* crop. This reflects that the cultivation of maize from *kharif* is gradually shifting towards *rabi*. The area under wheat and gram has also increased.

TABLE 8(D). AREA UNDER DIFFERENT CROPS OF SAMPLED BENEFICIARIES IN DAHOD

(*ha*)

| Name of crops/ | Pre development | | | Post development | | |
|---|---|---|---|---|---|---|
| Seasons | Irrigated | Unirrigated | Total | Irrigated | Unirrigated | Total |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| *Kharif* | | | | | | |
| Paddy | 8.1 | 12.9 | 21.0 | 13.5 | 15.7 | 29.2 |
| Maize | 7.5 | 32.7 | 40.2 | 15.4 | 8.4 | 23.8 |
| Tuar | 0.9 | 1.9 | 2.8 | 8.8 | 3.8 | 12.6 |
| Urad | 1.1 | 3.8 | 4.9 | 4.4 | 2.7 | 7.1 |
| Groundnut | 0.1 | 0.2 | 0.3 | 0.1 | 0.2 | 0.3 |
| Vegetables and fruits | 0.2 | 0.4 | 0.6 | 0.2 | 0.1 | 0.3 |
| Fodder | 0.7 | 0.8 | 1.5 | 0.3 | 0.8 | 1.1 |
| Total | 18.6 | 52.7 | 71.3 | 42.7 | 31.7 | 74.4 |
| *Rabi* | | | | | | |
| Maize | 2.20 | 1.10 | 3.30 | 10.14 | 10.70 | 20.84 |
| Wheat | 1.60 | 5.14 | 6.74 | 6.59 | 5.68 | 12.27 |
| Gram | 0.60 | 1.86 | 2.46 | 7.37 | 6.52 | 13.89 |
| Total | 4.40 | 8.10 | 12.50 | 24.10 | 22.90 | 47.00 |
| GCA | 23.0 | 60.8 | 83.8 | 66.8 | 54.6 | 121.4 |
| Cropping Intensity | 123.7 | 115.4 | 117.5 | 156.4 | 172.2 | 163.2 |

*Source*: Field survey.

## 6.3 *Change in Productivity*

Table 9 reveals that during *kharif* season, the productivity of almost all the crops has increased in the selected districts during the post-project period except bajra and cotton in Rajkot, fodder in Sabarkantha and groundnut and varai in Dang. There is

TABLE 9. AGRICULTURAL PRODUCTIVITY AMONG THE SELECTED BENEFICIARIES

| Name of crops/ Seasons | Rajkot | | | Sabarkantha | | | Dang | | | Dahod | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Productivity (qtls/hec) | | Per cent change | Productivity (qtls/hec) | | Per cent change | Productivity (qtls/hec) | | Per cent change | Productivity (qtls/hec) | | Per cent change |
| | Pre dev. | Post dev. | | Pre dev. | Post dev. | | Pre dev. | Post dev. | | Pre dev. | Post dev. | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
| *Kharif* | | | | | | | | | | | | |
| Paddy | - | - | - | 19.2 | 22.2 | 15.6 | 12.3 | 15.2 | 24.1 | 12.8 | 14.6 | 14 |
| Jowar | 11 | - | - | 8.8 | 12.3 | 40 | - | - | - | - | - | - |
| Bajra | 10.9 | 9.6 | -12.1 | 10.5 | 12.8 | 21.7 | - | - | - | - | - | - |
| Maize | 15.2 | 16.1 | 5.9 | 13.6 | 15.6 | 14.5 | 13.2 | 13.5 | 2.4 | 13.2 | 15.3 | 16.3 |
| Moong | 3.6 | 4.6 | 26.4 | 4 | 5.8 | 46.7 | 3 | 5.6 | 87.3 | - | - | - |
| Moth | - | - | - | 2.9 | 10 | 249.7 | - | - | - | - | - | - |
| Tuar | 9.6 | 10.4 | 8.6 | 7.4 | 11.8 | 58.7 | 8.1 | 9.9 | 22.3 | 10.9 | 13.9 | 27.6 |
| Urad | 6.5 | 7.5 | 15.2 | 7.5 | 9.5 | 26.2 | 7 | 11 | 56.6 | 4.9 | 6.2 | 26.2 |
| Castor | - | - | - | 17.6 | 18.1 | 3 | - | - | - | - | - | - |
| Ground nut | 10.3 | 11.4 | 9.8 | 12.3 | 19 | 54.2 | 13.4 | 11.5 | -14.3 | 13.6 | 13.9 | 1.6 |
| Sesamum | 3.2 | 4.5 | 39.1 | 3.8 | 4.4 | 17.9 | - | - | - | - | - | - |
| Soyabean | 7.5 | 7.7 | 1.9 | 7.9 | 8.2 | 3.3 | - | - | - | - | - | - |
| Cotton | 7.7 | 6.4 | -16.9 | 7 | 9.2 | 31.6 | - | - | - | - | - | - |
| Guar | - | - | - | 5.5 | 11.2 | 103.7 | - | - | - | - | - | - |
| Nagli | - | - | - | - | - | - | 9.8 | 11 | 12.2 | - | - | - |
| Niger seed | - | - | - | - | - | - | 8.8 | 11.5 | 30.7 | - | - | - |
| Varai | - | - | - | - | - | - | 10.3 | 9.6 | -6 | - | - | - |
| Vegetables and fruits | 24.9 | 30.4 | 22 | 24.7 | 36 | 45.9 | 5 | 9.7 | 93.1 | 2.8 | 4.5 | 61 |
| Fodder | 37.5 | 51.4 | 37.1 | 52.5 | 48 | -8.6 | 37.6 | 41.2 | 9.8 | 14 | 24.5 | 75 |
| Others | 6.8 | 7.4 | 9 | 5.8 | 6.7 | 14.7 | - | - | - | - | - | - |
| *Rabi* | | | | | | | | | | | | |
| Jowar | - | - | - | - | - | - | 7 | 9.4 | 34.7 | - | - | - |
| Bajra | 7.3 | 8.2 | 12.7 | - | - | - | - | - | - | - | - | - |
| Maize | 11.5 | 12.8 | 11.9 | - | 26.8 | - | - | - | - | 18.2 | 18.6 | 2.4 |
| Wheat | 37.4 | 39.7 | 6.2 | 23.8 | 29.8 | 24.9 | 30.8 | 33.4 | 8.6 | 18.4 | 25.6 | 39.3 |
| Moong | 3.3 | 3.7 | 12.3 | - | - | - | - | - | - | - | - | - |
| Urad | 4.8 | 5.5 | 15.8 | - | - | - | - | - | - | - | - | - |
| Gram | 15.6 | 14.1 | -9.5 | 8.2 | 12.2 | 48.4 | 11.2 | 9.5 | -15.2 | 7.7 | 9.3 | 20.9 |
| Cumin | 3 | 3.5 | 19 | 2.9 | 3.6 | 23.3 | - | - | - | - | - | - |
| Groundnut | 8.3 | 10.1 | 22.9 | - | - | - | - | - | - | - | - | - |
| Fennel | - | - | - | 11.1 | 16.3 | 46.5 | - | - | - | - | - | - |
| Sesamum | 3.3 | 4.8 | 47.7 | - | - | - | - | - | - | - | - | - |
| Rapeseed and Mustard | - | 14.6 | - | 14.2 | 17 | 20.1 | - | - | - | - | - | - |
| Cotton | 7 | 8.3 | 17.9 | - | - | - | - | - | - | - | - | - |
| Tobacco | - | - | - | 20.4 | 25.2 | 23.5 | - | - | - | - | - | - |
| Guar seed | - | - | - | - | 6.3 | - | - | - | - | - | - | - |
| Isabgul | - | - | - | - | 10.3 | - | - | - | - | - | - | - |
| Vegetables and fruits | 154.3 | 157.8 | 2.3 | 72 | 80 | 11.1 | 13.8 | 18.6 | 34.1 | - | - | - |
| Fodder | - | - | - | 44.6 | 52.9 | 18.4 | - | - | - | - | - | - |
| Zaid / Summer | | | | | | | | | | | | |
| Bajara | - | 25.9 | - | 24.3 | 27.8 | 14.4 | - | - | - | - | - | - |
| Maize | - | - | - | - | 30.1 | - | - | - | - | - | - | - |
| Moong | - | 5.5 | - | - | 6.4 | - | 5.4 | 6.9 | 29.1 | - | - | - |
| Urad | - | 10 | - | - | 7.6 | - | - | 4.8 | - | - | - | - |
| Groundnut | - | 18.8 | - | 27.7 | 28.1 | 1.3 | 18.4 | 15.2 | -17.4 | - | - | - |
| Sesamum | - | 10.9 | - | 2.9 | 5.2 | 80.9 | - | - | - | - | - | - |
| Guar seed | - | - | - | - | 5.5 | - | - | - | - | - | - | - |
| Vegetables and fruits | 142 | 145.2 | 2.3 | - | 42 | - | - | - | - | - | - | - |

*Source*: Field survey.

remarkable increase in the productivity of moong, sesamum and fodder in Rajkot, moth, guar, tuar, groundnut and vegetables and fruits in Sabarkantha, vegetables and fruits, moong and urad in Dang and fodder, vegetable and fruits, tuar and urad in Dahod. During *rabi* season, there is an increase in productivity of sesamum and groundnut in Rajkot, gram, fennel and wheat in Sabarkantha, vegetable and fruits in Dang and wheat and gram in Dahod. During the zaid season, increase in productivity of the already existing crops and cultivation of some new crops is observed, particularly in Rajkot, Sabarkantha and Dahod.

6.4 *Change in Agricultural Income*

It is evident from Table 10 that the sampled farmers in the selected districts are benefitted in the post-development situation[5] by an amount of Rs. 0.44 lakh per hectare (approx.). The benefits are appreciably high in Sabarkantha (Rs. 1.49 lakh) and lowest in Rajkot (Rs. 0.04 lakh).

TABLE 10. PER HECTARE CHANGE IN AGRICULTURAL INCOME OF THE SAMPLED FARMERS

(*Rs./ha*)

| District | Total agricultural income | | Total cost of production | | Net income | | Net incremental income |
|---|---|---|---|---|---|---|---|
| | Pre dev. | Post dev. | Pre dev. | Post dev. | Pre dev. | Post dev. | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Rajkot | 15765.59 | 22785.65 | 14857.38 | 17571.69 | 908.2126 | 5213.96 | 4305.75 |
| Sabarkantha | 110032.10 | 262936.6 | 16743.72 | 20993.27 | 93288.34 | 241943.3 | 148654.90 |
| Dang | 43974.23 | 55268.09 | 10957.37 | 11150.73 | 33016.86 | 44117.36 | 11100.50 |
| Dahod | 17357.55 | 26064.95 | 14335.20 | 12960.12 | 3022.34 | 13104.83 | 10082.49 |
| Overall | 46782.35 | 91763.81 | 14223.42 | 15668.95 | 32558.94 | 76094.86 | 43535.92 |

*Source*: Based on previous Tables.

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VII

EMPLOYMENT GENERATION AND WAGES

The development of agricultural activity on the one hand increases employment opportunities and on the other, the increase in demand for agricultural labour improves the wages.

(i) *Recurring*

Table 11 (A) show a net increase in recurring employment by 0.66 lakh man days which values to Rs. 83.76 lakh. The value of employment generated is highest in Sabarkantha (approx. Rs. 60 lakh) and lowest in Dang (Rs. 3.4 lakh). In Rajkot, the impact of migration is clearly visible in employment generation.

(ii) *Non-Recurring*

For non-recurring employment, there is a net increase of 0.20 lakh man days [11(B)]. The value of non-recurring employment generation is Rs. 30.12 lakh. The

benefits are high in Sabarkantha as number of man days has increased by 0.12 lakh and value of employment generation by Rs. 23.2 lakh. These figures are lowest in Dang. Considering both recurring and non-recurring employment generation together, the total value addition comes out to Rs. 113.88 lakh.

TABLE 11(A). CHANGES IN EMPLOYMENT AND WAGES (RECURRING)

| Districts | No. of man days | | | Wage rate | | | Value of employment generation (Rs. in lakhs) |
|---|---|---|---|---|---|---|---|
| | Pre | Post | Change | Pre | Post | Change | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Rajkot | 24838.32 | 42619.85 | 17781.53 | 100 | 200 | 100 | 17.78 |
| Sabarkantha | 16468.73 | 56392.57 | 39923.85 | 120 | 270 | 150 | 59.89 |
| Dang | 3406.13 | 7538.44 | 4132.31 | 45 | 100 | 55 | 3.39 |
| Dahod | 4109.257 | 7963.28 | 3854.023 | 50 | 120 | 70 | 2.70 |

Total employment generation = 65691.7 man days.
Total value of employment generation = Rs. 83.76 lakh.

TABLE 11(B). CHANGES IN EMPLOYMENT AND WAGES (NON-RECURRING)

| Districts | No. of man days | | | Wage rate | | | Value of employment generation (Rs. in lakhs) |
|---|---|---|---|---|---|---|---|
| | Pre | Post | Change | Pre | Post | Change | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Rajkot | 12800 | 18400 | 5600 | 130 | 225 | 95 | 5.3 |
| Sabarkantha | 11400 | 23250 | 11850 | 104 | 300 | 196 | 23.2 |
| Dang | 2200 | 3875 | 1675 | 52 | 100 | 48 | 0.8 |
| Dahod | 1900 | 3220 | 1320 | 58 | 120 | 62 | 0.82 |

Total employment generation = 20445 man days.
Total value of employment generation = Rs. 30.12 lakh.

*Source*: Field survey.

VIII

OVERALL GAINS FROM CHECK DAMS

Table 12 show that overall gains from the sampled check dams comes out to Rs. 490.42 lakh from the investment of Rs. 193.50 lakh. The net return per Rs. 10,000 investment is Rs. 25345 (more than doubled). This is attributed to larger returns in Sabarkantha. Sabarkantha has experienced more than five times returns on investment of Rs. 10000, while the other districts have not experienced such gains. The factors that have contributed to high agricultural returns in Sabarkantha are multidimensional. The use of drip irrigation in the villages of Bayad and Vadali allows irrigation even during the lean months and enables them to take three crops during the year. Easy approach to market have encouraged the farmers to grow vegetables and fruits through which returns are high. Besides, the villages of Sabarkantha have additional advantages in terms of access to credit facility, electricity for agricultural use and high literacy rate, that allows the farmers to employ modern technology in their farms enabling them to efficiently utilise the harvested rain water for increasing the agricultural income. The employment and wages have improved and in some villages, reverse migration is observed. Though Rajkot is also in a relatively better situation in terms of their socio-economic factors,

TABLE 12. TOTAL VALUE ADDITION TO GDP

*(Rs. lakh)*

| Particulars | Rajkot | Sabarkantha | Dang | Dahod | Overall |
|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) |
| Benefits from agriculture | 13.9 | 345.82 | 9.21 | 7.61 | 376.54 |
| Benefits from employment generation (recurring) | 17.78 | 59.89 | 3.39 | 2.7 | 83.76 |
| Benefits from employment generation (non-recurring) | 5.3 | 23.2 | 0.8 | 0.82 | 30.12 |
| Total benefit | 36.98 | 428.91 | 13.4 | 11.13 | 490.42 |
| Cost of the project | 69.46 | 76.32 | 27.96 | 19.76 | 193.5 |
| Net return per Rs. 10,000 investment | 5323.93 | 56198.90 | 4792.56 | 5632.59 | 25344.70 |

*Source*: Calculations based on previous Tables.

but lack of co-operation among the farmers (as found during the field survey) has increased the per unit cost of construction of checkdams and decreased the returns. Also the farmers of the selected villages in Rajkot were found to be least interested in practicing agriculture. Majority of them have business in the Rajkot city. As a consequence, the benefits of check dam were not realised to the desired extent. Dang, despite having heavy rain fall is able to get comparatively less agricultural return after the construction of check dam on account of less developed socio-economic factors like lack of electricity to lift water from the check dam to the agricultural farm, lack of connectivity, non-availability of bank/agricultural credit societies, poor literacy rate and high level of social backwardness. Dahod is also less benefitted due to poor development of socio-economic factors. As reported by the respondents in Dang and Dahod, the high cost of transportation increases the cost of production and decreases the returns. As a result, the farmers are reluctant to sell their produce in the market. On account of this, a major part of the produce is destroyed. Particularly in Dang, even after the construction of check dams, farmers are doing subsistence farming, cultivating a part of their agricultural land. They are more interested in doing labour in other's farm as it is less cumbersome and releases them from arranging the inputs and selling the output. Despite all bottlenecks, the check dams in Dang and Dahod have reduced the duration of migration from 8 months to 4 months in a year.

IX

ECONOMIC VIABILITY OF THE PROJECT

Further, in order to check the economic viability of the check dams constructed under RIDF tranche XVI, BCR and ERR are calculated. After conversion and updation of the cost and investment (Table 13), the results of BCR and ERR are presented in Table 14.

Since the costs and benefits are discounted at 8 per cent, the project is viable if the ERR is worked out to be more than 8 per cent. Table 14 reveals that the project has high economic viability in Sabarkantha. Its benefit-cost ratio discounted at 8 per

cent is equal to 6.14 and ERR is greater than the social discount rate. The project is less viable for Dahod and Dang. The BCR for these districts at 8 per cent discount factor is calculated as 1.89 and 1.61 respectively with economic rate of return as 12 and 9 per cent respectively. The project has not appeared to be viable in Rajkot as the BCR is less than 1 and ERR is negative. Rajkot has high rate of migration from rural to urban area resulting into less motivation for agricultural activity. As a whole, the project is feasible as overall benefits are greater than approximately 5 units for 1 unit of cost incurred and the ERR is 28 per cent which is greater than the social discount rate.

TABLE 13. CONVERSION AND UPDATION OF THE COST OF INVESTMENT

(*Rs. lakhs*)

| District (1) | Historical prices (2009-10) (2) | Reference year prices (2014-15) (3) | Economic price for labour (4) | With economic price for labour (5) |
|---|---|---|---|---|
| Rajkot | 69.46 | 127.81 | 51.12 | 117.58 |
| Sabarkantha | 76.32 | 140.43 | 56.17 | 129.19 |
| Dang | 27.96 | 51.45 | 20.58 | 47.33 |
| Dahod | 19.76 | 36.36 | 14.54 | 33.45 |
| Overall | 193.5 | 356.04 | 142.42 | 327.56 |

*Source*: Computed using the financial cost of the project.

TABLE 14. BENEFIT COST RATIO AND ECONOMIC RATE OF RETURN

| Outcome (1) | Rajkot (2) | Sabarkantha (3) | Dang (4) | Dahod (5) | Overall (6) |
|---|---|---|---|---|---|
| BCR | 0.98:1 | 6.14:1 | 1.61:1 | 1.89:1 | 4.95:1 |
| ERR | 4 per cent | 44 per cent | 9 per cent | 12 per cent | 28 per cent |

*Source*: Computed.

The sensitivity analysis is carried for Sabarkantha, Dang, Dahod and overall. Rajkot is not included as the project is not found to be beneficial (as observed from Table 14). The results of sensitivity analysis are reported in Table 15. An increase in discount rate by 1 per cent is critical in Dang district. Dang is the tribal area where the topographical conditions are very adverse and there is very poor level of socio-economic development. The results for a cost increase of 10 per cent is above the threshold for all the districts. Maintenance cost is of very small amount, therefore a change in marginal cost by 10 per cent do not have much influence on the outcome

TABLE 15. SENSITIVITY ANALYSIS

| Change in key variables (1) | Outcome variables (2) | Sabarkantha (3) | Dang (4) | Dahod (5) | Overall (6) |
|---|---|---|---|---|---|
| 1 per cent increase in social | BCR | 6.06:1 | 1.50:1 | 1.76:1 | 4.71:1 |
| discount rate | ERR | 43 per cent | 8 per cent | 11 per cent | 27 per cent |
| 10 per cent increase in cost | BCR | 6.11:1 | 1.60:1 | 1.88:1 | 4.93:1 |
| | ERR | 44 per cent | 9 per cent | 12 per cent | 28 per cent |
| 10 per cent decrease in benefit | BCR | 5.97:1 | 1.45:1 | 1.70:1 | 4.55:1 |
| | ERR | 42 per cent | 7 per cent | 10 | 26 per cent |

*Source*: Computed.

variables. A 10 per cent decrease in benefit has made the project unfeasible in Dang. The feasibility of the overall results in all the three situations emphasises to look into the impact of structural and socio-economic factors.

X

FACTORS EXPLAINING VARIATIONS IN ECONOMIC BENEFITS FROM CHECKDAMS
(ESTIMATION RESULTS)

The variations in ERR (as calculated above) are explained with the help of regression results in Table 16. The estimates show that length of the check dam do not have significant influence on ERR. Rather storage capacity of the check dam along with some of the socio economic variables are found to be important. Storage capacity of check dams depends upon topographical characteristics. Storage capacity which was having negative and significant influence in the first model became positive and significant in the second model with the inclusion of socio-economic variables. This shows the importance of socio-economic variables in maximising the gains in agriculture by efficiently utilising the harvested rain water through checkdams. Among the socio-economic variables, both cropping intensity and agricultural yield are found to have a positive and significant impact on economic rate of return. Also the literacy rate, electricity supply, market availability and connectivity and information access are found to be important variables, while credit facility do not show any significant impact. A high level of literacy enables the farmer to support in the construction of dam structure as well as understanding the market conditions and improved techniques of production. Even if rain water is harvested through checkdams, it will not give the results if electricity supply is not there to lift the water and utilise it for irrigation purpose. Market is essential for selling the produced goods in time as well as for purchase of inputs. Connectivity and

TABLE 16. REGRESSION RESULTS
DEPENDENT VARIABLE: ECONOMIC RATE OF RETURN

| Explanatory variables | Model I | Model II |
|---|---|---|
| (1) | (2) | (3) |
| Constant | 143.01* | -121.85 |
| Length of Checkdam | -2.15 | 1.11 |
| Storage capacity | -202.36* | 20.43* |
| Per cent increase in cropping intensity | - | .039** |
| Per cent increase in yield | - | .075** |
| Literacy rate | - | 1.63* |
| Credit facility | - | -.801 |
| Electricity supply | - | .085** |
| Market availability | - | 321.24*** |
| Connectivity and Information access | - | .622* |
| R square | 0.428 | 0.842 |
| Adjusted R square | 0.404 | 0.806 |
| F Ratio | 7.19 | 68.2 |

*Source*: Computed.

*Note*: ***, ** and * shows significance at 1, 5 and 10 per cent level respectively.

information access helps the farmers to know the price trends, climate conditions as well as the updated production techniques. The study finds that in order to maximise the gains from checkdams, the minor irrigation projects should be supplemented with development of the socio-economic factors in the villages.

XI

CONCLUDING REMARKS

The study finds that rain water harvesting through minor irrigation projects, viz. checkdams have importance in raising the farm productivity and income which ultimately checks the rural poverty. The increase in the duration of availability of water for irrigation enables the farmers to cultivate more than one crop in a year. This has increased the employment, improved the wage rates and also checked distress migration. However, the project is not found to be viable in Rajkot. The results of benefit-cost ratio and ERR are found to be sensitive to increase in social discount rate and decrease in benefit. It is found that the variation in returns from check dams in the selected districts is not influenced by length of the check dams, but storage capacity and the status of socio-economic factors in the villages. These factors are increase in cropping intensity, increase in yield from agriculture, literacy rate, electricity for agricultural use, market availability and connectivity and information access.

The study concludes that the efficient utilisation of rain water harvested through check dams depends upon the topographical factors as well as on the socio-economic factors. Therefore, it is suggested that policies for irrigation development should have integrated approach. It should include the overall development of the village. Since the resources are scarce, it is better to focus on a smaller area. Development of few villages would act as a nuclei and have a demonstration effect for the neighbouring villages.

NOTES

1) The characteristics of sampled beneficiaries is shown in Annexure A1.

2) In economic analysis, the costs and benefits of a project are analysed from the point of view of society rather than point of view of a single agent's utility of land owner or developer. Therefore, there is a need to convert all financial costs into economic costs in order to take care of distortion in prices due to market imperfections.

3) See Guidelines for Economic Analysis of Projects, Asian Development Bank, 2017, Page 127, weblink: https://www.adb.org/sites/default/files/institutional-document/32256/economic-analysis-projects.pdf accessed on 23-06-2018. Also suggested in IFAD's Internal Guidelines Economic and Financial Analysis of Rural Investment Projects: Basic Concepts and Rationale, IFAD, 2015, Page 17, weblink; https://www.ifad.org/documents/10180/a53a6800-7fab-4661-ac78-faefcb7f00f8 accessed on 23-06-2018.

4) http://hydro.imd.gov.in/hydrometweb/(S(trjulcna5jb0me55lhspe545))/DistrictRaifall.aspx accessed on 24-06-2018.

5) The detail about calculation of agricultural income of the sampled beneficiaries is given in Annexures Tables A2 to A7.

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ANNEXURES

A1. CHARACTERISTICS OF SAMPLED BENEFICIARIES

| Characteristics (1) | Rajkot (2) | Sabarkantha (3) | Dang (4) | Dahod (5) | Total (6) |
|---|---|---|---|---|---|
| Sex wise Distribution | | | | | |
| Males | 76 | 72 | 25 | 13 | 186 |
| Females | 4 | 3 | 0 | 7 | 14 |
| Age wise Distribution | | | | | |
| 20-40 yrs | 36 | 27 | 8 | 11 | 82 |
| 40-60 yrs | 32 | 40 | 17 | 7 | 96 |
| > 60 yrs | 12 | 8 | 0 | 2 | 22 |
| Caste wise Distribution | | | | | |
| Scheduled Tribes | 0 | 19 | 25 | 7 | 51 |
| Scheduled Castes | 0 | 13 | 0 | 9 | 22 |
| Other Backward Classes | 32 | 26 | 0 | 4 | 62 |
| General | 48 | 18 | 0 | 0 | 65 |
| Distribution according to land holding | | | | | |
| Marginal farmer | 4 | 24 | 5 | 2 | 35 |
| Small farmer | 20 | 21 | 2 | 4 | 47 |
| Large farmer | 56 | 30 | 18 | 14 | 118 |
| Income wise distribution | | | | | |
| <.5 lakh | 0 | 12 | 15 | 0 | 27 |
| .5-2.5 lakh | 44 | 37 | 10 | 16 | 107 |
| 2.5-5 lakh | 24 | 10 | 0 | 4 | 38 |
| 5-7.5 lakh | 12 | 6 | 0 | 0 | 18 |
| 7.5-10 lakh | 0 | 8 | 0 | 0 | 8 |
| >10 lakh | 0 | 2 | 0 | 0 | 2 |

A2. DETAIL OF SELECTED CHECK DAMS AND INTERNAL RATE OF RETURN

| District (1) | Block (2) | Village (3) | Year of construction (4) | Length (5) | Storage (6) | Cost (7) | IRR (8) |
|---|---|---|---|---|---|---|---|
| Rajkot | Rajkot | Jaliya | 2013 | 40.2 | 0.14 | 5.8 | 5.98 |
| | | | 2013 | 50 | 0.1 | 5.98 | 6.02 |
| | | | 2013 | 54 | 0.12 | 5.99 | 6.15 |
| | | Vadali | 2013 | 39.8 | 0.1 | 5.83 | 7.46 |
| | | | 2013 | 27 | 0.09 | 4.82 | 7.15 |
| | | | 2013 | 12.45 | 0.08 | 2.78 | 6.99 |
| | | | 2013 | 19 | 0.02 | 3.28 | 6.65 |
| | | | 2013 | 14 | 0.07 | 2.97 | 5.89 |
| | Jasdan | Mota Matra | 2012 | 48 | 0.48 | 4.84 | 7.55 |
| | | | 2012 | 30 | 0.36 | 3.6 | 7.18 |
| | | | 2012 | 14 | 0.22 | 2.51 | 6.66 |
| | | | 2012 | 17.65 | 0.32 | 3.16 | 7 |
| | | Virnagar | 2012 | 36.1 | 0.48 | 4.84 | 7.32 |
| | | | 2012 | 14.5 | 0.27 | 2.66 | 6.05 |
| | | | 2012 | 17.7 | 0.29 | 2.88 | 5.77 |
| | | | 2012 | 35 | 0.49 | 4.86 | 7.08 |

*Contd.*

A2. CONCLD.

| District (1) | Block (2) | Village (3) | Year of construction (4) | Length (5) | Storage (6) | Cost (7) | IRR (8) |
|---|---|---|---|---|---|---|---|
| Sabarkantha | Bayad | Amargadh | 2011 | 16.45 | 0.01 | 4.34 | 228.94 |
| | | | 2011 | 42 | 0 | 11.98 | 238.24 |
| | | Ambliyara | 2011 | 18 | 0 | 5.96 | 219.17 |
| | | Ramas | 2012 | 17 | 0 | 5.64 | 250.24 |
| | | | 2012 | 18 | 0 | 5.83 | 276.59 |
| | | Talod | 2012 | 12 | 0 | 5.06 | 295.14 |
| | Vadali | Bhajpura | 2012 | 15 | 0.14 | 4.38 | 301 |
| | | | 2012 | 11 | 0.09 | 4.87 | 308.22 |
| | | | 2012 | 13 | 0.12 | 3.95 | 322.5 |
| | | | 2012 | 10 | 0.09 | 4.55 | 318.9 |
| | | Himatpur | 2012 | 24 | 0.19 | 5.82 | 332.63 |
| | Prantij | Katwad | 2013 | 10 | 0.05 | 4.14 | 231.89 |
| | | | 2013 | 15 | 0.04 | 3.4 | 223.41 |
| | | | 2013 | 18 | 0.09 | 5.39 | 242.44 |
| | | | 2013 | 25 | 0.23 | 6.67 | 264.78 |
| Dang | Ahwa | Ambapada | 2012 | 26 | 0.03 | 7.5 | 21.04 |
| | | Gaykhas | 2012 | 22 | 0.18 | 3.8 | 16.55 |
| | | | 2012 | 28 | 0.06 | 6.02 | 16.72 |
| | | Supdahad | 2012 | 22 | 0.05 | 5.94 | 20.09 |
| | | Chikhali | 2012 | 23 | 0.08 | 3.9 | 14.15 |
| Dahod | D'Baria | Satkunda | 2013 | 16 | 0.2 | 3.83 | 18.05 |
| | | Ankali | 2013 | 20 | 0.12 | 4.41 | 19.47 |
| | Limkheda | Rai | 2013 | 55 | 0.32 | 14.26 | 24.17 |
| | | | 2013 | 52 | 0.22 | 13.38 | 22.08 |

A3. RAINFALL DEVIATIONS IN THE SELECTED DISTRICTS

| Year (1) | Rajkot (2) | Sabarkantha (3) | Dang (4) | Dahod (5) |
|---|---|---|---|---|
| 1996 | 8.46 | -11.12 | 24.38 | - |
| 1997 | 9.00 | 11.72 | 25.16 | - |
| 1998 | -7.12 | 18.28 | 61.07 | 13.03 |
| 1999 | -38.92 | -33.03 | 33.99 | -36.69 |
| 2000 | -35.29 | -33.96 | -26.61 | -42.13 |
| 2001 | -26.33 | -21.00 | -3.44 | -16.93 |
| 2002 | -32.31 | -33.50 | 6.51 | 7.49 |
| 2003 | 6.86 | -1.47 | -6.35 | 25.91 |
| 2004 | -12.56 | -10.27 | -26.44 | 39.56 |
| 2005 | 5.69 | 13.26 | 62.38 | -13.05 |
| 2006 | 17.85 | 66.04 | 14.07 | 57.87 |
| 2007 | 39.63 | 33.09 | -17.41 | 21.03 |
| 2008 | 11.99 | -16.91 | 7.62 | -10.27 |
| 2009 | -14.38 (5) | -15.83 (7) | -27.43 (5) | -27.03 (7) |
| 2010 | 61.08 (1) | 2.54 (5) | -16.17 (2) | -10.72 (5) |
| 2011 | 18.92 (3) | 8.71 (2) | -26.65 (4) | 0.83 (3) |
| 2012 | -34.97 (7) | -5.64 (6) | -27.96 (6) | 6.26 (2) |
| 2013 | 46.99 (2) | 21.37 (1) | 4.66 (1) | 18.70 (1) |
| 2014 | -17.15 (6) | 4.31 (3) | -23.73 (3) | -7.61 (4) |
| 2015 | -7.44 (4) | 3.39 (4) | -37.62 (7) | -26.25 (6) |

*Note*: (1) The rainfall figures are normalised by the formula $Z_i = (X_i - X_{min})/(X_{max}-X_{min})$. Deviations in rainfall for each year are obtained from the mean of the normalised figures. (2) Figures in parentheses ( ) are the weights assigned. Weights are obtained by ranking method.

A4. CHANGE IN AGRICULTURAL INCOME OF SAMPLED BENEFICIARIES IN RAJKOT

*(Rs./ha)*

| Name of crops/seasons | Cost of cultivation | | Value of main produce | | Value of by-produce | | Total agri. income | | Net benefit |
|---|---|---|---|---|---|---|---|---|---|
| | Pre Dev. | Post Dev. | Pre Dev. | Post Dev. | Pre Dev. | Post Dev. | Pre Dev. | Post Dev. | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| *Kharif* | | | | | | | | | |
| Jowar | 12326 | 0 | 7842 | 0 | 5548 | 0 | 1064 | 0 | -1064 |
| Bajra | 21072 | 21877 | 17476 | 13564 | 6238 | 5600 | 2642 | -2712 | -5354 |
| Maize | 18221 | 24451 | 22648 | 24135 | 8180 | 9789 | 12607 | 9473 | -3134 |
| Moong | 9284 | 10539 | 16623 | 33048 | 6489 | 726 | 13828 | 23235 | 9407 |
| Tuar | 20807 | 17002 | 43733 | 47702 | 3722 | 3772 | 26648 | 34471 | 7823 |
| Urad | 8900 | 9502 | 25217 | 29586 | 781 | 1197 | 17098 | 21281 | 4182 |
| Ground nut | 32978 | 25647 | 44488 | 42846 | 8810 | 6622 | 20320 | 23821 | 3501 |
| Sesamum | 15621 | 12414 | 23612 | 26700 | 363 | 397 | 8354 | 14683 | 6329 |
| Soyabean | 13271 | 13002 | 20601 | 20702 | 970 | 777 | 8300 | 8477 | 178 |
| Cotton | 30728 | 31219 | 43405 | 31089 | 1020 | 875 | 13697 | 745 | -12952 |
| Vegetables and Fruits | 18254 | 21141 | 19336 | 29144 | 573 | 452 | 1655 | 8455 | 6800 |
| Fodder | 3807 | 3020 | 18264 | 31366 | 335 | 315 | 14792 | 28662 | 13870 |
| Others | 5933 | 6022 | 5673 | 6060 | 724 | 958 | 463 | 996 | 533 |
| *Rabi* | | | | | | | | | |
| Bajra | 18039 | 22000 | 12376 | 14445 | 5933 | 5612 | 270 | -1943 | -2213 |
| Maize | 18280 | 26952 | 17456 | 19262 | 7820 | 9603 | 6996 | 1912 | -5083 |
| Wheat | 22212 | 28140 | 74025 | 67694 | 3385 | 4500 | 55198 | 44054 | -11143 |
| Moong | 9434 | 9766 | 12757 | 24820 | 5705 | 5488 | 9029 | 20541 | 11513 |
| Urad | 9052 | 8900 | 20235 | 22000 | 742 | 962 | 11924 | 14062 | 2138 |
| Gram | 9661 | 9466 | 52248 | 39536 | 1134 | 1163 | 43721 | 31233 | -12488 |
| Cumin | 25065 | 25246 | 36251 | 38761 | 559 | 788 | 11744 | 14303 | 2559 |
| Groundnut | 31721 | 24996 | 31379 | 40560 | 8368 | 6420 | 8025 | 21984 | 13958 |
| Sesamum | 14488 | 12131 | 24723 | 29760 | 390 | 401 | 10624 | 18031 | 7407 |
| Rapeseed and Mustard | 0 | 18219 | 0 | 61110 | 0 | 977 | 0 | 43868 | 43868 |
| Cotton | 30618 | 28013 | 58574 | 33000 | 0 | 851 | 27956 | 5838 | -22118 |
| Vegetable and Fruits | 32301 | 34373 | 113118 | 102588 | 658 | 509 | 81474 | 68723 | -12751 |
| Zaid / Summer | | | | | | | | | |
| Bajara | 0 | 21626 | 0 | 34590 | 0 | 6900 | 0 | 19864 | 19864 |
| Moong | 0 | 8753 | 0 | 36708 | 0 | 4500 | 0 | 32456 | 32456 |
| Urad | 0 | 8039 | 0 | 25000 | 0 | 995 | 0 | 17956 | 17956 |
| Groundnut | 0 | 21159 | 0 | 80797 | 0 | 5986 | 0 | 65625 | 65625 |
| Sesamum | 0 | 11906 | 0 | 66246 | 0 | 372 | 0 | 54712 | 54712 |
| Vegetable and Fruits | 28503 | 29203 | 108027 | 90032 | 780 | 721 | 80304 | 61550 | -18754 |

Gross benefit per hectare = Rs. 7020/-

*Source*: Calculated on the basis of field survey.

A5. CHANGE IN AGRICULTURAL INCOME OF SAMPLED BENEFICIARIES IN SABARKANTHA

(Rs./ha)

| Name of crops/seasons (1) | Cost of cultivation | | Value of main produce | | Value of by-produce | | Total agri. income | | Net benefit |
|---|---|---|---|---|---|---|---|---|---|
| | Pre Dev. (2) | Post Dev. (3) | Pre Dev. (4) | Post Dev. (5) | Pre Dev. (6) | Post Dev. (7) | Pre Dev. (8) | Post Dev. (9) | (10) |
| *Kharif* | | | | | | | | | |
| Paddy | 27209 | 25700 | 25820 | 31486 | 8425 | 9732 | 7036 | 15517 | 8481 |
| Jowar | 12527 | 12851 | 18930 | 28175 | 6309 | 6085 | 12712 | 21410 | 8698 |
| Bajra | 21148 | 21906 | 16423 | 18998 | 6265 | 13034 | 1539 | 10126 | 8587 |
| Maize | 18505 | 24401 | 20480 | 20280 | 8018 | 9787 | 9994 | 5665 | -4329 |
| Moong | 9192 | 10543 | 16869 | 27772 | 683 | 729 | 8360 | 17958 | 9598 |
| Moth | 8232 | 7946 | 8528 | 50000 | 693 | 526 | 989 | 42580 | 41591 |
| Tuar | 21152 | 18804 | 33392 | 53378 | 3728 | 4151 | 15968 | 38725 | 22757 |
| Urad | 9737 | 9536 | 28640 | 38000 | 802 | 1213 | 19705 | 29678 | 9973 |
| Castor | 33852 | 27688 | 74975 | 59810 | 9509 | 7785 | 50632 | 39907 | -10725 |
| Ground nut | 33264 | 32439 | 77036 | 85275 | 9190 | 6907 | 52963 | 59743 | 6781 |
| Sesamum | 17393 | 12802 | 27271 | 27669 | 344 | 376 | 10222 | 15243 | 5021 |
| Soyabean | 13328 | 13286 | 24160 | 24198 | 953 | 951 | 11785 | 11863 | 78 |
| Cotton | 34668 | 32189 | 34197 | 37964 | 1180 | 1000 | 708 | 6775 | 6067 |
| Guar | 16385 | 23117 | 16178 | 24068 | 837 | 1072 | 630 | 2023 | 1393 |
| Vegetables and Fruits | 45642 | 38000 | 93851 | 174600 | 2170 | 2513 | 50379 | 139113 | 88734 |
| Fodder | 3851 | 3318 | 30352 | 30720 | 167 | 350 | 26668 | 27752 | 1084 |
| Others | 9936 | 8500 | 8383 | 7781 | 1841 | 1680 | 288 | 961 | 673 |
| *Rabi* | | | | | | | | | |
| Maize | 0 | 24564 | 0 | 35230 | 0 | 9544 | 0 | 20210 | 20210 |
| Wheat | 23357 | 25340 | 27180 | 40371 | 3463 | 5163 | 7286 | 20194 | 12908 |
| Gram | 9130 | 9564 | 25544 | 33303 | 1172 | 1200 | 17586 | 24940 | 7353 |
| Cumin | 26841 | 32639 | 32914 | 36090 | 610 | 876 | 6683 | 4327 | -2355 |
| Fennel | 23196 | 31294 | 55813 | 93934 | 647 | 950 | 33265 | 63590 | 30325 |
| Rapeseed and Mustard | 20905 | 17864 | 45240 | 44200 | 762 | 1032 | 25098 | 27368 | 2270 |
| Tobacco | 57241 | 50168 | 95639 | 151200 | 27 | 30 | 38426 | 101062 | 62636 |
| Guar seed | 0 | 3200 | 0 | 23213 | 0 | 860 | 0 | 20873 | 20873 |
| Isabgul (psyllium) | 0 | 12713 | 0 | 147836 | 0 | 977 | 0 | 136100 | 136100 |
| Vegetables and Fruits | 26838 | 52916 | 3069881 | 7420528 | 896 | 905 | 3043938 | 7368516 | 4324578 |
| Fodder | 4565 | 3461 | 355717 | 482362 | 517 | 890 | 351669 | 479791 | 128123 |
| Zaid / Summer | | | | | | | | | |
| Bajara | 21723 | 24460 | 22072 | 43429 | 6269 | 13921 | 6618 | 32890 | 26272 |
| Maize | 0 | 12851 | 0 | 36144 | 0 | 9210 | 0 | 32503 | 32503 |
| Moong | 0 | 10542 | 0 | 43486 | 0 | 723 | 0 | 33667 | 33667 |
| Urad | 0 | 10271 | 0 | 20206 | 0 | 1005 | 0 | 10941 | 10941 |
| Groundnut | 35469 | 36401 | 174429 | 139941 | 9933 | 5288 | 148893 | 108828 | -40065 |
| Sesamum | 17489 | 15072 | 18227 | 41844 | 377 | 413 | 1114 | 27186 | 26072 |
| Guar seed | 0 | 3800 | 0 | 22006 | 0 | 560 | 0 | 18766 | 18766 |
| Vegetables. and Fruits | 0 | 55614 | 0 | 503520 | 0 | 1020 | 0 | 448926 | 448926 |

Gross benefit per hectare = Rs. 152904.5

*Source*: Calculation based on field survey.

A6. CHANGE IN AGRICULTURAL INCOME OF SAMPLED BENEFICIAIRES IN DANG

(*Rs./ha*)

| Name of crops/seasons (1) | Cost of cultivation | | Value of main produce | | Value of by-produce | | Total agri. income | | Net benefit (10) |
|---|---|---|---|---|---|---|---|---|---|
| | Pre Dev. (2) | Post Dev. (3) | Pre Dev. (4) | Post Dev. (5) | Pre Dev. (6) | Post Dev. (7) | Pre Dev. (8) | Post Dev. (9) | |
| *Kharif* | | | | | | | | | |
| Paddy | 21993 | 18046 | 19710 | 21656 | 3849 | 3365 | 1566 | 6975 | 5409 |
| Maize | 12225 | 22291 | 14489 | 18239 | 5714 | 5278 | 7977 | 1225 | -6752 |
| 0gli | 33783 | 28655 | 31842 | 30912 | 3432 | 2754 | 1492 | 5011 | 3519 |
| Niger seed | 7669 | 8751 | 82782 | 121141 | 571 | 426 | 75685 | 112816 | 37131 |
| Varai | 19630 | 18085 | 25085 | 30540 | 800 | 1164 | 6255 | 13619 | 7364 |
| Moong | 5729 | 5046 | 13693 | 24054 | 344 | 476 | 8307 | 19483 | 11176 |
| Tuar | 13572 | 15871 | 38916 | 47735 | 2855 | 2393 | 28199 | 34257 | 6058 |
| Urad | 6383 | 5122 | 27769 | 42048 | 421 | 901 | 21806 | 37827 | 16021 |
| Ground nut | 19087 | 19367 | 52755 | 49306 | 6851 | 6127 | 40519 | 36066 | -4453 |
| Vegetables and Fruits | 1912 | 1626 | 12175 | 35770 | 362 | 567 | 10625 | 34710 | 24085 |
| Fodder | 2133 | 1952 | 96002 | 131968 | 183 | 440 | 94051 | 130456 | 36406 |
| *Rabi* | | | | | | | | | |
| Jowar | 7858 | 9317 | 7103 | 9637 | 4566 | 4502 | 3812 | 4822 | 1011 |
| Wheat | 11635 | 10413 | 49154 | 52804 | 2131 | 3014 | 39650 | 45405 | 5754 |
| Gram | 5796 | 5251 | 28166 | 26761 | 782 | 1042 | 23151 | 22552 | -599 |
| Vegetables and Fruits | 2389 | 2130 | 346374 | 416115 | 401 | 612 | 344386 | 414597 | 70211 |
| Zaid / Summer | | | | | | | | | |
| Moong | 6079 | 5422 | 24219 | 26462 | 330 | 456 | 18470 | 21496 | 3025 |
| Urad | 0 | 5114 | 0 | 13342 | 0 | 896 | 0 | 9124 | 9124 |
| Groundnut | 19361 | 18254 | 78468 | 57836 | 6476 | 4802 | 65583 | 44384 | -21199 |
| Gross benefit per hectare = Rs. 11294 | | | | | | | | | |

*Source*: Calculations based on field survey.

A7. CHANGE IN AGRICULTURAL INCOME OF SAMPLED BENEFICIARIES IN DAHOD

(*Rs./ha*.)

| Name of crops/seasons (1) | Cost of cultivation | | Value of main produce | | Value of by-produce | | Total agri. income | | Net benefit (10) |
|---|---|---|---|---|---|---|---|---|---|
| | Pre Dev. (2) | Post Dev. (3) | Pre Dev. (4) | Post Dev. (5) | Pre Dev. (6) | Post Dev. (7) | Pre Dev. (8) | Post Dev. (9) | |
| *Kharif* | | | | | | | | | |
| Paddy | 21893 | 21300 | 18500 | 19784 | 4273 | 3865 | 880 | 2349 | 1469 |
| Maize | 27832 | 23697 | 20538 | 21448 | 5916 | 5663 | -1379 | 3414 | 4792 |
| Tuar | 13740 | 14296 | 33167 | 47614 | 3007 | 2509 | 22434 | 35827 | 13394 |
| Urad | 6787 | 5371 | 19938 | 25353 | 457 | 945 | 13608 | 20926 | 7318 |
| Ground nut | 22241 | 20687 | 58105 | 54719 | 6493 | 6242 | 42357 | 40274 | -2083 |
| Vegetables and Fruits | 2615 | 1950 | 4133 | 9592 | 390 | 289 | 1908 | 7930 | 6022 |
| Fodder | 2969 | 2031 | 44761 | 68656 | 198 | 290 | 41990 | 66915 | 24925 |
| *Rabi* | | | | | | | | | |
| Maize | 26848 | 22314 | 32278 | 36588 | 5584 | 5446 | 11014 | 19721 | 8706 |
| Wheat | 12135 | 12313 | 35011 | 51280 | 2352 | 3513 | 25228 | 42480 | 17252 |
| Gram | 6291 | 5641 | 21004 | 25493 | 821 | 963 | 15534 | 20814 | 5280 |
| Gross benefit per hectare = Rs. 8707.40/- | | | | | | | | | |

*Source*: Calculations based on field survey.