Identifying adaptation effectiveness indicators using participatory approaches: A case study from the Gangetic Basin

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Abstract:

Indicator-based approaches have been used extensively for measuring adaptation. Adopting participatory approaches help in contextualizing the global level and generic indicators to suit the local level conditions for measuring adaptation effectiveness. This paper discusses the application of a methodology for identifying a set of adaptation effectiveness indicators that could assist in prioritizing adaptation interventions. Using participatory approaches, the indicators were selected to assess the social, environmental and economic effectiveness of bunding as an adaptation option in the Gangetic basin. The criteria for ranking of indicators was also determined along with an attempt to understand if there is an association between demographic factors and ranking of indicators by the respondents. The results showed that communities favored increase in fresh water availability as a measure for environmental effectiveness; food security for social effectiveness and farm income for economic effectiveness. The paper concludes by discussing the merits as well as limitations of using an indicators-based approach for assessing adaptation options.

Keywords:

Adaptation effectiveness, Indicator-based approach, Household survey, Gangetic Basin

Main Text

1. Introduction

Recent findings indicate likely temperature increase in all Representative Concentration Pathways (RCP) scenarios together with changing precipitation trends globally (IPCC, 2013). Communities and natural systems are likely to face multi-dimensional direct and indirect impacts as a consequence of these changes. There is a need for substantial interventions for building resilience of vulnerable communities

and adaptation to climate change. However, the key question remains how to ensure adaptation interventions are effective. In developing countries, although climate adaptation is being integrated into planning processes, implementation of interventions is still at a nascent stage (IPCC, 2014). There is an opportunity to integrate climate adaptation with the overall development process. The policy framework in many countries is heading towards mainstreaming of climate adaptation. As the number of adaptation projects being planned and implemented is on a rise it becomes indispensable to ensure the effectiveness of these interventions on the ground. It is necessary to ensure that climate adaptation strategies are sustainable and contribute to vulnerability reduction as some adaptation strategies may conflict with other development goals resulting in maladaptation. Better understanding and knowledge is required on what constitutes adaptation and its implications at the level of implementation. According to IPCC (2014), adaptation is the process of adjustment to actual or expected climate and its effects. Particularly, in human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. Defining adaptation and accordingly implementing and evaluating it can help in effectively adapting to climate change while addressing its underlying uncertainties (Doria et al., 2009).

There is still a debate over what constitutes successful adaptation. Largely, the success of an adaptation action can be defined in terms of the extent to which it is able to achieve the overall objectives of adaptation as envisaged in an implemented project (Adger et al., 2005). However, in many cases, the objectives of adaptation are not clearly defined which makes it difficult to assess the success or failure of adaptation (Doria et al., 2009). Also, at a micro level where adaptation options are being implemented, there might be several underlying factors which might affect the extent of its effectiveness and its definition of success. The perception of effectiveness of adaptation also varies with different stakeholders (Pringle, 2011). The effectiveness of an adaptation option might be dependent on actions of other stakeholders apart from the implementing agency and on future socio-economic scenarios of the region (Adger et al., 2005; Pringle, 2011).Nonetheless, as adaptation gets implemented at a wider scale, measurement of effectiveness of adaptation can be beneficial in understanding the complexities related to successful adaptation and to sustain effectiveness in the long term in the case of changing climate. Such measurement can provide feedback to decision makers and can thus contribute to future policy making on adaptation (Harley et al., 2008).

Although measurement of effectiveness of adaptation can significantly contribute towards decision-making, the focus on tracking successful adaptation has been limited (Ford et al., 2013). Adaptation assessments have been mostly limited to impacts, vulnerability, and adaptation planning, with little focus on assessment of processes of implementation or the effects of adaptation actions (IPCC, 2014). Monitoring and evaluation of adaptation usually track utilization of resources by adopting a Results-based Mapping framework. In many cases, such as that of the Adaptation Fund and Global Environment Facility (GEF) managed adaptation funds, the focus is largely on process or outcome-based indicators with limited inclusion of longer-term impact-based indicators (Stadelmann et al., 2014).This approach provides a practical method to track progress of adaptation at a broader level such as national level (Levin et al., 2015). Some studies have developed frameworks and methodologies to study effectiveness of adaptation. For instance, Brooks et al.(2013) developed an evaluative framework, Tracking Adaptation and Measuring Development (TAMD) for evaluating effectiveness of adaptation and

adaptation relevant development interventions using indicators. The framework involves a twin track approach combining evaluation of climate risk management processes as well as their development and adaptation outcomes and longer-term impacts. Another decision-making framework involving metrics was developed by taking into account tools to quantify total climate risk as well as use of cost-benefit approaches for evaluation of adaptation measures (ECAWG, 2009). Schipper et al. (2015) explored the practice of measuring resilience towards climate change in literature by examining 17 sets of indicators in internationally recognized resilience frameworks.

While many studies have stressed on having a systematic approach for measuring effectiveness of adaptation and tracking its implementation, the levels proposed for the application of methodologies for measurement differ. Some studies have emphasized on having broad level universal (Stadelmann et al., 2014) or national level (Pringle et al., 2015) indicators for assessing adaptation. On the other hand, Schipper et al. (2015), Bours et al. (2015) and ECAWG (2009) have highlighted the need to capture local, context specific information to track adaptation. A consultation workshop organized by IGES and World Bank on adaptation metrics also underscored the need of context specific indicators developed in a participatory manner (Srinivasan and Prabhakar, 2008). It has been further highlighted that indicator-based approaches may be more useful if quantitative information is complimented by qualitative information (Bours et al., 2015, Schipper et al., 2015, Pringle et al., 2015 and OECD, 2015). For instance, Chong et al., 2015 did a study on capturing children's perspectives on resilience through qualitative change indicators that could not have been captured through quantitative indicators. Capturing community perception provides an opportunity to collect context specific information required to understand what constitutes successful adaptation (Bours et al., 2015). Hence, a combination of qualitative and quantitative approaches are more desirable than the use of one of them alone. Calls for application of mixed methods approaches has been on the rise during recent years. For example, OECD (2015) suggests using mixed methods to ensure that both qualitative and quantitative aspects of adaptation are captured and to consider the unquantifiable impacts of adaptation. Similarly, Bours et al.(2015) suggested mixed methods with a focus on learning and context relevance of adaptation.

In general, community participation has long been advocated for an effective adaptation (Schipper et al., 2014). Further, community engagement in monitoring and evaluation of adaptation projects in a participatory M&E framework has also been widely advocated (Mathew et al., 2016; Ayers et al., 2012; Anderson and Karani, 2014; Bours et al., 2013). However, it has also been cautioned that participatory appraisals shouldn't be treated as a panacea and that the associated limitations should be duly considered. For example, it was opined that community participation may result in choosing short-term solutions over long-term solutions, not understanding and addressing the underlying power relations among communities that could result in a distorted picture (Ford et al., 2016; Cook and Kotari, 2001). Nevertheless, in the context of evaluation of adaptation effectiveness, it was advised to consider community preferences and opinions as they help obtain the context-specific inputs necessary for making adaptation successful (Noble et al., 2014).

Given this background, this paper discusses a study to use and apply an indicator-based approach for assessing effectiveness of adaptation options being implemented at local level. It presents a methodology which includes incorporation of perceptions of local communities on the factors which are

important for them to define an adaptation intervention as effective. The study aimed at identifying and ranking of a set of adaptation effectiveness indicators which could assist in prioritizing adaptation interventions being planned and implemented based on their effectiveness in the Gangetic Basin. The study also tried to explore if factors such as gender and economic background of survey respondents influence the indicators prioritized since these factors are important in participatory decision making. The methodology has scope for involvement of different stakeholders such as researchers, government officials making it more robust.

The first section presents the detailed methodology including the steps involved. The paper then presents the results of the application of the methodology for one particular site in Gangetic Basin which includes general perceptions of communities on climate change, ranking of indicators and finally the association between factors and ranking. The last section discusses the results and conclusion.

2. Methodology

The study followed a consultative approach for prioritizing or ranking of adaptation effectiveness indicators. The methodology adopted in this study is presented in Figure 1. Initially, a common set of adaptation effectiveness indicators were identified based on literature review published as in Prabhakar and Srinivasan, 2010; Prabhakar et al., 2013. The indicators from the review are presented in Table 1. Subsequently, this common set of indicators was discussed in stakeholder consultations with the government, local bodies, and researchers before eliciting community responses. Community responses were obtained by structured household questionnaire survey. The study location was identified based on the presence of some kind of adaptation intervention either by a local NGO or by government.

Figure 1: Steps involved in the methodology

STEP 1: Literature review and Questionnaire development

Literature review helped to identify indicators that can be used for measuring adaptation effectiveness (Prabhakar et al., 2013). The review was used as an input to develop a questionnaire. These indicators were broadly classified under three categories of measuring effectiveness namely, *environmental or ecological, social and economic effectiveness* (Table 1; Prabhakar et al., 2013). These indicators ranged from short-term output and outcome-based indicators to long-term impact-based indicators. It is clear from the Table 1 that 60% of the indicators are long-term indicators while 40% are short-term indicators. Further, it is apparent that some of these indicators have commonality with the development indicators usually used for tracking progress of reduction in vulnerability and enhancement of resilience in the context of National Adaptation Plan of Action (NAPAs) or of the Nationally Determined Contributions under the Paris Agreement (Levin et al., 2015). The focus of the study is about the adaptation effectiveness at the local level where the actual adaptation projects are implemented and there were no adaptation effectiveness indicators developed at the national level by the time this study being carried out to check the consistency between the local and national level indicators. As a next step, a list of criteria was also identified from the literature review based on which the indicators could

be ranked. Figure 2 presents a schematic view of key elements of analysis in this study. For collecting information related to these key elements a draft questionnaire was developed. It consisted of broad set of questions pertaining to prioritization of different adaptation practices, and to ranking of the identified indicators for measuring the effectiveness and criteria to be employed for such prioritization.

Figure 2: Key elements of the analysis in the study

Table 1: Adaptation effectiveness indicators subjected to household surveys

Step 2: Consultation with experts for identification of effectiveness indicators

Following the literature review, a national level consultation was organized with relevant experts . The experts included representatives of Central Government, research institutions and key funding agencies working in the area of climate change adaptation and natural resource management. The objective of the consultation was to identify the broad list of adaptation options being practiced in the Gangetic Basin and to get the list of indicators as well as criteria vetted and refined to the basin and hazard context (drought). Based on the inputs and suggestions from the consultation, the questionnaire was revised and subjected to pilot survey in the study location.

STEP 3: Site Selection and pilot testing of questionnaire

An appropriate site within the Gangetic Basin was selected for the study based on the criteria of being drought prone and where some kind of drought alleviation practices (also relevant for climate change adaptation) have been implemented either by the government or other organization. After consultation with the government and local organizations, Kanpur Dehat district (Ramabai Nagar) in the state of Uttar Pradesh in India, was selected as the study region (Figure 3). A consultative process of meetings with the government officials of this district was undertaken to understand the initiatives which are being implemented in the agriculture and water sector in response to frequent droughts in the region. Following this, villages in Amrodha Block and Malasa Block were selected where watershed development activities like construction of different types of bunds[1] has been undertaken by the state government. The study location is characterized by severe soil erosion and continuous land degradation due to water runoff in the ravine lands on the banks of River Yamuna and Sengur in the Gangetic Basin. Nearly 83% of the population in the region is largely dependent on agriculture and these agrarian communities have been facing problems of land degradation (Shramik Bharti, 2011). Increased land degradation has made conditions unviable for optimum crop growth. In addition, cultivation is low in these blocks due to uneven and undulating land and lack of dependable irrigation. Farmers face water scarcity due to high water runoff which also reduces groundwater recharge. To address these problems, Ravine Reclamation Pilot Project was undertaken in Kanpur Dehat district by *Uttar Pradesh Bhumi Sudhar Nigam* (UPBSN) in 2009-10 (GoUP, 2017). The project envisaged the treatment of ravine land by undertaking field bunding, contour bunding, peripheral bunding, gulley plugging and check dams, with farmers' participation. The development objective of the project was to increase agricultural productivity in selected areas of degraded lands by focusing on the reclamation of land for the poorest section of farmers. The project contributed significantly to poverty alleviation and improved food/nutrition security in the project areas.

Figure 3 Map of Kanpur Dehat District showing Amrodha and Malasa Block

Source: www.kanpurdehat.nic.in

The questionnaire developed in the first step described previously was pilot tested in the study location. The aim of pilot testing was twofold, firstly to assess if local communities are able to understand the questions being asked and secondly to ensure that site-specific issues were being reflected appropriately. The pilot survey also helped the researchers to understand the local socio-economic context. The pilot testing of the questionnaire was done with a small group of randomly selected households within the communities in Amrodha and Malasa Block. The questionnaire was then modified accordingly and the final questionnaire survey was carried out subsequently (Figure 1).

Step 4: Conducting final questionnaire survey

The improved questionnaire from the pilot survey was used for conducting the household questionnaire survey. The sample size of the household questionnaire survey was decided using the formula:

Base sample size (n) = $\frac{t^2 \times p(1-p)}{m^2}$

where,

t = confidence interval (taken 1.44 for 85% of confidence level)

p=estimated prevalence (presence of practice in the population being surveyed).

(The presence of practice here refers to the population which has benefitted from the bunding and ravine stabilization interventions)

m=margin of error

Stratified random sampling was done for identifying the household survey respondents. 195 (derived from the above statistic) households participated in the survey including both males and female. The sample size for the survey included both those who have benefited from field bunding as an adaptation option (practice group) and those farmers whose land has still not been covered under the activities of field bunding. This helped in assessing the specific contribution of the adaptation intervention. The respondents were chosen from different economic groups based on land holding size. The respondents provided their perceptions on the questionnaire of the survey that was divided into five major sections:

i. General understanding of respondent about climate change
ii. Ranking of major climate change impacts and adaptation options (infrastructure, management and policy-related options)
iii. Adaptation metrics: Ranking of indicators under each category of measuring effectiveness (environmental or ecological, social and economic effectiveness)
iv. Ranking of criteria of prioritizing indicators

v. Respondent profile including occupation, economic status and land holding

During the survey the respondents indicated their ranking under section ii, iii and iv starting from the most preferred to the least. Participants were asked to do ordinal ranking of choices during the survey to keep the process simple, easy to understand and keeping in view the limited time available for the participants to participate in the survey.

Step 5: Analysis of household questionnaire survey data

The household survey data was statistically analyzed to get the highest ranked effectiveness indicators and criteria. Statistical analysis of the data using 'Pearson chi-square test of independence' was carried out to understand the association between the demographic backgrounds of the respondents and the ranks assigned to indicators. The statistical significance test was carried out for association between gender vs. indicators, economic status vs. indicators and practice group vs. indicators at a significance level of 0.05.

3. Results and Analysis

The 195 respondents of the household survey conducted in Amrodha and Malasa Block comprised of 172 males and 25 females; hence, the gender-related results presented in this paper need to be interpreted from the light of limited female participation. About 40% of the respondents were in the age group of 25 to 45 while another 40% of the respondents were in the age group of 45 to 65. All the respondents were primarily farmers. Majority of them had more than ten years of experience in farming (76%). Land ownership was confined to small area of farms as about 60% of agricultural landowners had less than one hectare of land.86% of the respondents belonged to low and middle-income group based on area of land owned while only 14% represented the high-income group. The key results from the analysis of household surveys are summarized in this section.

3.1 Perceptions of communities on climate change and adaptation

The survey revealed high levels of climate change awareness among the respondents. More than 75% of respondents had directly observed changes in the climate in the past 10-15 years while others came to know about it through their neighbors and friends. Since the focus of the study was drought, the respondents were asked about the changes in drought characteristics of the region. Most of the respondents noted that the drought characteristics had changed in the past 10-15 years. 60% of the respondents observed changes in duration of drought (droughts are getting longer) while the rest of the respondents (40%) had observed changes in drought intensity (droughts are getting more intense).

Subsequent to the discussion on climate change and drought, the respondents were asked to rank the likely adaptation options for dealing with droughts that were categorized into 3 groups – infrastructure-related, management-related and policy-related. Majority of the respondents (60%) chose improved irrigation system as the top ranked infrastructure-related adaptation option (Figure 4). 14 % respondents chose improved drought forecasting and early warning systems as top ranked adaptation option indicating the preference to have long term solutions to cope with climate variability. Better and

efficient irrigation systems can help in saving the crop even if rainfall is less or there is a drought situation. Another probable reason for this trend can be the awareness of farmers towards these types of adaptation options. There is a need for drought forecasting and early warning systems in the region and for making the farmers aware of their benefits.

Figure 4: Top ranked infrastructure-related adaptation options

With regard to the management-related adaptation options, about 40% of respondents preferred improved soil management (Figure 5) indicating that the farmers consider soil as a critical factor determining crop productivity. Around 38% respondents chose water harvesting as top ranked adaptation option, recognizing the benefits from watershed structures constructed in their region in the last couple of years. Better crop management and ensuring timely supply of inputs were among the least ranked adaptation options (less than 5%) in this category as respondents believed that the relative benefits accrued from a water harvesting structure outweighs the benefits from these practices.

Figure 5: Top ranked management-related adaptation options

'Introduction of water conservation policies' was considered as the top ranked policy-related adaptation option by 37% respondents followed by 'insurance schemes such as crop insurance' by 27% respondents. Since the area is drought prone, the farmers in the region opined that water conservation policies can help in ensuring better water availability in future. A number of people ranked insurance as the most preferred option as farming involves substantial inputs and failure of rainfall can result in major losses for the farmer which can be compensated to some extent with the help of insurance schemes.

3.2 Ranking of indicators to measure adaptation effectiveness

The survey elicited responses on adaptation effectiveness indicators, with respect to implementation of an adaptation intervention i.e. construction of bunds and check dams in the study site. As discussed in the methodology section, the indicators were categorized into three broad categories – environmental, social and economic effectiveness in order to understand the effectiveness of adaptation options from different dimensions.

Nine indicators of environmental effectiveness mainly related to water, soil and crop productivity were included in the questionnaire. 60% of the respondents considered increased water availability for irrigation as the most important indicator to monitor environmental effectiveness of the infrastructure interventions implemented in their region (Figure 6). Decreased duration of water stress period was selected as second most important indicator followed by change in groundwater level. The preference for increased water availability as an indicator for environmental effectiveness is justified as the purpose of check dams and bunds is to improve water infiltration and reduce soil erosion.

Figure 6: Ranking of indicators of environmental effectiveness

13 indicators were identified for discussing social effectiveness. According to the responses, food self-sufficiency along with access to and availability of food were the top ranked indicators to monitor social

effectiveness of the implemented intervention (Figure 7). Most of the respondents (36%) selected food availability as the most important factor for social effectiveness. The reason for this trend is probably reflected in the child health care data of the district. According to the data for 2010-11, about 35% of the children in the district (Kanpur Dehat) were suffering from malnutrition (UHI, 2013-14). The state of Uttar Pradesh in which the district is administratively located has very poor child health care track record. The percentage of infant deaths to total deaths in the state is 21.2% while the percentage of deaths of children under the age of five years to total deaths is 27.6%. Anemia prevalence is more than 70% in children while 42.4% of the children under 5 years of age are underweight indicating the severity of malnutrition in the state (UHI, 2013-14). The other indicators that were chosen by the respondents were related to health and education status within the household including percentage of income used for health care and number of students going to school.

Figure 7: Ranking of indicators of social effectiveness

Economic effectiveness of implemented intervention was monitored using indicators related to household income and assets. The data shows that total farm income was ranked as the most important indicator by about 50% of the respondents (Figure 8). The respondents established a direct correlation between the benefits from the construction of bunds and farm income by means of improved crop production. The economic status of the region is also poor as the per capita income of the Kanpur Dehat district is INR 1191 as compared to the State and National average of INR 2663 and INR 2648 respectively (NIC Kanpur Dehat, 2015). Also, as mentioned earlier, majority of the respondents were under low and medium economic category which might have resulted in the preference of this indicator. The other indicators that were chosen included increase in assets and decrease in damage per household due to drought as the most preferred indicator.

Figure 8: Ranking of indicators of economic effectiveness

3.3 Association of indicators with demographic factors

The above analysis of responses indicates that there could be several indicators to assess the environmental, social and economic effectiveness of adaptation options. However, research has indicated that the selection of indicators could be highly influenced by the demographic factors of the respondents (Prabhakar et al., 2013). To understand the extent to which the indicator ranking was influenced by the demographics of the respondents, the survey responses were analyzed for associations in four main categories: association between top ranked indicators and gender, economic status and practice group along with highest ranked criteria and indicators. This kind of analysis of associations helped in getting insights on the factors that influence the choices made by the respondents.

3.3.1 Gender and top ranked indicators

Gender can be a critical factor in understanding the pattern of ranking of indicators by respondents. A comparison was done between gender wise distribution of respondents and their respective ranking of indicators to assess how the ranking varies according to gender. Table 2 summarizes the results of the statistical analysis done using Pearson chi square test. The null hypothesis in this case was *that gender and ranking of indicators are independent of each other and there is no association between these two factors*.

Table 2: Statistical significance values of comparison of gender and indicators of effectiveness of adaptation options

The p values show that there is no association between the two factors. For the top five ranked indicators in all the three categories of effectiveness, the p values obtained were above the significance level and thus the null hypothesis was accepted (chi-square: 4.477, df: 7, p: 0.723). Thus, it can be inferred from the results that ranking of indicators of effectiveness of adaptation options was independent of gender influence. Similar responses from males and females on ranking of indicators can possibly attributed to active participation of both men and women in agriculture-related activities leading to homogenous viewpoints on livelihood priorities. The other interpretation of these results could be construed from the fact that only limited female participation was obtained for the household surveys while the sample size from males was much higher contributing to insignificant results. Census data for the district shows that there is not much difference in the percentage of cultivators to total workers for males (38.6) and females (25.3). In fact, females have a higher percentage of agricultural laborers out of total workers (46.2) as compared to males (34.8) (Census of India, 2011).

3.3.2 Economic Status and Top Ranked Indicators

To understand the linkages between economic status and indicator ranking, the former was taken as one of the factors for selecting the respondents in this survey. The respondents were from three main economic groups (low, medium and high) based on the expanse of land owned by the farmer. The land ownership ranged from one hectare to more than five hectares. The average land holding of households in the study area is around one hectare. 80% of the households have a landholding size of up to 0.6 hectare. Both Amrodha and Malasa blocks are characterized by 45% of farming community with a landholding of <0.5 hectare followed by 26% with a landholding size in the range of 0.5-1.0 hectare and 20% in the range of 1.0-2.0 hectare reflecting the fact that a very few percentage of farmers have large land holdings (Government of Uttar Pradesh, 2017). In order to understand the relation between economic status and ranking of indicators to monitor effectiveness of adaptation options, a Pearson Chi Square test was carried out. The null hypothesis was *that the economic status of the individual and their responses on ranking of indicators are independent of each other*. Table 3 shows the results of the statistical analysis of this comparison.

Table 3: Statistical significance values of comparison of economic status and indicators of effectiveness of adaptation options

The p-values obtained by the comparison of top 5 ranked indicators to monitor environmental effectiveness of adaptation options and the economic status of the farmers give mixed signals. For rank

1, the p value obtained is higher than the significance level (0.05) indicating no association between the type of top ranked indicator and economic status (chi-square: 16.839, df: 14, p: 0.265). On the other hand, for the 2nd and the 3rd ranked indicators, the p value obtained is less than the significance value and thus, in this case the null hypothesis cannot be accepted. This shows the presence of association between economic status and the second and third ranked indicators. For rest of the ranked indicators of environmental effectiveness (4th and 5th), again the p values are higher than the significance level showing that these are independent. For the other two categories of effectiveness, i.e., social and economic, all the p values obtained are more than the significance level showing no association between economic status of farmers and the social and economic effectiveness indicators of adaptation.

Overall, for the comparison between economic status and indicators to monitor effectiveness of adaptation options, it can be said that in most of the cases no association was found between these two factors. It can be inferred that to a large extent economic status did not influence the ranking of indicators of adaptation effectiveness. One of the probable reasons for this trend could be the marginal differences in the economic status of people. Although, the farmers were categorized based on economic status, there is not much difference in land holding sizes of people and the land holding didn't make much economic difference due to prevailing drought conditions in the region and most of the farmers fall in the category of small and marginal.

3.3.3 Practice group and top ranked indicators

Two sets of respondents were included in the survey – those who have implemented the drought mitigation intervention (practice group) and the other who were following traditional practices and had no adaptation intervention implemented in the their fields. A comparison was done between the responses on the ranking of the indicators for environmental, social and economic effectiveness obtained by these two practice groups. The null hypotheses for the statistical analysis between practice group and top ranked indicators of environmental, social and economic effectiveness was that *the two are independent of each other and there is no association between them*. The results of the statistical analysis done for the comparison between practice group and top ranked indicator under each category of monitoring effectiveness are summarized in Table 4.

Table 4: Statistical significance values of comparison of practice group and indicators of effectiveness of adaptation options

The values obtained as a result of the Pearson chi-square test showed that for all the top five ranked indicators in each of the three categories, the p value was more than the significance level inferring that the null hypothesis can be accepted.

It can be interpreted that the ranking of the indicators by respondents is independent of the practice group. It does not depend on whether they have been benefitted by the adaptation option or have been following the traditional practice and not benefitted by the option. Their responses and priorities remain same in terms of ranking indicators to monitor different aspects of effectiveness of adaptation options. This result is a significant finding since most of the expert consultations carried by the study team

stressed the possibility of practice-specific effectiveness indicators. The study reveals that there could be a common set of indicators that applies across practices.

3.3.4 Highest ranked criteria and indicators

After the ranking of indicators for monitoring effectiveness, the respondents were asked to rank the criteria for ranking of indicators. Criteria for ranking indicators such as social acceptability, communicability, simplicity, measurability and cost effectiveness were included in the questionnaire (Prabhakar et al., 2013).A statistical test was done for understanding the relation between highest ranked criteria and top ranked indicators for understating the perceptions that motivate ranking of indicators. The numbers obtained for the choice of the criteria showed that social acceptability indicator was the most often chosen criteria followed by the communicability of the indicator in a simple concise manner.

Analysis of the pattern of ranking of indicators to monitor the effectiveness of adaptation options by individuals who have chosen social acceptability as 1st rank and 2nd rank and communicability as 3rd rank was done. For the indicators of environmental effectiveness, it was found that irrespective of the criteria chosen, the responses for the top 3 ranked indicators are same. Increased water availability for irrigation was most frequently chosen indicator for the top rank by all three sets of individuals. Duration of water stress period was the most often chosen indicator for the second rank while change in groundwater level was the most frequently chosen indicator for the third rank.

For the top three ranks of indicators of social effectiveness, response of the three sets of individuals showed similar responses. Access to and availability of food, food self-sufficiency and percentage of income spent on health care were the most often chosen indicators for top three ranks. Thus, for these sets of respondents, food availability and health care are the most important social effectiveness indicators.

The responses for indicators of economic effectiveness also show that irrespective of criteria people have most frequently chosen gross household income and increase in assets as most important indicators (rank 1 & 2). Disposable income and inter-annual stability of household income are the next most often chosen indicators. This analysis indicates that the top three ranked indicators followed a similar pattern irrespective of the criteria applied by the respondent. This implies that there are certain indicators which hold importance in view of the communities and can be used in other situations or assessments.

4. Discussion

The findings of this study have helped gain insights on the kind of adaptation options preferred by the communities in a drought prone region and on the indicators and criteria chosen by them to measure the effectiveness of adaptation options. Analysis of the responses on the kind of adaptation options that can help in enhancing the adaptive capacity of the communities shows that the respondents in the study region gave more importance to adaptation options that can help in ensuring and increasing water availability. Interventions that can help in improving irrigation systems (infrastructure-related), facilitate

adoption of efficient irrigation systems such as drip and sprinkler (management-related) and introduction of water conservation policies (policy-related) were given more importance as compared to strategies related to crop and soil management. This is reasonable as agriculture in the study area is essentially rainfed with minimum irrigation facilities. Since it is a drought prone ravine area, where water and soil run–off is high, ensuring water availability is the key to enhance the adaptive capacity of the communities and increase their resilience towards current as well as future vulnerabilities to climate change.

The ranking of indicators done by the communities to assess the effectiveness of adaptation options with respect to construction of bunds and check dams also show similar trends. For the indicators of environmental effectiveness, preference was given to indicators related to water such as increased fresh water availability, and change in groundwater level. Indicators related to soil and crop productivity were ranked after these water-related indicators. The rationale behind this ranking done by the communities was that water is the primary requirement for ensuring good output from the field. For the indicators of social effectiveness, the responses show that food availability is the primary requirement for people followed by healthcare and education. Thus, adaptation options which can help in improving access to and availability of food and which can help in increasing their expenditure on healthcare and education were considered more effective in improving social well-being of communities. For economic effectiveness, the most important indicator was increase in farm income in terms of investment and income from sale of farm produce because an increase in income improves their purchasing power.

The comparisons done between demographic factors such as gender and economic status, and their respective ranking of indicators provides some understanding on how such choices are influenced or not influenced by these factors. In this particular study, for most of the comparisons done, no association was found between these factors and ranking of indicators. No association was found between gender and ranking of indicators to measure effectiveness of adaptation options which might be due to active participation of both men and women in agriculture-related activities resulting in similar preferences. Similarly, being benefitted by a particular practice was not found associated with ranking of indicators. It infers that ranking of the indicators was not dependent on whether the respondents have practiced a particular adaptation option or were following traditional practice in this particular case. It also indicates that the approach presented in this study can have a common set of indicators applicable for a wider set of adaptation practices. However, some degree of association was found between economic status and ranking of indicators. It can be said that in some cases, economic status was found to be influencing the choices made for indicators.

There were some limitations faced in this study while testing an indicator-based approach for assessing effectiveness of adaptation. The respondents ranked the likely adaptation options related to infrastructure, management and policy based on their understanding of benefits associated with them without taking into account the associated costs involved for implementing them. The consultation with national level experts for identification of effectiveness indicators was done using Chatham House Rule setup and thus the details of experts have not been included in this paper. The information for developing effective local indicators for measuring adaptation requires investment of time, resources and possibly permanent sampling plots representing practices. Similarly, to analyze traditional practices

and coping strategies, a participatory approach involving local farmers, service delivery line agencies, local NGO's and researchers over a reasonable period of time of 2 to 3 growing seasons is required which was beyond the scope of this particular study. The community responses were based on the past experiences of and trends in drought and no efforts were made to educate them on the future projections before ranking practices and indicators. Hence, the practices and indicators, identified and ranked are retrospective in nature rather than prospective. Also, this study was done in few distantly located clusters of villages in the vast Gangetic basin and hence the findings should not be treated as applicable to the entire Gangetic basin. This calls for a comprehensive bottom up studies in each distinct agro-ecological region of the Gangetic basin to see if there are real differences in indicators as influenced by demographic and agro-climatic contexts. Since the need of measuring effectiveness of adaptation in developing countries is being repeatedly emphasized, these limitations provide some lessons for consideration while doing more of such analysis such as incorporation of local issues while identifying the indicators.

5. Conclusions

This study was undertaken with the larger objective of finding means of facilitating adaptation decision making in the local context. The study gave an understanding of the perspective of the local communities on their preferences on adaptation options related to drought. It gave an indication of what can be the indicators preferred by the communities to monitor effectiveness of adaptation options. This can be a useful for prioritization of adaptation interventions. In addition, testing a methodology for a particular intervention has not only helped in getting meaningful insights on the local priorities and choices but also on variation of such choices based on demographic or economic factors. Usually adaptation decisions are taken and strategies are implemented at different scales. However, there are no proper mechanisms in place to measure the impacts of these adaptation strategies in terms of enhancing the adaptive capacity of the target groups. Also, even during the course of implementation of an adaptation project, it becomes important to track and review the progress of the goals under the project. Since climate change is a dynamic process and there are a number of uncertainties associated with it, it becomes very important to have a mechanism for tracking effectiveness and success of adaptation projects. This can help in making timely adjustments in projects, if necessary and can contribute in achieving the objectives of the adaptation intervention and avoiding maladaptation.

An indicator-based approach can be a useful tool in measuring effectiveness of adaptation interventions. There are a number of challenges in following this approach as adaptation applies in a local context and a particular set of indicators might not be applicable for every given region. Also, there are a number of factors influencing the effective implementation of adaptation interventions which cannot be assessed using indicators. The findings of this study highlight that a broad set of indicators can be identified which can be applicable at a local level for measuring the effectiveness of adaptation options. Participatory approaches can help in contextualizing the global level and generic indicators to suit to the adaptation and location-specific contexts for assessing the adaptation effectiveness. However, community participation should be combined with efforts to ensure that communities are fully appraised about the new practices, indicators and criteria of evaluation to enhance the value of their participation in assessing adaptation effectiveness. There is value in engaging communities in

monitoring and evaluation of adaptation interventions as it can reinforce mutual learning and can lead to enhanced ownership of interventions lack of which is often seen as a limitation in sustaining adaptation interventions. An indicator-based approach contextualized to local conditions provides a mechanism to understand the impact of adaptation intervention in quantitative terms and helps in assessing progress in the resilience of the communities towards climate change. In the future studies, it is important to look into synergies between the locally relevant effectiveness indicators identified in the study and the national level indicators to harmonize efforts from national level goals to the local level actions.

Footnote

1 A bund is an impervious embankment of earth, or a wall of brick, stone, concrete or other suitable material, which may form part or the entire perimeter of a compound that provides a barrier to retain liquid.

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Tables:

Table 1: Adaptation effectiveness indicators subjected to household surveys

CATEGORY	INDICATORS	Temporal nature of indicators
Environmental (Including Ecological) Effectiveness	Period of fresh water availability	Short-term
	Duration of water stress period	Short-term
	Number of droughts	Long-term
	Input use efficiency (output per unit of input in agriculture)	Short-term
	Vegetative cover (duration and extent)	Long-term
	Net primary productivity (total biomass produced by primary production systems)	Long-term
	Change in groundwater level	Long-term
	% of farms that have concerns related to soil erosion	Short-term
	Carbon storage in soil (organic matter content)	Long-term
	crop diversification (number of types of crops grown in an year)	Long-term
	Area under water logging	Short-term
	Biodiversity (Species used by local populations)	Long-term
	Nutrient balance in soil and water systems	Long-term
Social Effectiveness	Calorie intake per person (indicator of access to and availability of food)	Short-term
	% of income used for health care	Short-term
	% of households having access to sanitation facilities	Short-term
	% of households having access to information	Short-term
	% of children under the age of five with symptoms of malnutrition	Long-term
	% of households having access to safe drinking water	Long-term
	% of animals having access to safe drinking water	Short-term
	Employment rate	Long-term
	% of savings from income	Short-term
	Adoption rate of technology/practice	Long-term
	Literacy rate	Long-term
	Social capital (e.g. social networks, user group associations)	Long-term
	% of households having access to markets	Long-term
Economic effectiveness	Crop yield and yield variability	Short-term
	Increase in assets	Long-term
	Disposable income	Long-term
	% of non-agricultural income	Long-term
	Gross income of the household	Short-term
	Cost-benefit ratio and internal rate of return of adaptation options	Long-term
	inter-annual stability of Household income	Long-term
	% of households having access to credit	Long-term
	Damage per household due to drought	Short-term

Table 2: Statistical significance values of comparison of gender and indicators of effectiveness of adaptation options

	Pearson chi-square	**df**	**P value**
Gender vs. Indicators of Environmental effectiveness			
Rank 1	4.477	7	0.723
Rank 2	1.447	7	0.984
Rank 3	12.781	8	0.120
Rank 4	7.742	8	0.459
Rank 5	3.386	8	0.908
Gender vs. Indicators of Social effectiveness			
Rank 1	4.115	6	0.661
Rank 2	4.715	6	0.581
Rank 3	4.126	6	0.660
Rank 4	6.222	6	0.399
Rank 5	0.687	6	0.995
Gender vs. Indicators of Economic effectiveness			
Rank 1	8.275	5	0.142
Rank 2	1.032	5	0.960
Rank 3	3.988	5	0.551
Rank 4	4.754	6	0.576
Rank 5	3.208	5	0.668

Table 3: Statistical significance values of comparison of economic status and indicators of effectiveness of adaptation options

Comparison	Pearson chi-square	df	P value
Economic Status vs. Indicators of Environmental effectiveness			
Rank 1	16.839	14	0.265
Rank 2	26.291	14	0.024
Rank 3	34.758	16	0.004
Rank 4	17.600	16	0.348
Rank 5	19.019	16	0.268
Economic Status vs. indicators of Social effectiveness			
Rank 1	15.276	12	0.227
Rank 2	14.153	12	0.291
Rank 3	18.308	12	0.107
Rank 4	9.613	12	0.650
Rank 5	6.559	12	0.885
Economic Status vs. Indicators of Economic effectiveness			
Rank 1	9.033	10	0.529
Rank 2	15.771	10	0.106
Rank 3	10.750	10	0.377
Rank 4	5.563	12	0.937
Rank 5	3.166	10	0.977

Table 4: Statistical significance values of comparison of practice group and indicators of effectiveness of adaptation options

	Pearson chi-square	**df**	**P value**
Practice vs. Indicators of Environmental effectiveness			
Rank 1	12.030	7	.100
Rank 2	12.885	7	0.075
Rank 3	4.520	8	.807
Rank 4	18.823	8	0.016
Rank 5	3.451	8	0.903
Practice vs. Indicators of Social effectiveness			
Rank 1	2.747	6	0.840
Rank 2	6.609	6	0.359
Rank 3	5.714	6	0.456
Rank 4	4.254	6	0.642
Rank 5	6.087	6	0.414
Practice vs. Indicators of Economic effectiveness			
Rank 1	0.864	5	0.973
Rank 2	2.371	5	0.796
Rank 3	5.611	5	0.346
Rank 4	3.950	6	0.683
Rank 5	1.795	5	0.877