Interactive comment on "Hydrological, ecological, land use, economic, and sociocultural evidence for resilience of traditional irrigation communities in New Mexico, USA" by A. Fernald et al.

Anonymous Referee #1

Received and published: 6 March 2014

Response. We greatly appreciate the detailed comments. We provide specific feedback only on the ones that appear to call for comment or revision

General comments
This is an ambitious paper, and I understand that it is a discussion paper, not a standard research paper. I enjoyed reading much of the content and found it quite interesting. That said, I have two general comments and many specific ones that I think should be addressed prior to publication.

Comment: My first general comment is that it is difficult to follow the course that the article takes. Many topics are discussed, presumably by each of the different authors. I think this paper suffers from what many multi-authored papers suffer from, which is a lack continuity across the differently authored sections. -
Response: Went through and smoothed content from one writer's perspective.

Comment: As a result, it is sometimes hard to keep track of all of the questions and methods going on in this paper. Some of the language makes it sound like novel research was done for this paper, which feels odd given that it is a discussion paper. Also, the different sections are mostly unattached from each other. As an example, in section 3.1 a decrease in cattle and the implications of this for acequia adaptability is discussed. But then in section 3.2.1 we read about a shift towards a cattle-dominated system, and this is seen as an indicator of acequia strength and adaptability. How do we reconcile these different trends into one coherent story?
Response: Moved text to make more logical and fit together showing overall trends first and then more recent changes: Fig. 6 section after land use section to point out that even though cattle have dropped since the mid 1990s (Fig. 6), the overall pattern for a longer period of time (about 75 years) is that cattle have increased.

My second general comment is that this paper feels in parts more hopeful than empirical. By that I mean it feels like claims are made about the resilience of the acequias that are not necessarily supported by data. I am sensitive to this because I feel like I have seen this before, when the ecosystems service-based benefits supposedly derived from the acequias have been discussed. There is material out there that makes large claims that the acequias produce such benefits with little to no scientific documentation of this. I should say that I strongly suspect that such benefits exist, but this doesn't mean we can assume they do and claim this without doing the empirical work.

I would strongly urge the authors to avoid language that makes this paper feel like a rallying cry for the acequias. Even though many of us strongly believe in their importance, in my view that is not the appropriate role for scientific papers. One way this could be addressed is

to be clear on how much evidential basis there is for certain claims throughout the paper. Do we have (1) data, (2) scenarios/simulations, or (3) hypotheses as the basis for such claims?
Response: Revised text to highlight the evidence. Tried to emphasize the new data we do provide in this paper. For example, section 4.3 gives totally new data collected for this paper. Some of the hydrology data that were previously published are cited in addition to the brand new hydrology presented for the first time in this paper (see Figures 3,4,5)

Specific comments

Comment: There isn't really a segue into section 2.3 and it doesn't seem to fit very well with the rest of section 2 (which deals with acequia functionality as it interacts with larger-scale forces). I would try to include a better segue and make it fit better with this section, or drop it.
Response: We revised and added substantial text to make a better fit including link showing recent literature connections between acequias and ecosystem services.

Comment: For figure two I would think it would help to label when the irrigation input events occurred (one presumes before the spikes in the graphs, but it would be better not to have to assume this).
Response: Title reworded to avoid giving impression we are identifying every irrigation event and associated peak - Caption will instead refer to seasonal water table fluctuations in an acequia irrigated agricultural valley in northern New Mexico.

Comment: Page 1833, line 20: you say here that you found a "decrease in the average agricultural parcel size. . ." Doesn't this contradict your findings from the agricultural census data just previous discussed? How do you reconcile this contradiction?
Response: This has been reworded to indicate that the local village (Alcalde) did not follow the county wide trend for parcel size.

Comment: Page 1833, lines 26-30: you claim that a shift towards cattle production maintained the "resiliency" of the irrigation system" but I'm not sure how meaningful this statement is. In general I'm a bit fuzzy on what you mean by resiliency here, and sometimes it seems like you use it as a compliment to these systems, or an expression of hope more than as an empirically well-measured and well-documented fact.
Response: The sentence has been reworded.

***Comment*:** Sometimes you say "resilience" and sometimes you say "resiliency." I would use only one (and I prefer resilience, for what that's worth).
Response: Used resilience throughout manuscript.

Comment: Page 1835, line 14: what survey is this? And where was it conducted? How many respondents were there? Also I don't really understand the second half of this sentence . . . "strongest factors among those considered for contributing to the community's adaptive capacity, preparedness, and resilience." In general there are a lot of terms here that are used without much explanation (e.g. "strength" on line 20).
Response: Yes, agree that clarification is needed. This paragraph has been expanded to include more details.

Comment: Overall I don't really see how the concept of a "balance sheet" is needed to understand the results discussed in section 3.3. I have seen such results before, as they are widely discussed within the acequia communities and among those studying them, and I haven't seen them attached to this concept before.
Response: As to the use and application of the 'balance sheet' concept. It is true that it is not a concept commonly associated with or applied to acequia communities. The intent is to highlight that community welfare and well-being extend beyond traditional economic wealth and income measures to include 'cultural wealth' and 'environmental wealth.' The point is that important household decisions, for example, concerning willingness to sell and leave compared to willingness to hold on and remain in the community are driven by broader considerations than simple economic conditions. The balance sheet concept is meant to capture and reflect the integration of these multiple measures of combined wealth, and to highlight that flows into or out from one account (i.e., strengthen or diminish the wealth) can be balanced by activities affecting the other accounts. Balance sheet reflects the changes in the wealth balances across categories.

Comment: Section 4.1 feels like an introduction to acequias in general, which feels odd at this point in the paper after we have been talking about them for a while. I would probably move it up towards the beginning of the paper or greatly change the language.
Response: Moved text addressing general aspects to introduction

Comment: Section 4.2: it would be good to know a bit more about how this survey was distributed and to whom.
Response: The survey was distributed to acequia officers who serve as commissoners and mayordomos as the targeted group due to their knowledge about their local acequias. In some cases individual member irrigators completed the surveys when the governing body was not available. I have added this info to a revised paragraph for Section 4.2.

Comment: Figure 7: It would probably be good to label the years associated with the two drawings at the bottom of this figure.
Response: Figure was be redone.

Comment: Figures 9 and 10: The labels for the x-axis in each of these figures are excessively cluttered. You could cut out the word "farms" and I would cut down on the number of categories.
Response: Figures were revised to eliminate the word farm so that the graphs are less cluttered. However, it is important to leave the range in farm size which gives a more accurate depiction of the data examined.

Comment: Are figures 6 and 11 telling the same story with respect to cattle? It seems like they are not.
Response: The different time scales may appear to be telling different stories, but both figures are consistent with cattle numbers being lower in 2007 that 1975.

Comment: Figure 15: I wouldn't list every year here on the x-axis.
Response: Good suggestion, see corrected figure.

Technical corrections

Comment: Page 1831, line 15: I don't think "exemplify" is the right word here...
Response: "Exemplify" has been replaced with "illustrate."

Comment: Page 1831, line 24: I don't think "morphology" is the right word here.
Response: The word morphology is very appropriate because the term relates to a common methodological framework in the field of Urban Planning and Design. We would like to keep the text as written.

Comment: Page 1833, line 11: "Begins" should probably be past tense.
Response: Word changed to past tense.

Interactive comment on "Hydrological, ecological, land use, economic, and sociocultural evidence for resilience of traditional irrigation communities in New Mexico, USA" by A. Fernald et al.

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Response. We greatly appreciate the detailed comments. We provide specific feedback only on the ones that appear to call for comment or revision

General comments

Comment: The paper deals with an important issue in sociohydrology, which is linking the "socio" and the "hydrology", through a detailed case study in New Mexico. The title already reflects the ambition of this paper, but it also suggests the main pitfall at the same time. I agree that linking the diverse issues mentioned in the title are key to really develop an interdisciplinary approach based on socio-hydrological ideas, and it is obvious that this is rather challenging. However, the paper itself reads like a summing up of evidence from those different fields, with many promises of connections between them, but without connecting them too much in this paper. In itself, I have no problem with research-agenda setting papers, especially for new fields, and especially not for the type of research suggested in the paper. However, I have my doubts whether this paper is the one to go for.
Response: Changed title to Linked hydrologic and social systems that support resilience of traditional irrigation communities. Revised text with focus on evidence and linkages.

Comment: First, the different paragraphs seem to be collected from the different authors. *Style* and language differ, but what is more problematic is that each new issue starts with a (new) introduction of the case under study, the acequia system. New (interesting) information on the case study is spread out in the text, and would need to be synthesized earlier. The same goes for the data sets used and discussed, and the specific questions on those data. This paper may propose interdisciplinarity, but it reads like a multidisciplinary effort as it is now.
Response: Attempted to bring together content by topic instead of relying on originating author.

Comment: ***Second***, although it is clear that working on the socio-side of sociohydrology does require detailed understanding of those issues (labour, production strategies, organization), one would also expect that there is considerable attention for hydrology. The paper mentions hydrological issues a few times, but most of the hydrology seems to be based on the 2010 publication of the main author. The redistributing effects of irrigation on the natural hydrology (problematic as that term may be) are important indeed, but this new paper does not provide anything new on it, it seems to me.
Response: We provide new hydrology related data in Fig. 3, 4, and 5. We will describe these new data along with the new data in other sections of the paper as part of our renewed emphasis on evidence and data.

Comment: ***Third***, once connections with hydrology are made, the paper is full of "if" and "could". Anytime a connection between hydrology and society is assumed or suggested, one of those two words pop up. Indeed, this would fit in an agenda-setting paper, but if that agenda is not detailed too much, I would think it does not really work. The modelling approach briefly mentioned in the final pages, could be a description for many systems; what makes it specific for this one? How does it build on the one

already discussed in the 2012 Sustainability paper? How can the different data sets be related, what time steps are used, how to use both quantitative and qualitative data?
Response: In this paper we present substantial new evidence and data not published in the Sustainability paper. Instead of talking about the modeling we will do, we focus on the evidence from this paper that will form the basis of completing the model, and we emphasize that our combined data collection and community causal loop diagrams appear to show that there are different data sets from different disciplines that can all shed light on resilience.

Comment: Fourth, the suggestion is made that the acequia community is able to adapt pretty nicely. What I do miss, however, is more detail on the relevant socio-economic relations within that same community. I do not know that many social groups in which everyone wins in a process of change. I would be surprised this community would be the exception to that experience. But if so, more discussion would be needed.
Response: The suggestion that acequia communities may have adaptation capacity beyond those of more contemporary counterparts (e.g., urban and suburban neighborhoods) is not meant to imply that 'everyone wins' as the winds of change blow across the acequias. Rather, it highlights the reality that there has been a capacity shown by these communities to persist through long periods of time and to endure through significant stresses and challenges. The real question is whether or not those capacities remain intact under present circumstances, and is there any evidence that a 'tipping point' might be identifiable that could cause significant fissures that erode the long-enduring adaptive capacity of such communities.

Comments

Comment: Abstract: to what extent can climate changes, "specific practices" and "community cohesion" be analyzed on the same time scale?
Response: This a great question. Reworded to revise.

Already on the first page, words like "benefits" and "threaten" show where the sympathy of the authors is. That may be a little distracting?
Reponse: Attempted to clarify these and reworded to remove "threaten" on the first page.

Comment: Page 1824, line 25: change is not just an issue for traditional irrigation systems.
Response: Deleted "traditional" to be inclusive of other irrigation systems that depend on surface water.

Comment: Page 1825, line 9/10: this is a strong statement, but not really surprising anymore, given the thematic issue . . . it is not about the relevance of the connection, but about the how.
Response: We agree, but also feel this bears stating particularly for people who have not been involved in this discussion

Comment: Page 1825, last paragraph of intro: the language is rather optimistic, and a little general.
Response: No response required

Comment: Page 1825, line 23: how does one "increase water distribution"? One can distribute more water, but is that meant here?
Response: Reworded.

Comment: Page 1825, line 26: biological diversity suddenly drops in.
Response: Reworded for better transition.

Comment: Page 1826, first paragraph of 2.1: this may go to an earlier part of the paper?
Response: Moved other general acequia content to Introduction, so we left this where it was.

Comment: Page 1826 and figure 2: can the claims made be seen from one image, without comparing to another setting? I would need more explanation.
Response: Text is illustrating point we are making with this example transect. We cite Ochoa 2013 that shows graphs from larger area of Alcalde-Velarde valley. We are simply using this one figure to cite other paper.

Comment: Page 1827, last paragraph of 2.1: again a very general paragraph, what about the case?
Response: We are focusing on the aquifer here, so we don't think it works as well to move to Introduction. We are not sure what "what about the case?" refers to.

Comment: Page 1828, lines 19-21: only one example of the suggested results, but not based on any results, at least not explained.
Response: **This is intended to be conceptual based on evidence of groundwater return flow and expected climate change impacts**

Comment: Paragraph 2.3: the text does not really defend the species richness as a suitable proxy for the type of issues discussed in the paper, nor is the scenario selection explained. Are combinations of economic and environmental scenarios not taken into account?
Response: **Text revisions incorporated. The completed system dynamics model will incorporate economic and environmental scenarios**.

Comment: Page 1830, line 24: why is cattle reduction a sign of decreased stability? Why not see this as an indication of change, to which communities adapt?
Response: This is a good point. Perspective is important, as are the ranchers' specific reasons why they are decreasing numbers.

Comment: Paragraph 3.2: apart from some very general remarks, the direct link between land use and such to hydrology is completely absent in this part. I agree that the information presented would be useful, as it is hard to imagine no relation to hydrology, but how that link works in this case remains hidden.
Response: an example of a direct effect of land use change on hydrology is now included in the paragraph.

Comment: Page 1834, line 25: the concept of "storages" for capital assets may work on community level – even though I am not sure the concept of storage would hold in theoretical terms – but the issue of political-economic power relations to contribute to or extract from the "reservoirs" would need to be introduced as well. "The community" does not exist.
Response: This relates to the other reviewer's comment on the usefulness and appropriateness of the 'balance sheet' concept. I am puzzled by the last statement that 'the community does not exist.' How so? Cultural traditions, relationships, family-ties, sharing of resources and responsibilities, shared governance and shared values, and history, etc., form the bonds and give rise to the notion of community and importantly for the notion of cultural wealth. The idea of storages and reservoirs for this 'cultural wealth' is intended to imply that the manifestations of culture can be strengthened or weakened. The addition to or subtraction from these community-based bonds and commitments can affect, for example, individual households mobility decisions and hence affect land and water values, and the patterns of land tenure and ownership.

Comment: Page 1836, line 25, to page 1837, line 12: linking economic data to stream flows seems to be at the heart of sociohydrology, and could be a topic this paper discusses much more. Where is the stream flow measured? Is that taking into account the redistribution effects? If so, how does the human-natural system allow for using those data, as the two data sets are not independent anymore? Can flow be used as proxy for economic success? The text seems to suggest that economic success is independent from the water: what does this mean for the connection suggested in the paper between water and acequia success? Looking at image 15 suggests that the links may be different for the two different communities shown. What is the cause-effect direction? Does water drive the economy, or the other way around? This part of the text would be a possible focus for a deeper analysis. Although lines 4-7 on page 1837 suggest that not much is known yet about it?

Response: The present analysis of the correlation between agro-economic performance and streamflow is limited by available historical data. I agree that the relationship between the agro-economy and surface water patterns deserves additional and far deeper exploration, including a wider investigation beyond the current study area. It is clear that the strength and pattern of such a correlation is highly variable across communities if for no other reason than comparative reliance on surface and aquifer diversions is highly variable. The relationship is also complicated by the relative balance of irrigated crops and livestock enterprises. The latter being less susceptible to streamflow variations, and more easily supplemented by the importation of feed (and 'virtual water').

Comment: Page 1837 and further: the start of paragraph 4.1 is another example of a new introduction, with information that might have been used for a general introduction.

Response: Most of this section was moved to the introduction.

Comment: Page 1837, line 14: the concept of "traditional local knowledge" is highly problematic. I would not suggest that the authors show all details about the debate on such knowledge, but using the term here in such standard way does not do credit to the richness of issues and data sets this paper proposes to be of relevance. The paragraph is of rather general nature as well (eg lines 23-26 on page 1838, and lines 11 to 22 on page 1839).

Response: We have edited and moved this paragraph. Doing this should also help with the concern of repeating introductory information at the beginning of sections.

Comment: Paragraph 4.2: the survey results suggest that community members are concerned about participation, irrigation and infrastructure. What does this say about community resilience? How do community members use that concern? It at least shows that human agency is needed, but the paper does not take up that issue.

Response: The purpose of the two example charts from the NMAA survey was to highlight both important values that hold the members together, as well as elements that need strengthening. The NMAA in fact does take action to resolve needs and concerns by way of programs, workshops, and leadership development projects intended to assist acequias in recruiting youth (Sembrando Semillas project), train the next generation of mayordomos (Mayordomo Project), strengthen acequia administration (Governance Workshops) and recruit community leaders to take active roles in policy development (Escuelita de las Acequias project). With respect to infrastructure repairs, the NMAA holds workshops on how member acequias can qualify for ditch rehabilitation financing available from state and federal agencies. Lastly, the entire survey was designed and conducted by the NMAA with the explicit purpose of gathering information about "the overall concerns and trends of acequias in order to generate effective governance program planning and strategies that benefit acequias." This additional information is now included in a revised paragraph.

Comment: Page 1841, lines 7-9: “adaptability is self-evident” etcetera: this short sentence hides a larger problem, at least to me. Those acequia communities we find today are the winners per definition; they are the ones that survived. That may yield interesting data on what they did, but one would need some evidence of the “loosing groups” to be able to analyze success factors properly (?).
Response: The paragraph as written substantiates the historical record: acequias have demonstrated resilience despite changes in political administration and water law regimes of four historical periods (Spanish Colonial, Mexican Period. U.S. Territorial, and NM Statehood). The fact that they have not disappeared is testimony in and of itself. The reviewer does not quote this paragraph completely, since we also bring attention to "other disturbances, unexpected events, or changing climate that affects water supply." We say that "adaptability" is self evident by acequias as "human and social institutions." So, we don't claim that 100% of all acequias have survived, but that the institution of the acequia still operates and functions. The purpose of our study was not to compare winners and losers, or to determine factors of success versus failure. We recommend that the paragraph remain as written. This was also touched on in the response to the comment above, "*Fourth, the suggestion is made that the acequia community is able to adapt pretty nicely…”*

Comment: On the modelling approach, basically paragraph 5: how does one avoid that the proposed explanations of acequia resilience are not already included in the system dynamics? In other words, how to avoid that the modelling results are self-evident?
Response: This comment is unclear, because the intent is to include resilience in the system dynamics model.

Comment: Page 1846, lines 14 to 16: are acequias resilient because they are in line with nature (first sentence) or because they adapted/manipulated nature to be in line (second sentence)? What does this debate tell us about the human and the natural?
Response: Interesting question, and it is really both (in line with nature and adapted to nature).

Comment: Figure 1: why is the top-category “Growth”?
Response: We indicated “population” growth in the text.

Interactive comment on “Hydrological, ecological, land use, economic, and sociocultural evidence for resilience of traditional irrigation communities in New Mexico, USA” by A. Fernald et al.

Reviewer 3.

Response. We greatly appreciate the detailed comments. We provide specific feedback only on the ones that appear to call for comment or revision

Comment: (In response to"Presentation quality.") Many figures are proposed … but no maps to precise where are done the analysis and how it fit in the region
Response. Added map to situate New Mexico and upper Rio Grande study area for the reader.

***Comment. (In response to "*Are the scientific methods and assumptions valid and clearly outlined?") Because of the limited volume of texts, each part of the article is too shortly explained. I wonder if this article should be transformed in three articles introduced by a shorter one, preparing the articulations between each articles.
Response. The whole point of the paper is that we are trying to integrate disciplines, and if we separate out it will be by discipline and lose the original intent.

Comment. Geographical figures and comments are not well included
Response. We included the map.

Comment. The paper present only some final results (figures) with few calculation. One curious point is the 2095-2099 period of modelisation…
Response. 1994 was selected because there were good local data available for model calibration, then the 2095 -2099 period was selected as the simulation to represent 100 years later.

Comment. Maps of the region, the valley and cade studies should be included
Response. We included the additional map.

Comment. Some figures are difficult to read
Response. We revised multiple figures to make them somewhat easier to read.