Tien Dung Khong, Adam Loch, Michael D. Young

Perceptions and responses to rising salinity intrusion in the Mekong River Delta: what drives a long-term community-based strategy?

Science of the Total Environment, 2020; 711:134759-1-134759-11

Final publication at: http://dx.doi.org/10.1016/j.scitotenv.2019.134759

Elsevier Editorial System(tm) for Science of the Total Environment

Manuscript Draft

Manuscript Number: STOTEN-D-19-07389R1

Title: Perceptions and responses to rising salinity intrusion in the Mekong River Delta: what drives a long-term community-based strategy?

Article Type: Research Paper

Keywords: salinity, adaptation measures, smallholder farmers, Mekong River Delta

Corresponding Author: Dr. Tien Dung Khong, Ph.D

Corresponding Author's Institution: Can Tho University & The University of Adelaide

First Author: Tien Dung Khong, Ph.D

Order of Authors: Tien Dung Khong, Ph.D; Adam Loch, Ph.D; Michael Young, Professor

Abstract: This study analyses data on perceptions of the adverse impacts of salinity intrusion on rice farming in the Mekong River Delta. Collected from interviews with the head of 441 households and several focus group meetings, the data is used to provide an understanding of current adaptation or coping strategies and, from the insights gained make recommendations for the management of this increasing challenge. We find that most households are concerned about the impact of salinity intrusion on their livelihood and their capacity to cope in the future. Some strategies are already failing and many many farmers will struggle to adapt in the medium-term. Censored generalised Poisson regression and negative binomial regression models are used to identify and test the effectiveness of alternative management strategies. The results suggest that farmers have a preference for the construction of dykes as a means to prevent salinity intrusion. We conclude that farmer willingness to support the construction and improvement of dykes can be improved by providing more information and training.

Response to Reviewers: Response Letter - Ms. Ref. No.: STOTEN-D-19-07389
Title: Perceptions and responses to rising salinity intrusion in the Mekong River Delta: what drives a long-term community-based strategy?
Journal: Science of the Total Environment

Editor's comments:
Please see below the comments and suggested MAJOR revisions made by the individual(s) who reviewed your manuscript. If provided, the referee's report(s) indicate the revisions that need to be made before it can be accepted for publication in STOTEN. These reports are available as files you may download from the journal website. Authors are responsible for preparing their papers in correct English language. If the reviewers indicate that your manuscript requires substantial grammatical revisions in its present form, then you must address this concern. If this is the case, we strongly recommend that you get somebody to help you with the

grammatical editing of your paper. You will find help at the online submission website in the Author Information box by clicking on the Language Services link. Your manuscript will not be accepted unless both the technical and grammatical revisions have been made successfully. Please make the necessary revisions and return the manuscript to me within 4 weeks from the time you receive this message.

Response: We wish to thank the Associate Editor and two anonymous Reviewers for very helpful comments and valuable suggestions to improve our paper. We have carefully noted Associate Editor recommendations and each of the Reviewer comments, and responded to them in turn below.

Reviewers' comments:
Reviewer #1: This work consists of a survey carried out with the farming population of the Mekong River Delta in order to bring more understanding on the solutions and options to solve a quite severe salt water intrusion.

There are some minor details that need to solved:

On what concerns the abstract, on line 5, authors should consider writing the initials (MRD) after Mekong River Delta because they are written on line 18 without any former indication.

Line 440 - The reference Khong (2018) is missing in the references. Please verify if there some confusion with Khong et al. (2018).

Response: We have now revised as suggested—it should have been Khong et al.

In the references there is a general problem because the date is not placed after the authors.
I leave you with the reference style proposed by Elsevier:
https://www.elsevier.com/journals/science-of-the-total-environment/0048-9697/guide-for-authors

Text: All citations in the text should refer to:
1. Single author: the author's name (without initials, unless there is ambiguity) and the year of publication;
2. Two authors: both authors' names and the year of publication;
3. Three or more authors: first author's name followed by 'et al.' and the year of publication.
Citations may be made directly (or parenthetically). Groups of references can be listed either first alphabetically, then chronologically, or vice versa.
Examples: 'as demonstrated (Allan, 2000a, 2000b, 1999; Allan and Jones, 1999)…. Or, as demonstrated (Jones, 1999; Allan, 2000)… Kramer et al. (2010) have recently shown …'
List: References should be arranged first alphabetically and then further sorted chronologically if necessary. More than one reference from the same author(s) in the same year must be identified by the letters 'a', 'b', 'c', etc., placed after the year of publication.
Examples:
Reference to a journal publication:
Van der Geer, J., Hanraads, J.A.J., Lupton, R.A., 2010. The art of writing a scientific article. J. Sci. Commun. 163, 51-59. https://doi.org/10.1016/j.Sc.2010.00372

Reference to a journal publication with an article number:
Van der Geer, J., Hanraads, J.A.J., Lupton, R.A., 2018. The art of writing a scientific article. Heliyon. 19, e00205. https://doi.org/10.1016/j.heliyon.2018.e00205
Reference to a book:
Strunk Jr., W., White, E.B., 2000. The Elements of Style, fourth ed. Longman, New York.
Reference to a chapter in an edited book:
Mettam, G.R., Adams, L.B., 2009. How to prepare an electronic version of your article, in: Jones, B.S., Smith , R.Z. (Eds.), Introduction to the Electronic Age. E-Publishing Inc., New York, pp. 281-304.
Reference to a website:
Cancer Research UK, 1975. Cancer statistics reports for the UK. http://www.cancerresearchuk.org/aboutcancer/statistics/cancerstatsreport/ (accessed 13 March 2003).
Reference to a dataset:
[dataset] Oguro, M., Imahiro, S., Saito, S., Nakashizuka, T., 2015. Mortality data for Japanese oak wilt disease and surrounding forest compositions. Mendeley Data, v1. https://doi.org/10.17632/xwj98nb39r.1.e

Response: We appreciate and thank the Reviewer for pointing that out. We have corrected the reference style as suggested.

Reviewer #2: Review: Perceptions and responses to rising salinity intrusion in the Mekong River Delta

Overall the manuscript makes a potentially valuable contribution to the literature. The issue addressed is important and the scope of the analysis undertaken is significant and fundamentally solid. After some fairly significant revisions it should be a good candidate for publication in STOTEN.

Response: We appreciate this positive feedback and thank the Reviewer for these opening comments about the value of the paper and its findings.

The main issues that require further revision in my opinion are:

1. A need for better descriptions of econometric methods in many instances.

Response: We have rewritten and expanded our discussion of the econometric approaches to ensure that this is now clearer in the material section.

2. A need to separate results from discussion and to create two sections from the material that is currently in the results section. Once the authors have done this, I also believe that they will be able to provide better more decisive and clear conclusions and rationale for conclusions will be more easily understandable to the reader. The paper can also be made more concise in a number of places.

Response: We have considered this carefully and followed the Reviewer's advice. The Results are now separated from the Discussion sections such that the insights from the paper are now made more clear.

3. Increased citation in the first introduction section page. The section is oddly unbalanced with excellent citation backing assertation after line 59 and nearly no citation to back assertion on lines 27-59
Response: We agree with the Reviewer, and have included more citations from related previous research in literature into the introduction.

4. The writing is reasonably OK but can be improved in many instances. I note inconsistency in tense switching from past to present in some instances and some sentence that would benefit from more direct subject, verb, object construction followed by modify phrases.

Response: We thank the Reviewer for pointing this out to us, and we have rewritten where appropriate.

5. A fair bit of repletion, especially statements regarding policy relevance.

Response: We have re-arranged the order of discussion parts and revised statements of the results as per the Reviewer's suggestion.

Detailed comments
First figure - claim "secure 18 million …" seems possible over attribution, better to say "contribute to securing 18 million …"

Response: This figure has now been revised in the Graphical Abstract.

Intro
First sentence isn't necessary, can be deleted or if included note other rivers like Ganges that have same issue and add citation.
Comment 3 above

Response: This has since been deleted.

Line 42 better wording would be "loss of total yield"
Line 71 - "studies have been done" - a bit awkward – rephrase

Response: This has now been revised.

I don't think lines 84 to 93 and figure are necessary to me. I could understand what the paper is about without this. I suggest delete.

Response: These have since been deleted.

Materials and methods
161-168 - I'd suggest deleting this. This type of sample size calculation is for confidence interval in estimation of population proportion from a sample such as is used in polling. But the authors don't use such confidence intervals.

Response: This has since been deleted.

" it should be "Open-ended"

Response: Corrected.

178-9 drop "four data collection objective including"

Response: Deleted.

193-4 drop first part of sentence start at "The classification…"

Response: Deleted.

Lines 222 to 231 are pretty confusing could be much more succinctly described as "A Poisson regression for count data was employed to examine extent of farm household adaptation strategy uptake." Followed directly by sentence on 229-30 "the dependent variable …." And drop sentence starting on 227 and the one starting on 230.

Response: Revised in line with the Reviewer's suggestions.

Delete sentence on 242-244 - it's not clear what this is about and it's not necessary.

Response: Deleted.

253 - before begin of first sentence add phrase "For the district where salinity intrusion had already occurred". More general point is that different analyses you did were for different sub-samples or full sample. I often didn't know which until I dug down into text. Please remedy this throughout with a short statement upfront is each subsection.

Response: We have updated the text on this paragraph.

I didn't understand sentence on line 269-271. It's also one of many places where discussion is intermingled with results reporting. Please address point 2 in general comments.

Response: We thank the Reviewer for suggesting this as it is a good idea. We totally agree with the Reviewer, and this text has been moved accordingly.

286 presumably not "a Kruskal-Wallis H test" but rather "a set of Kruskal-Wallis H tests"

Response: Corrected.

286-291 - could you show difference graphically and discuss?

Response: It would be possible of course to graphically represent these differences, but we elected not to do that in this instance. However, we have added a new chart to the Discussion section that shows the perceived impacts for each group in contrast to the others and used that to guide the text that follows now that it is separated from the Results section.

335-8 - I wondered does this differ by district - can you comment on that?

Response: In our view the group/location aspects to the findings go hand in hand and we tended to aggregate them together in our analysis and interpretation. Reflecting on the comment we reviewed how we had interpreted the results to see if we had at any time separated the group characteristics from location characteristics and found that we always interpret it as impact related to location and exposure—which was the purpose of the groupings.

343 - I could see dark blue in my black and white print-out and you don't indicate figure number.

Response: We have changed the pattern fill in all figures into black and white print-out style to make it clear for any readers. We also added figure number as suggested.

368 you say "Only four strategies are significant" but figure 7 seems to show 13?

Response: Since four strategies are current public responses to salinity intrusion, 13 are alternative salinity intrusion mitigation options proposed for future public planned adaptation strategies. We have made this clearer by altering the text. We apologise for any confusion.

386-93 - most of the relating from steps proceeding justification is unnecessary wordy and make it less rather than more easily understood. The same applies to other parts of the manuscript.
I suggest - delete entire text lines 386-393 - just before "farm households …" on line 393 add - "A final step in the research was to investigate determinants of the extent (number of) adaptations made by" - or something similar.

Response: We agree that this was a little unnecessary, and so we have rewritten that section as suggested to clarify things.

397-398 confusing and unnecessary sentence - but what is needed here is a straightforward explanation of exactly what is the dependent variable.

Response: We agree with the Reviewer, and have added the text to explain the dependent variable in this sentence.

Section 3.3 - a general econometric question - this is essentially a censored Poisson distribution because count can only be as many as survey included options - is it then potentially less dispersed than actual Poisson, I'm not expert in Poisson but believe there are a few options to deal with this? The authors should investigate, at least comment and potentially change analysis if necessary.

Response: This is a very valid point, we appreciate and thank Reviewer for this. After testing for dispersed as the Reviewer suggested, rather than actual Poisson, both censored generalised Poisson model and negative binomial regression, which are appropriate with this type of data as indicated in literature, were employed in the revised manuscript version to reveal determinants of adaptation measures, and also enhance the reliability of the determinants from two proposed models.

406 - I think you mean "statistically significantly influence" – if correct, then say so.

Response: Corrected.

412-415 - It seems that you statistically tested but don't describe the test?

Response: Revised.

420-22 awkward sentence especially 422 - use more direct language like "undertook fewer adaptation strategies"

Response: Revised.

425-30 can't understand the basis for this assertion - also seems more like discussion than results per se.

Response: This has been addressed as per the suggested change above.

443-455 Again the econometric model description can be made shorter and more direct to enhance understanding. I also suggest to move sentence from 461-463 to 453 before sentence starting "The coefficients …"

Response: Revised.

482-488 again better suited to a discussion section and I don't understand basis for sentence starting on 481 " These results.."

Response: Revised. Again, we are grateful to the Reviewer for their attention to details.

Research Data Related to this Submission

There are no linked research data sets for this submission. The following reason is given:
Data will be made available on request

*Title Page

Perceptions and responses to rising salinity intrusion in the Mekong River Delta: what drives a long-term community-based strategy?

Tien Dung Khong[ab†], Adam Loch[a] and Michael D. Young[a]

[a] The Centre for Global Food and Resources, University of Adelaide, South Australia, Australia

[b] College of Economics, Can Tho University, Vietnam

[†] Corresponding author email: ktdung@ctu.edu.vn

Declarations of interest: none

Acknowledgments This work was supported by an Australian Awards Scholarship, managed by the Australian Department of Foreign Affairs and Trade; the data collection was assisted by Can Tho University College of Economics and Department of Agriculture and Rural Development of Cau Ke, Tra On and Vinh Thanh district.

Response Letter - Ms. Ref. No.: STOTEN-D-19-07389
Title: Perceptions and responses to rising salinity intrusion in the Mekong River Delta: what drives a long-term community-based strategy?
Journal: Science of the Total Environment

Editor's comments:

Please see below the comments and suggested MAJOR revisions made by the individual(s) who reviewed your manuscript. If provided, the referee's report(s) indicate the revisions that need to be made before it can be accepted for publication in STOTEN. These reports are available as files you may download from the journal website. Authors are responsible for preparing their papers in correct English language. If the reviewers indicate that your manuscript requires substantial grammatical revisions in its present form, then you must address this concern. If this is the case, we strongly recommend that you get somebody to help you with the grammatical editing of your paper. You will find help at the online submission website in the Author Information box by clicking on the Language Services link. Your manuscript will not be accepted unless both the technical and grammatical revisions have been made successfully. Please make the necessary revisions and return the manuscript to me within 4 weeks from the time you receive this message.

> ***Response:*** *We wish to thank the Associate Editor and two anonymous Reviewers for very helpful comments and valuable suggestions to improve our paper. We have carefully noted Associate Editor recommendations and each of the Reviewer comments, and responded to them in turn below.*

Reviewers' comments:
Reviewer #1: This work consists of a survey carried out with the farming population of the Mekong River Delta in order to bring more understanding on the solutions and options to solve a quite severe salt water intrusion.

There are some minor details that need to solved:

On what concerns the abstract, on line 5, authors should consider writing the initials (MRD) after Mekong River Delta because they are written on line 18 without any former indication.

Line 440 - The reference Khong (2018) is missing in the references. Please verify if there some confusion with Khong et al. (2018).

> ***Response:*** *We have now revised as suggested—it should have been Khong et al.*

In the references there is a general problem because the date is not placed after the authors. I leave you with the reference style proposed by Elsevier:
https://www.elsevier.com/journals/science-of-the-total-environment/0048-9697/guide-for-authors

Text: All citations in the text should refer to:
1. Single author: the author's name (without initials, unless there is ambiguity) and the year of publication;
2. Two authors: both authors' names and the year of publication;
3. Three or more authors: first author's name followed by 'et al.' and the year of publication.
Citations may be made directly (or parenthetically). Groups of references can be listed either first alphabetically, then chronologically, or vice versa.
Examples: 'as demonstrated (Allan, 2000a, 2000b, 1999; Allan and Jones, 1999)…. Or, as demonstrated (Jones, 1999; Allan, 2000)… Kramer et al. (2010) have recently shown …'

List: References should be arranged first alphabetically and then further sorted chronologically if necessary. More than one reference from the same author(s) in the same year must be identified by the letters 'a', 'b', 'c', etc., placed after the year of publication.
Examples:
Reference to a journal publication:
Van der Geer, J., Hanraads, J.A.J., Lupton, R.A., 2010. The art of writing a scientific article. J. Sci. Commun. 163, 51-59. https://doi.org/10.1016/j.Sc.2010.00372
Reference to a journal publication with an article number:
Van der Geer, J., Hanraads, J.A.J., Lupton, R.A., 2018. The art of writing a scientific article. Heliyon. 19, e00205. https://doi.org/10.1016/j.heliyon.2018.e00205
Reference to a book:
Strunk Jr., W., White, E.B., 2000. The Elements of Style, fourth ed. Longman, New York.
Reference to a chapter in an edited book:
Mettam, G.R., Adams, L.B., 2009. How to prepare an electronic version of your article, in: Jones, B.S., Smith , R.Z. (Eds.), Introduction to the Electronic Age. E-Publishing Inc., New York, pp. 281-304.
Reference to a website:
Cancer Research UK, 1975. Cancer statistics reports for the UK. http://www.cancerresearchuk.org/aboutcancer/statistics/cancerstatsreport/ (accessed 13 March 2003).
Reference to a dataset:
[dataset] Oguro, M., Imahiro, S., Saito, S., Nakashizuka, T., 2015. Mortality data for Japanese oak wilt disease and surrounding forest compositions. Mendeley Data, v1. https://doi.org/10.17632/xwj98nb39r.1.e

Response: *We appreciate and thank the Reviewer for pointing that out. We have corrected the reference style as suggested.*

Reviewer #2: Review: Perceptions and responses to rising salinity intrusion in the Mekong River Delta

Overall the manuscript makes a potentially valuable contribution to the literature. The issue addressed is important and the scope of the analysis undertaken is significant and fundamentally solid. After some fairly significant revisions it should be a good candidate for publication in STOTEN.

Response: *We appreciate this positive feedback and thank the Reviewer for these opening comments about the value of the paper and its findings.*

The main issues that require further revision in my opinion are:

1. A need for better descriptions of econometric methods in many instances.

Response: *We have rewritten and expanded our discussion of the econometric approaches to ensure that this is now clearer in the material section.*

2. A need to separate results from discussion and to create two sections from the material that is currently in the results section. Once the authors have done this, I also believe that they will be able to provide better more decisive and clear conclusions and rationale for conclusions will be more easily understandable to the reader. The paper can also be made more concise in a number of places.

Response*: We have considered this carefully and followed the Reviewer's advice. The Results are now separated from the Discussion sections such that the insights from the paper are now made more clear.*

3. Increased citation in the first introduction section page. The section is oddly unbalanced with excellent citation backing assertation after line 59 and nearly no citation to back assertion on lines 27-59

Response: *We agree with the Reviewer, and have included more citations from related previous research in literature into the introduction.*

4. The writing is reasonably OK but can be improved in many instances. I note inconsistency in tense switching from past to present in some instances and some sentence that would benefit from more direct subject, verb, object construction followed by modify phrases.

Response: *We thank the Reviewer for pointing this out to us, and we have rewritten where appropriate.*

5. A fair bit of repletion, especially statements regarding policy relevance.

Response: *We have re-arranged the order of discussion parts and revised statements of the results as per the Reviewer's suggestion.*

Detailed comments
First figure - claim "secure 18 million …" seems possible over attribution, better to say "contribute to securing 18 million …"

Response: *This figure has now been revised in the Graphical Abstract.*

Intro
First sentence isn't necessary, can be deleted or if included note other rivers like Ganges that have same issue and add citation.
Comment 3 above

Response: *This has since been deleted.*

Line 42 better wording would be "loss of total yield"
Line 71 - "studies have been done" - a bit awkward – rephrase

Response: *This has now been revised.*

I don't think lines 84 to 93 and figure are necessary to me. I could understand what the paper is about without this. I suggest delete.

Response: *These have since been deleted.*

Materials and methods
161-168 - I'd suggest deleting this. This type of sample size calculation is for confidence interval in estimation of population proportion from a sample such as is used in polling. But the authors don't use such confidence intervals.

Response: *This has since been deleted.*

" it should be "Open-ended"

Response: *Corrected.*

178-9 drop "four data collection objective including"

Response: *Deleted.*

193-4 drop first part of sentence start at "The classification…"

Response: *Deleted.*

Lines 222 to 231 are pretty confusing could be much more succinctly described as "A Poisson regression for count data was employed to examine extent of farm household adaptation strategy uptake." Followed directly by sentence on 229-30 "the dependent variable …." And drop sentence starting on 227 and the one starting on 230.

Response: *Revised in line with the Reviewer's suggestions.*

Delete sentence on 242-244 - it's not clear what this is about and it's not necessary.

Response: *Deleted.*

253 - before begin of first sentence add phrase "For the district where salinity intrusion had already occurred". More general point is that different analyses you did were for different sub-samples or full sample. I often didn't know which until I dug down into text. Please remedy this throughout with a short statement upfront is each subsection.

Response: *We have updated the text on this paragraph.*

I didn't understand sentence on line 269-271. It's also one of many places where discussion is intermingled with results reporting. Please address point 2 in general comments.

Response: *We thank the Reviewer for suggesting this as it is a good idea. We totally agree with the Reviewer, and this text has been moved accordingly.*

286 presumably not "a Kruskal-Wallis H test" but rather "a set of Kruskal-Wallis H tests"

Response*: Corrected.*

286-291 - could you show difference graphically and discuss?

Response*: It would be possible of course to graphically represent these differences, but we elected not to do that in this instance. However, we have added a new chart to the Discussion section that shows the perceived impacts for each group in contrast to the others and used that to guide the text that follows now that it is separated from the Results section.*

335-8 - I wondered does this differ by district - can you comment on that?

Response*: In our view the group/location aspects to the findings go hand in hand and we tended to aggregate them together in our analysis and interpretation. Reflecting on the comment we reviewed how we had interpreted the results to see if we had at any time separated the group characteristics from location characteristics and found that we always interpret it as impact related to location and exposure—which was the purpose of the groupings.*

343 - I could see dark blue in my black and white print-out and you don't indicate figure number.

Response*: We have changed the pattern fill in all figures into black and white print-out style to make it clear for any readers. We also added figure number as suggested.*

368 you say "Only four strategies are significant" but figure 7 seems to show 13?

Response*: Since four strategies are current public responses to salinity intrusion, 13 are alternative salinity intrusion mitigation options proposed for future public planned adaptation strategies. We have made this clearer by altering the text. We apologise for any confusion.*

386-93 - most of the relating from steps proceeding justification is unnecessary wordy and make it less rather than more easily understood. The same applies to other parts of the manuscript. I suggest - delete entire text lines 386-393 - just before "farm households …" on line 393 add - "A final step in the research was to investigate determinants of the extent (number of) adaptations made by" - or something similar.

Response*: We agree that this was a little unnecessary, and so we have rewritten that section as suggested to clarify things.*

397-398 confusing and unnecessary sentence - but what is needed here is a straightforward explanation of exactly what is the dependent variable.

Response*: We agree with the Reviewer, and have added the text to explain the dependent variable in this sentence.*

Section 3.3 - a general econometric question - this is essentially a censored Poisson distribution because count can only be as many as survey included options - is it then potentially less dispersed than actual Poisson, I'm not expert in Poisson but believe there are a few options to deal with this? The authors should investigate, at least comment and potentially change analysis if necessary.

Response*: This is a very valid point, we appreciate and thank Reviewer for this. After testing for dispersed as the Reviewer suggested, rather than actual Poisson, both censored generalised Poisson model and negative binomial regression, which are appropriate with this type of data as indicated in literature, were employed in the revised manuscript version to reveal determinants of adaptation measures, and also enhance the reliability of the determinants from two proposed models.*

406 - I think you mean "statistically significantly influence" – if correct, then say so.

Response*: Corrected.*

412-415 - It seems that you statistically tested but don't describe the test?

Response*: Revised.*

420-22 awkward sentence especially 422 - use more direct language like "undertook fewer adaptation strategies"

Response*: Revised.*

425-30 can't understand the basis for this assertion - also seems more like discussion than results per se.

Response*: This has been addressed as per the suggested change above.*

443-455 Again the econometric model description can be made shorter and more direct to enhance understanding. I also suggest to move sentence from 461-463 to 453 before sentence starting "The coefficients …"

Response*: Revised.*

482-488 again better suited to a discussion section and I don't understand basis for sentence starting on 481 " These results.."

***Response**: Revised. Again, we are grateful to the Reviewer for their attention to details.*

*Revised manuscript with changes marked

Click here to view linked References

Perceptions and responses to rising salinity intrusion in the Mekong River Delta: what drives a long-term community-based strategy?

Formatted: Bottom: 2.54 cm, Header distance from edge: 1.25 cm, Footer distance from edge: 1.25 cm, Numbering: Restart each page, Not Different first page header

Abstract

This study analyses data on perceptions of the adverse impacts of salinity intrusion on rice farming in the Mekong River Delta. Collected from interviews with the head of 441 households and several focus group meetings, the data is used to provide an understanding of current adaptation or coping strategies and, from the insights gained make recommendations -for the management of this increasing challenge.

We find that most households are concerned about the impact of salinity intrusion on their livelihood and their capacity to cope in the future. Some strategies are already failing and many many farmers will struggle to adapt in the medium-term.

Censored generalised Poisson regression and negative binomial regression models are used to identify and test the effectiveness of alternative management strategies. -The results suggest that farmers have a preference for the construction of dykes as a means to prevent salinity intrusion. We conclude that farmer willingness to support the construction and improvement of dykes can be improved by providing more information and training

~~Rice farming in the Mekong River Delta plays an important role in food security, rural household income, and Vietn Nam's economy through export. Current salinity intrusion is a major cause of rice productivity loss,. T and the risk of further impact across the Delta requires a risk reduction framework based on an in-depth understanding of farmers' salinity impact perceptions and current adaptation behaviours. In this study, we use focus group and survey methods to in a sample 441 farm households to collect data on salinity perceptions and adaptation behaviour. We find that most households expressed concerns about salinity intrusion impacts and their capacity to cope in future, and that households already impacted by salinity have adopted individual short-term strategies which vary in effectiveness.~~

Formatted: Highlight

Consistent with other research findings, this suggests that, while farm households have a good perception about the risk of salinity intrusion, many farmers will struggle to adapt to salinity intrusion using short- and medium-term approaches (e.g. altered planting windows). We therefore, therefore, identify alternative strategies and test the drivers of possible farmer adoption using a Poisson regression models. Our results indicate positive MRD farmer preferences for the construction of salinity intrusion mitigation as a means of long-term risk reduction. Further, by providing more information and training, local authorities can expect to enhance farmer's participation in public salinity intrusion risk reduction projects, and/or developing community-based projects in VietnamViet Nam.

Keywords salinity, adaptation measures, smallholder farmers, Mekong River Delta

JEL classification Q54, Q59

1 Introduction

Tropical river deltas around the world are experiencing decreased flooding and increased negative water quality impacts. VietnamVietnam's Mekong River Delta (MRD) isin particular has experiencinged rising levels of salinity intrusion in a manner that is significantly , with significantly associated reductingons in agricultural production and farm income. There are three causes of this salinity intrusion First, sSea-level rise is changing MRD hydrological conditions and increasing the pressure on the Deltato create increased pressure along coastal areas (Khong et al., 2019). Second, Tthe development of dams and reservoirs in countries upstream of the MRD has reduced freshwater flows in a manner that has further altered the hydrologic properties of the Delta, reducing freshwater flows (Kondolf et al., 2018). Third, farmers have been Finally, increasinged water extraction within the Delta so that they can to support annual three-rice crop agricultural systems. When all three of these processes come together the rate of has also reduced total freshwater flows to the sea necessary to stop the sea from intruding is significant (Dan, 2015; Khong et al., 2019).

The MRD covers an area of 4 million ha, 78% of which is used annually for rice production. It contributes more than 55% of VietnamVietnam's rice production and more than 85% of national rice exports (General Statistics Office of Vietnam, 2018). Under salinity intrusion impacts, rice yield loss estimates vary from 2.5 tons to 4 tons per hectare (or 18 to 30 per-cent of loss of total yield loss) depending on the area and level of impact (Khai et al., 2018). Salinity intrusion impacts have increased since the 2014-2016 period, especially during the dry season, enabling salt-water to intrude further inland to causinge significant negative impacts on rice yields. In total, nine out of 13 provinces in the MRD are now affected (The Vietnam Academy for Water Resources, 2015). In response to salinity intrusion, MRD farmers have adopted various strategies based on their own knowledge of farming and/or based on neighbour suggestions. These include changes to planting times, adjustments to fertilizer and chemical use, and accessing alternative sources of freshwater (e.g. groundwater) (Smajgl et al., 2015; Toan, 2014). However, while these strategies may provide some short-term mitigation, long-term adaptation benefits remain uncertain. Alternatively, infrastructure such as coastal sea dikes and sluice gates have been identified as a viable strategy for salinity intrusion risk reduction. Recent studies by Danh (2012)~~)~~ and Danh and Khai (2014)~~)~~ performed benefit-cost analysis to calculate the net present value of concrete sea dikes in the MRD. The analyses concluded that salinity intrusion mitigation benefits from concrete sea dikes would exceed the total costs, including construction and on-going operation and maintenance costs, with farmers as the principal~~e~~ beneficiaries. However, sea dike infrastructure construction, operation and maintenance would require significant public investment; which ~~Vietnam~~Vietnam would struggle to achieve (Danh and Khai, 2014; Khong et al., 2018).

As the primary beneficiaries of sea dike construction,~~,~~ MRD farmers could be called upon to contribute to fully fund its upfront and ongoing costs (Khong et al., 2019; Khong et al., 2018). To assess the potential for MRD farmer contributions toward this mitigation project, it will be useful to better understand their current salinity impact perceptions, as adaptation strategies are typically not effective without information about farmers' awareness and perceptions (Alam et al., 2017), and very few smallholder farms are able to adapt to climate variability impacts individually (Nyamadzawo et al., 2013). Further, successful policy implementation depends on the specific context in which mitigation is to occur (Dost, 2010; Hoornweg, 2011). A better understanding of current and intended adaptation strategies may positively inform program implementation and policy decision-making. For ~~Vietnam~~Vietnam, any lack of information about farm household perceptions of salinity intrusion risk may lead to ineffective individual and/or group adaptation measures (Alam et al., 2017).

Research on Numerous studies have been done on climate change adaptation behaviour and responses have been emerging in recent years. However, there is insufficient information and findings in the context of salinity intrusion (Ho and Ubukata, 2017; Khong et al., 2018). Moreover, private adaptation strategies are typically short-term in nature (Dubey et al., 2017), may be insufficient for reliable mitigation into the future (Ayanlade et al., 2017), and dependent upon the specific country context (Margulis et al., 2010). It has been suggested that more data about farmer perceptions and adaptation strategies are needed in Southeast Asia (Schad et al., 2012), together with accurate information for each farming season (Mamba et al., 2015). In addition, few previous studies have approached climate issues in details, and while even less have identified empirical evidence about the determinants of farmers' adaptation behaviour which is essential for vulnerability assessment design (Tánago et al., 2016). It is therefore also recognised that data improvements are required with respect to smallholder farmers, particularly the information and resources that they will need to adapt and cope with future conditions (Ayanlade et al., 2017). Therefore, compared with previous studies related to climate changes issues, the main contribution of this research is aimed to obtain more accurate and convincing findings related to MRD salinity intrusion. By providing descriptions and explanations about the divergence of adaptation measures and strategies that have been applied by farm households in the MRD we expect to offer insights, information and policy suggestions to government officers, policymakers and other researchers in this field. It is also expected that the study findings may enhance MRD farm household policy participation and acceptance. The following conceptual framework (Figure 1) was designed and applied during focus group discussion (FGDs) and a farm household survey based on the United Nations' Intergovernmental Panel on Climate Change classification of mitigation adaptation strategies (1994).

We are ultimately interested in: (1) whether farm households are aware of the causes and impacts of salinity intrusion on their livelihood and farming activities; (2) what independent strategies and measures farm households are currently adopting in response to salinity intrusion; (3) what salinity intrusion adaptation strategies (if any) farmers are intending to adopt in future; (4) what future planned public salinity intrusion mitigation strategies farm households would prefer by analyzing farmers' preferences on the introduction of concrete sea dyke long-term measures; and (5) what drives those decisions/preferences in order to propose relevant recommendations prior to the introduction of any large projects? It is expected that this study will contribute to the existing literature on climate risk response adaptations in developing countries by understanding how local farmers have tried to adapt to salinity intrusion, and provide insights about what adaptation strategies the Vietnamese national and local governments might explore for long-term salinity mitigation solutions.

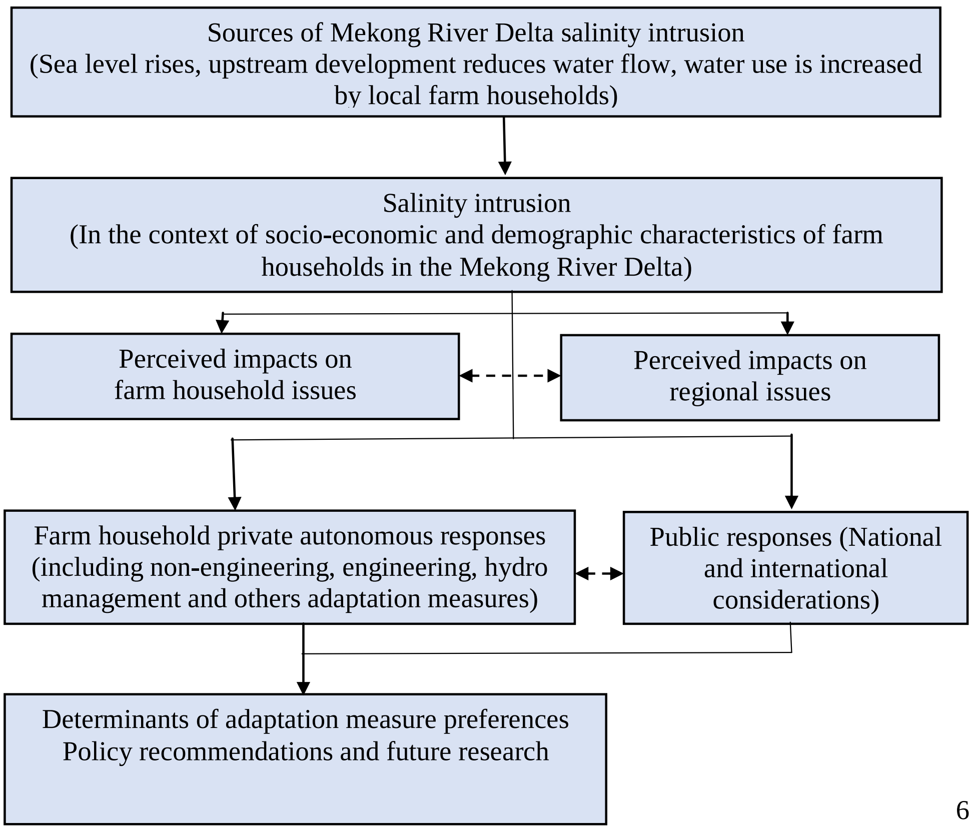


Figure 1. ~~Conceptual framework of matching salinity intrusion causes, farmers' adaptation strategies and drivers of public intervention as bases for this research~~

2 Materials and methods

2.1 Data collection

We used available data from the ~~Vietnam~~Vietnam Academy for Water Resources and maps of rice crop vulnerability to ~~sea~~ sea-level rise (Khang et al., 2008) to identify three ~~wo~~ survey areas. Two areas with different levels of salinity impact (*currently affected* and *at high risk*), and one area unaffected by salinity intrusion (*control group*). The area currently affected by salinity intrusion is the Cau Ke district located close to the coast of the MRD. The "at high risk of future salinity intrusion impact" area includes part of Cau Ke district and the Tra On district which is located further inland from the coast. Finally, the control-group area where there is very limited risk of salinity intrusion at present—or in the immediate future—is the Vinh Thanh district (Figure 1~~2~~).

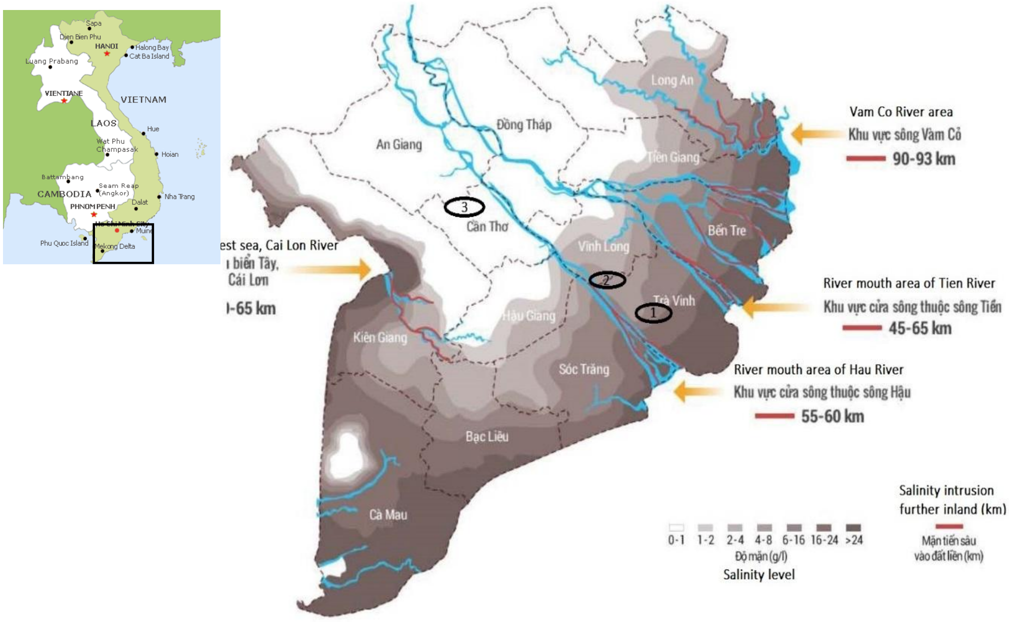


Figure 12. Mekong River Delta salinity intrusion levels in 2015 and the study area locations (1-Cau Ke district, 2-Cau Ke and Tra On districts, and 3-Vinh Thanh district)

Source: Adapted from Khong et al. (2018)), cited from the VietnamVietnam Academy for Water Resources (2015)

These districts were also recommended by local officials from the Department of Agriculture and Rural Development, who are knowledgeable about, and familiar with, the local characteristics of MRD farm households. Using a random sampling procedure, this study surveyed 441 farm households from the study districts listed above. A list of farm households was provided by government officers from the Department of Agriculture and Rural Development. Survey respondents were chosen randomly from these lists. The sample size (n) was achieved by using the following equation:

$$n = \frac{Z^2 p(1-p)}{d^2}$$

where *Z* equals 1.96 for a 95% confidence level, *p* is the probability of being selected into the sample (in this case 0.5 used for the sample size needed), and *d* is the confidence interval.

The number of farm households required for analysis based on this equation was 384. Thus, allowing for a margin of error, the study employed an objective to survey at least 150 farm households in each of the three different districts, with the aim of completing 450 observations in total. Before the official survey was implemented, the questionnaire was pilot tested with 30 -farm household-heads to ascertain whether or not farmers could understand the questions and information provided. The opportunity was also taken to test Moreover, technical language was noted for the enumerator comprehension of technical notes attached to questionnaire in a manner that would help to s to translate and/or explaiin concepts -to the farmers' in local/everyday language. Enumerators for the study were carefully chosen from

Formatted: Justified, Tab stops: Not at 11 cm staff and final year students with prior experience of farm household surveys at the Department of Agricultural Economics, Can Tho University.

2.2 Survey instrument

Based on the range of adaptation drivers specified in the previous section, open-ended categories were first used to identify perceptions of salinity intrusion drivers~~,~~ and to classify any private adaptation strategies adopted by farm households. The survey instrument was focused on ~~four data collection objectives including~~ (1) farmers' awareness of salinity intrusion causes and impacts, (2) current individual adaptation measures, (3) farmers' intention to adapt to salinity intrusion, and (4) perceptions of proposed public intervention strategies/measures.

However, farmers were not expected to be fully knowledgeable about future adaptation options~~,~~, especially at the public~~-~~ provision level. T~~herefore, t~~o identify possible future adaptation strategies and mitigation options~~,~~ focus group discussions (FGDs) were employed in advance of pilot-testing the survey instrument. This involved consultations with local experts (one in each district) from the Department of Rural Development in each survey area, and experienced rice farmers (three in each district)~~ who had lengthy experience with rice farming~~. The outputs from these FGDs were then used to formulate a series of close-ended questions focused on future adaptation options in the farm household survey.

The FGD~~s~~ approach resulted in a total of four adaptation strategy groups identified for use in the survey: i) non-engineering adaptations (e.g. crop changes); ii) engineering adaptations (e.g. earthen dikes); iii) hydro-management adaptations (e.g. new water sources); and iv) other adaptation measures (e.g. off-farm employment). ~~Although differences related to salinity intrusion causes and location characteristics exist, t~~The classification in this study is consistent with definitions from World Bank Group (2010)~~)~~, WHO - Regional Office for Europe (2002)~~)~~, and a recent study in America (Barlow and Reichard, 2010).

Ultimately, a series of seven-point Likert scales were employed to collect responses for perceptions about to salinity intrusion impacts (i.e. 1=No effect to 7=Extreme effect), drivers of salinity intrusion in the MRD (i.e. 1=Strongly disagree to 7=Strongly agree), the effectiveness of adopted strategies (i.e. 1=Very ineffective to 7=Very effective), and proposed future salinity mitigation programs (i.e. 1=Strongly disagree to 7=Strongly agree).

2.3 Data analysis

Likert scales are widely employed by marketing researchers for examining consumer behaviour, commercial market indicator evaluations, and public attitudes (Cabooter et al., 2016; Dawes, 2008; Green and Rao, 1970; Weijters et al., 2010). To date, a number of risk perception and attitudinal studies have also adopted/modified Likert-scale measurement in their field research (e.g. Le Dang et al., 2014). Different formats are often employed by different researchers, depending on the respondents and the research categories (Cabooter et al., 2016; Harpe, 2015). Researchers often find similar results using five- and seven-point scales (Dawes, 2008), and it has been suggested that the appropriate scale depends on the population survey and analysis target (Harpe, 2015; Weijters et al., 2010). ~~However, i~~In terms of a standard methodological recommendation,, however, the seven-point scale appears to be widely preferred because it contains a neutral position that enhances measurement quality (Nowlis et al., 2002) and avoids poor information recovery without overburdening respondents (Cabooter et al., 2016). Hence, the dimensions in this analysis were measured based on the seven-point Likert-type scale suggested by Vagias (2006)). An *ex-post* calibration was also employed to improve the certainty of farm household answers~~,~~ and the reliability of the findings. To do this, the perception and awareness questions were followed by a question asking farm household-heads to rank how certain they were about this choice on a scale of 1 to 3 (where 1=Not confident, 2=Confident, and 3=Very confident). Any farm household-head who reported a certainty level of one was asked to review their perception/awareness answer.

To estimate coefficients for drivers of adaptation strategy adoption~~,~~ regression models for count data w~~as~~ere employed to examine the extent of farm household adaptation strategy uptake. The Poisson, hurdle Poisson, truncated Poisson and the negative binomial models are considered ~~as~~appropriate statistical techniques for modelling count data (Famoye and Wang, 2004; Mahmoud and Alderiny, 2010; Ozonur et al., 2017). ~~D~~A detailed discussion of Poisson models can be found in Ozonur et al. (2017)~~, in which~~where the response variable $Y_j(j=1,....,n)$ has a Poisson distribution with mean of λ_i and the covariates are included in the parameter $\lambda_i = \exp(x_i^{'}\beta)$

$$f_{Y_i}(y_i) = \frac{e^{-\lambda_i}\lambda_i^{y_i}}{y_i\,!}$$

However, the Poisson model is appropriate ~~for a particular data set~~ only when the dependent variable follows the Poiss~~i~~on distribution with the conditional mean and conditional variance are the same, ~~this~~which is ~~called~~known as equi-dispersion (Mahmoud and Alderiny, 2010). In practical applications, when the data is over-dispersed or ~~the~~a restrictive assumption~~s~~ that the variance is equal to the mean made by the Poisson model ~~are~~is loosen~~s~~ed, negative binomial reg~~e~~ression models (NBRM) (Caudill and Mixon, 1995) and/or ~~the~~ censored generalized Pois~~i~~on regression models (CGPR) are more appropriate. ~~To estimate coefficients for drivers of adaptation strategy adoption, a Poisson regression model (PRM) for count data was employed to examine the determinants of farm household adaptation strategies at the individual level, and the drivers of farm household preferences for public adaptation strategic investment. This research focuses on providing empirical results from the model but a definition for, and detailed technical discussion about, PRM models can be found in Long (1997)) and Winkelmann (2008)). Based on the collected data, farm~~

Formatted: Font: Not Italic

Formatted: Lowered by 6 pt

Formatted: Font: Not Italic

Formatted: Centered

Formatted: Lowered by 15 pt

Formatted: Font: Not Italic

household adaptation choices offer multiple options and/or evaluation opportunities. Hence, t. he dependent variable will take a numeric form, denoting how many private adaptation actions have been adopted by farm households. In such cases, the PRM offers an appropriate multiple regression model (Long, 1997; Mahmoud and Alderiny, 2010; Winkelmann, 2008). In our data set, the variance of the dependent variable (67.58) is nearly five times larger than the mean (13.44) signalling . Hence, the distribution of it signs of over-dispersion. Moreover, thea Pearson goodness-of-fit resultsstatistic indicates that the distribution of dependent variable differs significantly differs forfrom that of a Poisson distribution (, according to the large value of Chi-square value of (453.0845) and thewith a Prob > chi2p value of– 0.000 (“Prob > chi2”) which falls below the 0.05 threshold). Therefore, we conclude that CGPR (Mahmoud and Alderiny, 2010) and NBRM (Famoye and Wang, 2004) models are more appropriate for our data set (Famoye and Wang, 2004) and . Thus we employ both CGPR and NBRM in order to identify determinants of adaptation measures. and also, compare the validity of these two models across count data type. In these twoCGPR and NBRM models, our dependent variable will take a numeric form, denoting how many private adaptation actions have been adopted by farm households, t. The modelled independent variables include farm households characteristics and theirfarmer perceptions about salinity intrusion risk impacts on their farming, livelihoods and related aspects..

Formatted: English (United States)

Finally, an ordered logit regression model was used to estimate specific drivers of MRD farm householdss’ preferences for the implementation and heightening of sea dike systems in this the area. (Frondel et al., 2017; Goebbert et al., 2012; Nikolopoulou et al., 2011) This adaptation strategy is proposed as a potential long-term public adaptation strategy investments and revealed as one of thewith strong farmer investment preferences for particular public adaptation strategy investments (see Figure 67). TheOther dependent

Formatted: Indent: First line: 0.5 cm

variables comprised strategies not currently included in the planned approach to salinity intrusion mitigation (e.g. training, implementing and heightening sea dike systems), selected based on the number of Strongly Agree responses provided by farm household survey respondents. We also expanded the vector of predicted salinity intrusion impacts across all observations in the three groups rather than focusing on farm household perceptions during the last three years.

Our selection of an ordered logit regression model wass were used based on a discussion by Clogg and Shihadeh (1994). This regression is suitable for modelling Likert scale dependent variables, and can also be estimated with censored dependent variables. Other detailed discussions related to applications of this model can be found in (Guagnano et al., 2016) and Hill and Fomby (2010). The results of these models are discussed in the following section.

3 Results and Discussion

3.1 Farm household perceptions of salinity intrusion impact

The majority (73%) of MRD farm household-heads are male with an average age of 47 years. Most farm households reported a relatively low level of education (up to secondary school), and high levels of experience working on farms (more than 23 years). These findings confirm our initial expectations of some limitations for survey engagement, requiring specific enumerator training and attention to language during the responses. The demographic characteristics of respondentsour respondents in our data indicatessuggests that our sample was drawn from households with sufficient tThea high level of farm experience , also increasesing our confidence to respond in the sampled farmers' ability to respond meaningfully to questions about salinity intrusion perceptions and awareness. Importantly for survey finding generalizability and policy guidance purposes the farm/er characteristics present in our survey sample, — together together with the survey household size and household income results, are — are broadly consistent with data metrics from the national VietnamVietnam Household Living Standard Survey (VHLSS) -which is a national survey of the Vietnamese population conducted every two years by the VietnamViet Nam General Statistics Office (GSO).

3.1.1 Perceptions of salinity impacts

For the district where salinity intrusion had already occurred, wWe first asked farm household-heads how salinity intrusion hasd affected their family and region by asking *"For your worst affected plot, to what extent do you think salinity intrusion has affected your household to date?"* The results reveal that over 60% of respondents rated salinity intrusion results as having negative influences on their agricultural output/productivity and farm income. Since freshwater provides essential functions for rice paddy farming, nearly 50% of respondents also perceived that salinity intrusion had had negative effects on their water supplies for agricultural activities—although far fewer were concerned about impacts on daily water supplies (Figure 32).

Noticeably, the fourth fourth-highest observed perceived impact of salinity intrusion in our survey results was mental health, which we elaborate on later. Our findings are consistent with other studies of broader issues suggesting that climate change-related issues affect both physical and mental health (Berry et al., 2011). One explanation may be that physical impacts of flood or drought events are more immediate, manifesting as sickness or famine over shorter periods (i.e. months), while the impacts of salinity intrusion take longer to manifest (i.e. years) with an attendant mental toll. However, since the data related to mental problems in this study stem from one Likert scale answer it is necessary to conduct more research before drawing any wider policy implications. Temporal aspects to salinity intrusion may

Formatted: Indent: First line: 0 cm

also explain the roughly equal split between farmer perceptions of regional economic impacts. While some are experiencing problems at present, other districts would have less familiarity with regional changes. This highlights a need for more data collection with regard to health impacts, as well as improved information from local authorities to farmers in currently/future affected districts about salinity intrusion.

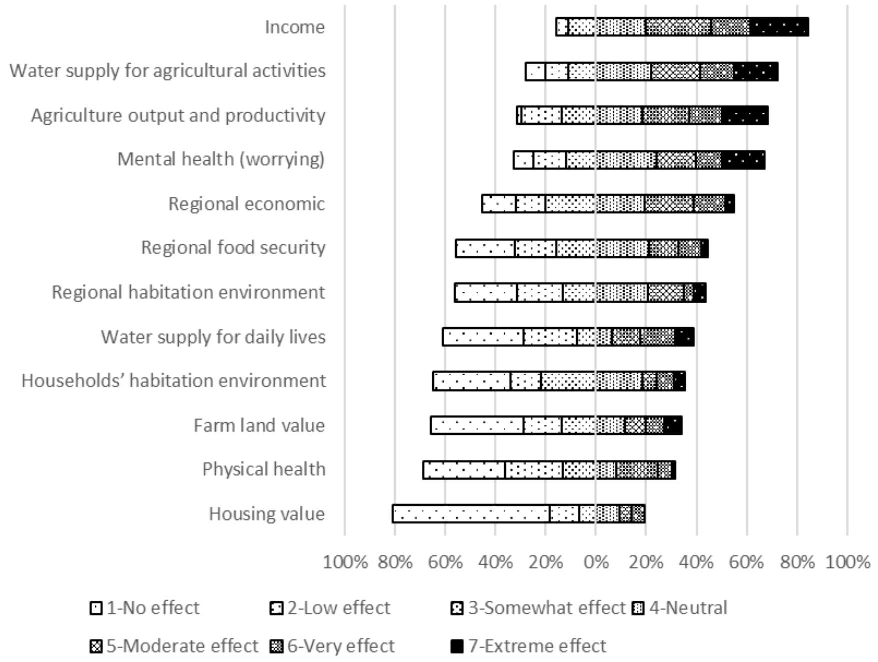


Figure 23. Distribution of perceived salinity intrusion impacts on farm household and regional issues (n=146 - Only included Group One where salinity intrusion has occurred)

3.1.2 Future perceived salinity impacts

Next, household-heads were asked to indicate their perceived salinity intrusion impacts if nothing were done over the next three years to mitigate its effects. Again, more than half of the respondents indicated that salinity intrusion would be expected to have an extreme effect on their agricultural output, productivity and income as well as negative impacts for water supply and farmland values in the long-term. Interestingly, the expected future impacts of

Formatted: Indent: First line: 0.5 cm

salinity intrusion on income were less than those for agricultural output, possibly suggesting an intention by farm households to explore income diversification within that period (Figure 43). A set of Kruskal-Wallis H tests was conducted to determine if farm households' perceptions about salinity intrusion impacts were different across the three groups and even different areas.. Unsurprisingly, the test showed that there was a statistically significant difference in each dimension between the three groups, with significanceet levels (p-value of $\chi^2(2)$) below the standard threshold of 0.05. Theis result suggesteds that farm household perceptions were shaped by their location and exposure to salinity intrusion risk, which is consistent with other adaptation research (Alam et al., 2017).

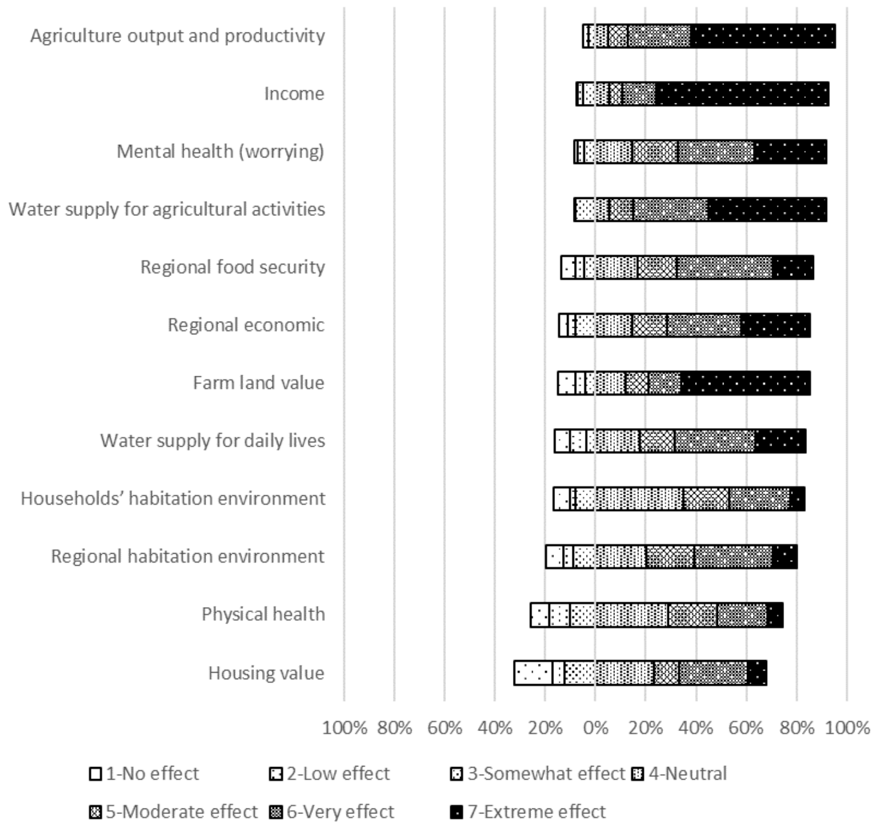


Figure 43. Distribution of expected salinity intrusion impacts on farm households' and regions over the next 3 years (n=441)

3.1.3 Perceived causes of salinity impacts

Each farm household head was then asked to identify their perceived causes of salinity intrusion in the MRD, ranging from 1=Less important to 4=Most important. In general, most farm households are very aware of the major causes of MRD salinity intrusion, with ≥50% of respondents identifying that ~~sea~~ sea-level rise, upstream development impacts on river flows~~,~~ and drought are the main causes. ~~However, m~~More than 70% of farm household-heads in the MRD viewed increasing water demand (e.g. to support three-crop rice production) as a less important reason for salinity intrusion. ~~This suggests that, although changes to three-crop rice production systems in recent years has required increased water usage in the MRD, few farm households appear to have made the connection between that and increasing salinity levels. This may drive both a continued reliance on private short-term autonomous adaptation strategies, as well as a requirement for public planned adaptation interventions, if the effectiveness of these strategies reduces over time. Interestingly, recent evidence suggests that third-rice cropping strategies are already becoming less effective, with lower productive returns and higher chemical costs (Dan, 2015). The following section~~We ~~therefore~~, therefore, ~~explores~~looked to identify current and intended autonomous adaptation responses at the farm and regional levels.

3.2 Private and public responses to salinity intrusion

3.2.1 Farm household autonomous responses

Those farm households located in the current salinity intrusion affected area were asked to indicate any adaptation strategies they had adopted~~,~~ and ~~their~~ its effectiveness. Only a small number of farm households had failed to adapt in any way. The majority of farm households had adopted at least one autonomous strategy over the last three years, consistent with other

Formatted: Normal, Line spacing: single studies that find farmers generally apply more than one adaptive strategy to cope with adverse impacts (Alam, 2015; Trinh et al., 2018).

The most popular non-engineering adaptation measures were changes to farming systems through altered planting times, shifting to other crop varieties, changed irrigation schedules and altered uses of farm inputs (e.g. fertilizer). Again, this supports studies which find that changed planting times are a popular adaptation strategy in the MRD (Van et al., 2015). Farm households also indicated the successful adoption of engineering strategies such as independent dike structures, dredging of local canals, increased water storage in farm dams or ponds, and water-saving techniques; all with reasonable perceptions of effectiveness (Figure ~~5~~4).

Figure ~~5~~4. Distribution of the effectiveness of salinity adaptation strategies adopted by farm households (n=146)

~~However, effectiveness results f~~For farm households that explored shifting from rice to aquaculture or livestock~~,~~ and/or sought off-farm employment activities~~,~~ the strategy-effectiveness, however, results were relatively lower, suggesting limited success. This may be due to the fact that changes of this nature require new skillsets and training, which may be challenging for farmers with low levels of education and limited non-farming experience ~~away from the farming environment~~. Notably, many of the autonomous strategies listed appear to score mixed effectiveness results, which may be an indication of their short-term nature depending on the location of the farm and relevant exposure to salinity impacts.

3.2.2 Intended adaptation responses

Following our exploration of current adaptation strategies, we asked all ~~the~~ respondents~~MRD farmers~~ to identify any adaptive strategies that they intended to adopt in future. Most reported an intention to continue with autonomous adaptation strategies such as changes to planting times, irrigation schedules, and input usage. However, as indicated by the darkest colour ~~blue~~ areas (Figure 5), the strongest future adaptation strategy adoption preferences were for salt-tolerant crop varieties and engineering measures such as canal dredging and dike maintenance/heightening. Increased access to information from local and national authorities also rated quite strongly. By way of example, salt-tolerant varieties are only suitable in areas where salinity is moderate, but many farmers remain unaware of this limitation.

Many farm households also believed that agricultural insurance could be an effective future strategy to salinity impacts (25% strongly agree) which we also return to later. ~~This is of interest, as many studies suggest that agricultural insurance, particularly in developing countries such as Vietnam, is not very effective (Khoi, 2014; Thong, 2014). Most farmers do not participate in agricultural insurance schemes due to low affordability and availability~~

from insurance providers. Finally, the very low intended migration of farm households away from the MRD should be carefully noted, along with its implications for the importance of future policy/programs to mitigate salinity intrusion impacts. Farmers do not seem willing to leave the area, and therefore careful attention may be needed to ensure effective public interventions in support of those intentions (Figure 56).

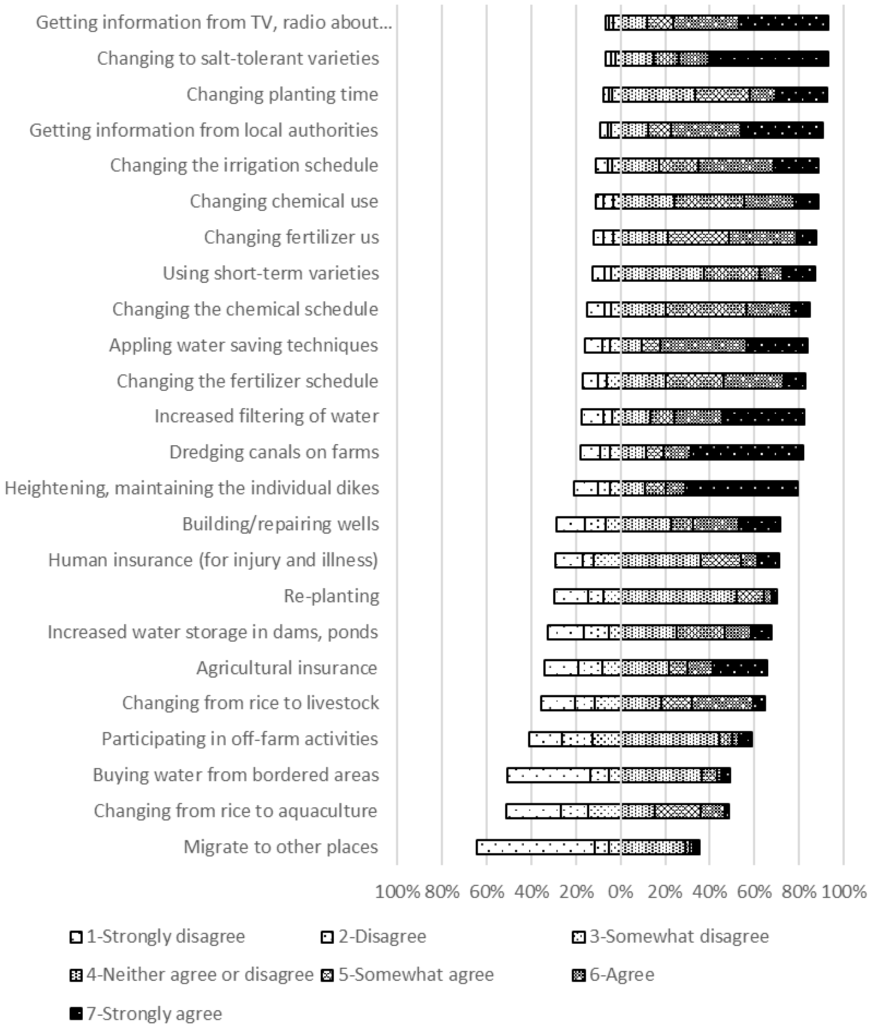


Figure 65. Distribution of intended future salinity adaptation strategies (n=441)

Note: The aggregate percentage in some is less than 100 per cent since several households did not apply any adaptation measures/strategies, and observations are only included farm households where salinity intrusion is already present.

3.2.3 Public responses to salinity intrusion risks

With regard to current public responses to salinity intrusion, farm households in three districts ~~of~~in the survey area were asked to identify relevant programs/strategies and evaluate the perceived effectiveness of those options. Only four strategies were reported, all with reasonable levels of effectiveness as far as farmers were concerned. Of those, training programs enjoyed relatively low levels of effectiveness perception~~,~~; which is of some ~~may be~~ concern~~ing~~ as training for risk mitigation has been recommended ~~is suggested~~ as an important driver of farmers' adaptation decisions (Trinh et al., 2018). Overall, however, the support by farmers for current MRD mitigation strategies appears solid.

Finally, farm households were asked to indicate alternative salinity intrusion mitigation options for future public planned adaptation strategies (Figure 6). In addition to the current strategies identified above~~,~~ farmers stated their short-term preference for additional salt-tolerant crop varieties~~,~~ and increased ~~information~~ information-communication programs (~50% Strongly agree). In terms of longer-term adaptation,~~;~~ the implementation of early-warning systems, updat~~ing~~ed freshwater supply systems, river-mouth sluice gate construction, and sea dike heightening/changes to concrete construction were the most popular strategies (>60% strongly agree~~)~~—with sea dike heightening recording the highest overall Strongly agree response~~)~~ ~~. This offers useful insight for policy-makers and local authorities in their consideration of future long-term adaptation solutions to salinity intrusion in the MRD~~ (Figure ~~7~~6).

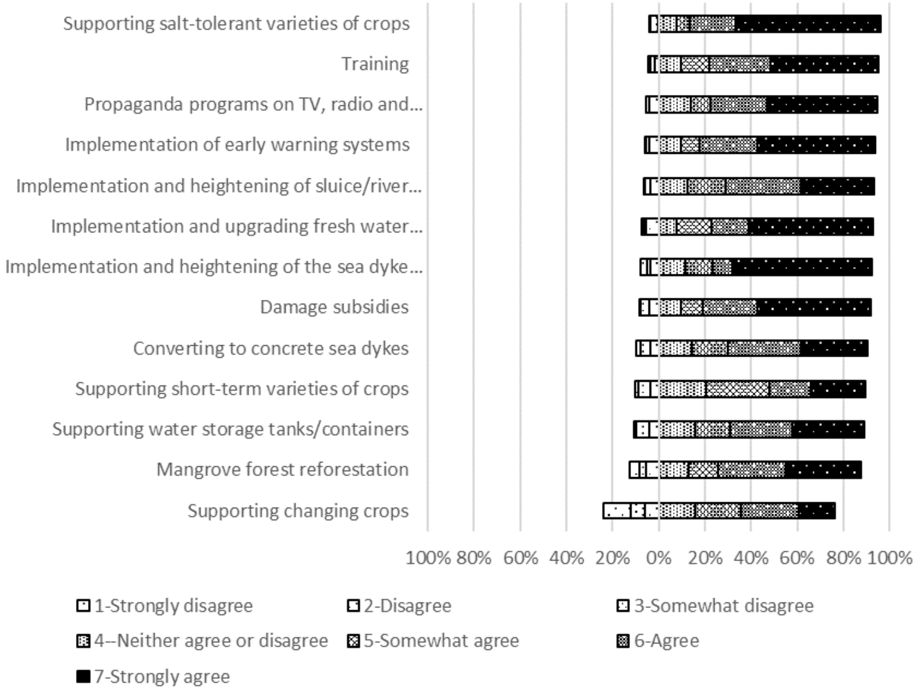


Figure ~~7~~6. Distribution of farmers' responses for future public strategies (n=441)

3.3 Determinants of farm household adaptation preferences

~~We have seen that farm households in the MRD are aware of salinity intrusion impacts, that they are taking steps both now and in the future to adapt to those impacts, and that they have preferences for what public authorities might do to support their adaptation. It only remains then to investigate what drives farmer different adaptation strategy choices as a source of further information for those policy-makers interested in requirements for planned interventions. Recall that our research hypothesis indicates critical factors determining adaptation strategy choices and household capacity to adapt to salinity intrusion impacts. These factors are directly related to~~ Table 1 illustrates the determinants of ~~the extent~~ 24 different adaptations made by farm households' based on a range of socio-demographic characteristics (i.e. the gender of the household head, number of household members, education level, the age of the household head, experience working on farms and household

Formatted: Indent: First line: 0.5 cm income), and farm household perceptions about salinity intrusion impacts at individual and regional levels.. Initial tests for multicollinearity were undertaken using the Variance Inflation Factor (VIF) checks, with the resultant values indicating no significant multicollinearity issues (i.e. all VIF less than 5.0). The parameters estimates and their significantce level using both NBRM and CGPR models are givenshown, with both models returning largely similar estimates. Slight differences include It shows closer estimates to the CGPR and NBRM, only some small differences such as "the impact on housing value" which is less significant underin the NBRM at the 10% level than the but it significant under CGPR model at 5%. Therefore, it indicatesThis supports our earlier view that modelling under-dispersed data using both NBRM and CGPR is appropriate than the conventional Poisson regression model and can be usedgiven our capacity to check the reliability of determinants betweenacross the two models.

We combined these variables in the Poisson regression model of adopted strategies over the last three years to identify influential factors in those choices. Initial tests for multicollinearity were undertaken using the Variance Inflation Factor (VIF) checks, with the resultant values indicating no significant multicollinearity issues (i.e. all VIF less than 5.0). TheA test offor the the over-dispersion parameter alpha was also performed byusing the Pearson likelihood--ratio test. The result indicates that alpha is significantly different from zero, therefore, it is confirmed thatconfirming our use of the both NBRM and CGPR are appropriatedmodels. The results also provide broad confirmation for the research hypothesis by indicating that the model is well—-explained by the independent variables (Prob>chi2=0.0000), while identifying some critical variables influencing farmer adaptation decisions.

). (Mahmoud and Alderiny, 2010){Mahmoud, 2010 #552}{Mahmoud, 2010 #552}

Formatted: Indent: First line: 0 cm

~~Table 1 shows the estimated parameters of the PRM in terms of autonomous adaptation actions. The results provide broad confirmation for the research hypothesis by indicating that the model is well explained by the independent variables (Pseudo R^2 = 0.2445, Prob>chi2=0.0000), while identifying some critical variables influencing farmer adaptation decisions.~~

Formatted: Indent: First line: 0 cm

Seven factors have a statistically~~ly~~ significant~~ly~~ positive ~~positively~~ influence on increas~~inged~~ numbers of adaptation strategies~~,~~ including~~:~~ increased willingness-to-pay for collective salinity mitigation programs, age, salinity intrusion impacts on housing and farmland values, water supply, physical health, ~~and~~ impacts on ~~the~~ regional economy, and habitation environment. On the other hand, six indicators were found to be statistically significant and negatively associated with greater adaptation strategy adoption~~,~~ including ~~increased willingness-to-pay for collective salinity mitigation programs,~~~~:~~ increased farming experience, larger household sizes, larger impacts on mental health, higher changes to local habitation or environment, and concerns about regional food security. Noticeably, for those who have already tried to adopt more strategies over the last three years, the level of willingness-to-pay for risk reduction ~~decreases~~increases—which is expected where higher private adaptation would be viewed as offsetting any future public interventions ~~requirement~~from international agencies or the Vietnamese~~Vietnam~~ central government. This result is ~~are necessary, this result is~~ also consistent with recent research by Khong et al. (2018; 2019).

Formatted: Indent: First line: 0 cm

In addition, t~~T~~hese drivers are all broadly consistent with other studies into climate change adaptation in ~~Vietnam~~Vietnam (Nguyen et al., 2017); although other drivers such as off-farm experience and income were found to be relevant for different study areas (Ayanlade et al., 2017). Experienced farmers have a greater understanding of salinity intrusion impacts, and exercise caution when adopting new strategies in response. Further, farm households with more higher membership have more opportunities (and incentives) to seek alternative income sources, which leads to undertook fewer adaptation strategies being undertaken. This point is supported by the fact that in this study there are only slight differences in annual income among the currently affected, high future risk, and control group districts .

Overall, these statistically significant factors would seem to suggest that if autonomous adaptation strategies reduce over time, or begin to fail with individual (physical/mental health), private asset (house/land value), community (habitat/environment), and/or regional (food security/economy) impacts, increased planned interventions may be sought as an alternative approach (Table 1).

Table 1. Estimation results of the Poisson negative binomial regression model (NBRM) and censored generalised Poisson regression (CGPR models) (PRM) estimates of adaptation strategy choices for Group 1: Currently affected area (n=146 Group 1 - already affected areas)

Indicators	Description	Mean	Min	Max
Dependent variable				
Strategies adopted	Numeric variable	13.445 (8.1922)	0[1]	24
Independent variables	Description	Coefficients NBRM	P-valueCGPR	VIF
Willingness to pay[2]	1=Yes, 0=No	-0.2690.407***	0.0000.357***	1.25
Household head's age	Numeric variable	0.0260.026***	0.0000.024***	4.87
Household head's gender	1: Female, 0: male	0.038-0.008	0.5680.026	1.46
Household head's education	From 0 to 5	0.0250.012	0.2540.018	1.31
Household head's farming experience	Numeric variable	-0.019-0.019***	0.000-0.017***	4.50
Farm household size	Numeric variable	-0.058102***	0.008-0.064***	1.17
Farm household income	Numeric variable	-6.403.70e-07	0.110-4.66e-07*	1.28
Impact on income	7 point scale	0.008-0.009	0.7230.011	1.97
Impact on housing value	7 point scale	0.044*44	0.0540.047*	2.58
Impact on farm land value	7 point scale	0.062068***	0.0000.055***	2.46
Impact on agricultural output and productivity	7 point scale	0.020024	0.3260.016	2.48
Impact on water supply for agricultural activities	7 point scale	-0.001006	0.945-0.001	1.50
Impact on water supply for daily lives	7 point scale	0.026032*	0.0840.026*	1.85
Impact on physical health	7 point scale	0.1273***	0.0000.123***	3.01
Impact on mental health	7 point scale	-0.12936***	0.000-0.122***	2.02
Impact on households' habitation environment	7 point scale	-0.111121***	0.000-0.104***	3.24
Impact on regional food security	7 point scale	-0.07968**	0.001-0.059***	2.59
Impact on regional economics	7 point scale	0.0966***	0.0000.091	3.64

Formatted Table
Formatted: Centered
Formatted: Superscript
Formatted: Superscript
Formatted: Superscript
Formatted: Superscript
Formatted: Superscript
Formatted: Superscript
Formatted: Superscript
Formatted: Superscript
Formatted: Superscript
Formatted: Superscript
Formatted: Superscript
Formatted: Superscript
Formatted: Superscript

			***	
Impact on regional habitation environment	7 point scale	0.061104**	0.0350.054*	4.74
Cons		2.1231.732***	0.0001.593***	
/lnalpha		-1.682		
Alpha		0.186		
Log-likelihood		-472.729	-534.459	
LR chi2		79.20	355.58	
Prob>chi2		0.000	0.000	
Pseudo R2		0.077	-	
N (sample size)			146	
Log-likelihood		-538.08491		
LR chi2		348.33		
Prob>chi2		0.0000		
Pseudo R2		0.2445		
N (sample size)		146		

Likelihood-ratio test of alpha=0: chibar2(01)=123.46 Prob>=chibar2=0.000

Notes: ***, **, and * are statistically significant at 1%, 5% and 10% levels, respectively. Numbers in parentheses are Standard deviation.

(1) Zero values for the dependent variable here indicates that, although some farm households are currently affected by salinity intrusion, they have not adopted any adaptation strategies or measures.

(2) Since this research is part of wider research conducted by the authors, this value indicates farmers' willingness-to-pay level for a salinity intrusion risk reduction fund which was discussed and published in Khong et al. (2018)

3.4 Determinants of farm household preferences for planned adaptation

We estimated a second model to gain additional insight into the drivers of farm household preferences for a long-term public adaptation strategy. The dependent variable comprised strategies not currently included in the planned approach to salinity intrusion mitigation (e.g. training, implementing and heightening sea dike systems), selected based on the number of Strongly Agree responses provided by farm household survey respondents. We also expanded the vector of predicted salinity intrusion impacts across all observations in the three groups rather than focusing on farm household perceptions during the last three years.

Ordered logit regression models were used based on a discussion by Clogg and Shihadeh (1994)). This regression is suitable for modeling Likert scale dependent variables, and can also be estimated with censored dependent variables. Other detailed discussions related to

Formatted: Superscript

Formatted: Superscript

Formatted: Superscript

Formatted Table

Formatted Table

Formatted: Indent: First line: 0 cm

applications of this model can be found in (Guagnano et al., 2016) and Hill and Fomby (2010)). Once again, the VIF scores for each independent variables were less than five, indicating no serious multicollinearity. Table 2 presents the results for the sea dike construction projects as one of the most effective mitigation options currently offered in this area (Danh, 2012; Danh and Khai, 2014; Khong et al., 2018). Once again, the VIF scores for each independent variables were less than five, indicating no serious multicollinearity. The coefficients and marginal effects (average marginal effects) of the determinants of farmers' preferences of long-term public adaptation measure are presented. It should be noted that in the ordered logit model instead of coefficients, marginal effects are used to interpret the influences of the variance of the independent variables per unit on the dependent variable. The likelihood ratio Chi-square of 126.78 with a P-value of 0.0000 indicates that this model as a whole is statistically significant. Table 2 presents the results for the sea dike construction as one of the most effective mitigation options currently in this area (Danh, 2012; Danh and Khai, 2014; Khong et al., 2018).

Table 2. Ordered logit regression estimates of the determinants of farm household preferences for sea dikes as a long-term public adaptation measure

Dependent variable: Public strategies preference (7-point scale agreement level)			
Independent variables	Coefficients	Marginal effects (dy/dx)	P-value
Willingness to pay	-0.543	0.008**	0.031
Group	0.177	-0.002	0.294
Household head’s age	-0.012	0.001	0.526
Household head’s gender	-0.412	0.006	0.215
Household head’s education	0.025	-0.001	0.800
Household head’s farming experience	0.013	-0.001	0.450
Farm household size	-0.135	0.002	0.149
Farm household income	2.02e-06	-2.80e-08	0.126
Impact on income	0.147	-0.002	0.204
Impact on housing value	0.218	-0.003**	0.032
Impact on farm land value	-0.138	0.002	0.197
Impact on agricultural output and productivity	0.194	-0.003	0.163
Impact on water supply for agricultural activities	-0.231	0.003*	0.051
Impact on water supply for daily lives	0.069	-0.001	0.400
Impact on physical health	0.139	-0.002	0.204
Impact on mental health	-0.046	0.001	0.619
Impact on households’ habitation environment	-0.559	0.008***	0.005
Impact on regional food security	-0.154	0.002	0.283
Impact on regional economics	0.648	-0.009**	0.004
Impact on regional habitation environment	0.099	-0.001	0.366
Log-likelihood		-509.09192	
LR Chi2		126.78	
Prob>Chi2		0.0000	
Pseudo R2		0.1107	
N (sample size)		441	

Notes: ***, **, and * are statistically significant at 1%, 5% and 10% levels, respectively.

The results indicate that five determinants including willingness-to-pay ~~level~~, housing value impact, impact~~s~~ on water supply for agricultural activities, households’ habitation environment and regional economics ~~are~~ were significant determinants of farmers’ preferences. As we might expect, MRD farm households’ willingness-to-pay for planned interventions to mitigate salinity intrusion impacts ~~is~~ are positively associated with a proposed long-term strategy, suggesting a tendency for farmers to contribute financially to support this strategy. It is also interesting and important to note that the explanatory ‘Group’ factor does not affect farmers’ preferences. Recall that this ~~is~~ repr~~tesent~~esents the spatially~~-~~-differentiated groups to which farmers were classified based on salinity intrusion impact levels. It suggests that almost all farmers in this area realized ~~the~~ some negative impacts of salt~~-~~water intrusion on their agricultural activities and daily lives, leading to preferences that are not significantly different across the groups.

~~Other drivers of preferences for public investment include impacts on water supply and habitation environments which increase the level of proposed strategy agreement. However,~~ the ~~impact on housing value and regional economics decrease this agreement level. These results may be explained by noting that farm household preferences for long-term measure are also controlled by factors directly related to their farming activities. Thus, these drivers of preferences need more careful testing before any final recommendations for adaptation strategies can be made. The insight analysis discussed in this paper provides a useful starting point for that further study, which will be the objective of our future research. However, it is clear that our hypothesised expectation of mixed private and public adaptation strategies in response to salinity intrusion impacts will play an important future role.~~

Formatted: Indent: First line: 0.5 cm

4 Discussion

Formatted: Font: Bold

In this section, we discuss results and their implications based on a grouped-assessment of perceived salinity impacts (Figure 7). As can be seen from the graph, key impacts are similar across the three groups in~~lc~~cluding income, agricultural output, water supply and mental health. However, the level of anticipated impacts perceived by farmers are different. The highest score was high-risk group (Group 2) and the smallest score was affected group (Group 1).

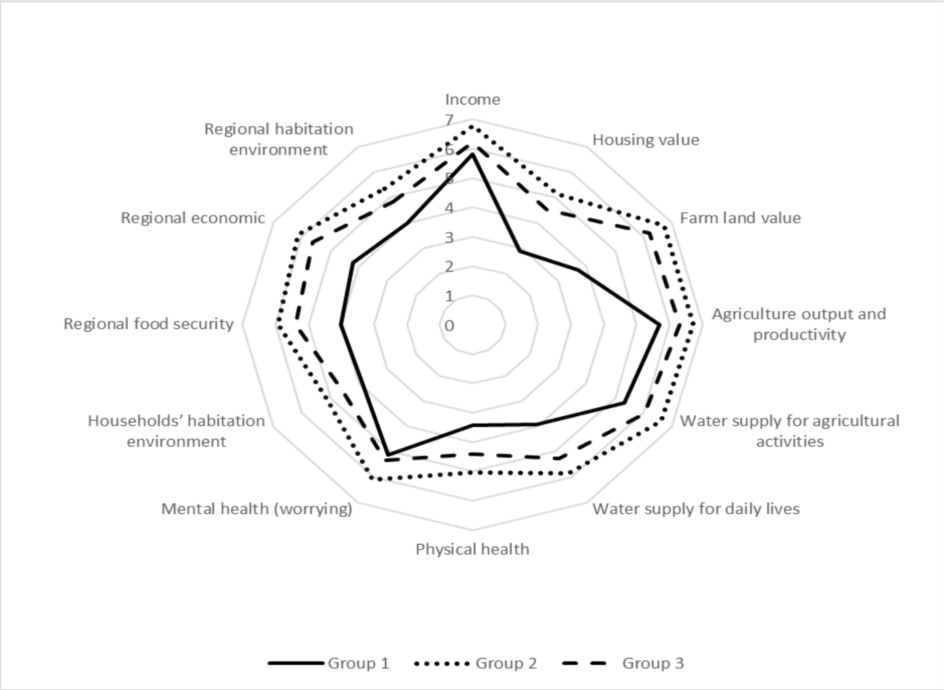


Figure 7. Farmers' perception of future salinity intrusion impacts on farm households' and regions over the next 3 years by group

Formatted: Font: Not Bold

With respect to reported mental health issues, a plausible explanation may be that physical impacts of flood or drought events are more immediate, manifesting as sickness or famine over shorter periods (i.e. months), while the impacts of salinity intrusion take longer to manifest (i.e. years) with an attendant mental toll. Our findings are consistent with other studies of broader issues suggesting that climate change-related issues affect both physical and mental health (Berry et al., 2011). However, since the data related to mental problems in this study stem from one Likert scale answer it is necessary to conduct more research before drawing any wider policy implications.

Temporal aspects to salinity intrusion may also explain the roughly equal split between farmer perceptions of regional economic impacts. While some are experiencing problems at present, other districts would have less familiarity with regional changes. This suggests highlights a need for more data collection with regard to health impacts, as well as improved information from local authorities to farmers in currently/future affected districts about salinity intrusion.

MRD farmers also did not necessarily equate productivity or livelihood impacts with increased salinity. For example, although changes to three-crop rice production systems in recent years has required increased water usage in the MRD, few farm households appear to have made the connection between that and increasing salinity levels. This may drive both a continued reliance on private short-term autonomous adaptation strategies, as well as a requirement for public planned adaptation interventions~~,~~ if the effectiveness of these strategies reduces over time. Interestingly, recent evidence suggests that third-rice cropping strategies are already becoming less effective, with lower productive returns and higher chemical costs (Dan, 2015). In addition, while crop insurance may be viewed as a mitigation strategy in other contexts, in Viet Nam this option is not very effective (Khoi, 2014; Thong, 2014). Most farmers do not participate in agricultural insurance schemes due to low affordability and availability from insurance providers.

Finally, the statistically significant drivers of adaptation strategies presented in our models would seem to suggest that if autonomous adaptation strategies reduce over ~~-~~time—or begin to fail with individual (physical/mental health), private asset (house/land value), community (habitat/environment), and/or regional (food security/economy) impacts—a rise in planned public-policy interventions may be sought as an alternative strategy.

Drivers of preferences for public investment include impacts on water supply and habitation environment which increases the level of proposed strategy agreement. However, the impact on housing value and regional economics lowers this level of agreement ~~level~~. These results may be explained by noting that farm household preferences for long-term measure are also controlled by factors directly related to their farming activities. Thus, these drivers of preferences need more careful testing before any final recommendations for adaptation strategies can be made. However, insights provided by the analysis discussed in this paper offer a useful starting point for that further study, which will be the objective of the research team. Finally, it is clear that our hypothesised expectation of mixed private and public adaptation strategies in response to salinity intrusion impacts will play an important future role, highlighting possible future intervention by the Vietnamese government in the form of support/guidance of adaptation behaviour and outcomes via a range of policies and/or programs.

~~4~~ 5 Conclusion

This paper examines farm household perceptions of salinity intrusion impacts, as well as current/intended adaptation strategies in the MRD in an effort to ~~. A better understanding of farm household salinity intrusion awareness could~~ assist policymakers to develop and implement effective future planned public adaptation strategies. The approach taken is to focus on farm household awareness and the extent of ~~alongside~~ autonomous private adaptation to salinity intrusion and, also, the risk that the adverse effects of salinity intrusion could worsen~~activity~~. The empirical findings presented here show that farm households in the MRD have a clear perception of the existing salinity intrusion risk, as well as the future risks associated with the unchecked spread of saline water. One of the important findings from this study is that most farmers in this study area realize the causes and impacts of salinity intrusion—without necessarily linking the two. The findings also indicate~~s~~ farmers' perceptions and attitudes to salinity intrusion do not depend on the level of salinity intrusion impacts.

To date, when the data is examined, it is clear that predominantly short-term adaptation measures have been applied, with varying levels of effectiveness. One of the novel findings from this study ~~also indicates~~is that farm households believe it is hard for them to adapt to the

Formatted: Indent: First line: 0 cm

Formatted: Indent: First line: 0.5 cm issue by themselves. Moreover, it appears likely that tf the effectiveness of autonomous farm household these strategies will reduces over time and that, if the adverse effects of salinity intrusion are to be avoided, long-term planned salinity intrusion mitigation programs may be required under publicly funded programes will be necessarying arrangements. At present, as as Vietnam can do little to increase flows into the MRD, the only options is to construct This study has therefore examined a possible long-term future public salinity intrusion adaptation or intervention options in an effort to inform this investment choice – notably sea dikes construction.

If VietnamVietnam is required to invest in public interventions, such as sea dikes,, then the findings from this study can be used to should provide valuable evidence in support of appropriate guide policy choices and develop implementation guidelines. Our results suggest that time can be bought by using increased local farmer participation could be generated through enhanced by local awareness and information programs in the first instance. This could be achieved using media such as television, newspaper and radio to increase address salinity knowledge about the problem and provide the , training needed to expedite improvementand informa. tion gaps – some of which were identified by local officials during the pilot testing for this research survey. The findings from this study also indicate that engineering adaptation strategies such as sea dike construction are preferred by farm households as long-term planned public interventions and that they are willing to contribute to the cost of such an intervention. If this policy pathway is chosen, then further research on options for the collection of this money and its use would be necessary.

Farmers cannot achieve such large-scale mitigation interventions autonomously; they will require public assistance to generate private gains. However, our investigation into factors driving adaptation strategy adoption indicates that farmers may be willing to positively engage with government to achieve these outcomes through collaborative efforts in order to avoid individual, private, local and regional negative impacts as the problem of salinity intrusion grows. Future research on comparative research across different regions into the scope for farmer participation is therefore necessary. Finally, the result also indicates, which is consistent with previous research, that both NBRM performs as good as CGPR model in the case of under/over-dispersion data, which is expected to contribute to current literature related to analysing models for count data.

Formatted: Justified, Indent: First line: 0.5 cm, Line spacing: Double

5. References

Alam, G.M.M., Alam, K., Mushtaq, S., 2017. Climate change perceptions and local adaptation strategies of hazard-prone rural households in Bangladesh. Climate Risk Management 17, 52-63.

Alam, K., 2015. Farmers' adaptation to water scarcity in drought-prone environments: A case study of Rajshahi District, Bangladesh. Agricultural Water Management 148, 196-206.

Ayanlade, A., Radeny, M., Morton, J.F., 2017. Comparing smallholder farmers' perception of climate change with meteorological data: A case study from southwestern Nigeria. Weather and Climate Extremes 15, 24-33.

Barlow, P.M., Reichard, E.G., 2010. Saltwater intrusion in coastal regions of North America. Hydrogeology Journal 18, 247-260.

Berry, H.L., Hogan, A., Owen, J., Rickwood, D., Fragar, L., 2011. Climate Change and Farmers' Mental Health: Risks and Responses. Asia Pacific Journal of Public Health 23, 119S-132S.

Cabooter, E., Weijters, B., Geuens, M., Vermeir, I., 2016. Scale format effects on response option interpretation and use. Journal of Business Research 69, 2574-2584.

Caudill, S.B., Mixon, F.G., 1995. Modelling household fertility decisions: Estimation and testing of censored regression models for count data. Empirical Economics 20, 183-196.

Clogg, C.C., Shihadeh, E.S., 1994. Statistical models for ordinal data. Thousand Oakes: Sage Publications.

Dan, T.Y., 2015. A Cost-Benefit Analysis of Dike Heightening in the Mekong Delta.

Danh, V.T., 2012. Adaptation to sea sea-level rise in the Vietnamese Mekong River Delta: Should a sea dike be built?, No. 2011-RR13.

Danh, V.T., Khai, H.V., 2014. Using a Risk Cost-Benefit analysis for a sea Dike to adapt to the sea level in the Vietnamese Mekong River delta. Climate 2, 78-102.

Dawes, J., 2008. Do data characteristics change according to the number of scale points used? International Journal of Market Research 50, 61-77.

Dost, S., 2010. Development and climate change: a strategic framework for the World Bank Group.

Dubey, S.K., Trivedi, R.K., Chand, B.K., Mandal, B., Rout, S.K., 2017. Farmers' perceptions of climate change, impacts on freshwater aquaculture and adaptation strategies in climatic change hotspots: A case of the Indian Sundarban delta. Environmental Development 21, 38-51.

Famoye, F., Wang, W., 2004. Censored generalized Poisson regression model. Computational statistics & data analysis 46, 547-560.

General Statistics Office of Vietnam, 2018. 2018 Vietnam Statistics Data https://www.gso.gov.vn/Default.aspx?tabid=706&ItemID=13412.

Green, P.E., Rao, V.R., 1970. Rating Scales and Information Recovery--How Many Scales and Response Categories to Use? Journal of Marketing 34, 33-39.

Guagnano, G., Santarelli, E., Santini, I., 2016. Can Social Capital Affect Subjective Poverty in Europe? An Empirical Analysis Based on a Generalized Ordered Logit Model. Social Indicators Research 128, 881-907.

Harpe, S.E., 2015. How to analyze Likert and other rating scale data. Currents in Pharmacy Teaching and Learning 7, 836-850.

Hill, C., Fomby, T., 2010. Maximum simulated likelihood methods and applications. Emerald Group Publishing.

Ho, T.T., Ubukata, F., 2017. Climate change in Vietnam's Mekong Delta: Soc Trang rice farmers' perceptions and adaptive behaviors. Journal of Environmental Science for Sustainable Society 8, 1-14.

Hoornweg, D., 2011. Cities and climate change: responding to an urgent agenda. World Bank Publications.

Khai, H.V., Dang, N.H., Yabe, M., 2018. Impact of Salinity Intrusion on Rice Productivity in the Vietnamese Mekong Delta. 九州大学大学院農学研究院紀要 63, 143-148.

Khang, N.D., 小寺昭彦, 坂本利弘, 横沢正幸, 2008. Sensitivity of salinity intrusion to sea level rise and river flow change in Vietnamese Mekong Delta-impacts on availability of irrigation water for rice cropping. 農業気象 64, 167-176.

Khoi, P.D., 2014. The determinants of shrimp farmers' decision to participate into shrimp insurance at Bac Lieu province (in Vietnamese), Socio-Economic development at Mekong River Delta. School of Economics and Business Administration, Can Tho ~~Univeristy~~University.

Khong, T.D., Loch, A., Young, M.D., 2019. Inferred valuation versus conventional contingent valuation: A salinity intrusion case study. Journal of Environmental Management 243, 95-104.

Khong, T.D., Young, M.D., Loch, A., Thennakoon, J., 2018. Mekong River Delta farm-household willingness to pay for salinity intrusion risk reduction. Agricultural Water Management 200, 80-89.

Kondolf, G.M., Schmitt, R.J., Carling, P., Darby, S., Arias, M., Bizzi, S., Castelletti, A., Cochrane, T.A., Gibson, S., Kummu, M., 2018. Changing sediment budget of the Mekong: Cumulative threats and management strategies for a large river basin. Science of The Total Environment 625, 114-134.

Le Dang, H., Li, E., Bruwer, J., Nuberg, I., 2014. Farmers' perceptions of climate variability and barriers to adaptation: lessons learned from an exploratory study in Vietnam. Mitig Adapt Strateg Glob Change 19, 531-548.

Mahmoud, M.M., Alderiny, M.M., 2010. On estimating parameters of censored generalized Poisson regression model. Applied Mathematical Sciences 4, 623-635.

Mamba, S.F., Salam, A., Peter, G., 2015. Farmers' Perception of Climate Chang-e a Case Study in Swaziland. Journal of Food Security 3, 47-61.

Margulis, S., Narain, U., Chinowsky, P., Cretegny, L., Hughes, G., Kirshen, P., Kuriakose, A., Lange, G., Nelson, G., Neumann, J., 2010. Cost to developing countries of adapting to climate change: New methods and estimates.

Nguyen, T.L.H., Yao, S.B., Shah, F., 2017. Farmers' perception, awareness and adaptation to climate change: evidence from northwest Vietnam. International Journal of Climate Change Strategies and Management 9, 555-576.

Nowlis, S.M., Kahn, B.E., Dhar, R., 2002. Coping with Ambivalence: The Effect of Removing a Neutral Option on Consumer Attitude and Preference Judgments. Journal of Consumer Research 29, 319-334.

Nyamadzawo, G., Wuta, M., Nyamangara, J., Gumbo, D., 2013. Opportunities for optimization of in-field water harvesting to cope with changing climate in semi-arid smallholder farming areas of Zimbabwe. SpringerPlus 2, 100.

Ozonur, D., Akdur, H.T.K., Bayrak, H., 2017. Comparisons of tests of distributional assumption in Poisson regression model. Communications in Statistics-Simulation and Computation 46, 6197-6207.

Schad, I., Schmitter, P., Saint-Macary, C., Neef, A., Lamers, M., Nguyen, L., Hilger, T., Hoffmann, V., 2012. Why do people not learn from flood disasters? Evidence from Vietnam's northwestern mountains. Natural hazards 62, 221-241.

Smajgl, A., Toan, T.Q., Nhan, D.K., Ward, J., Trung, N.H., Tri, L.Q., Tri, V.P.D., Vu, P.T., 2015. Responding to rising sea levels in the Mekong Delta. Nature Clim. Change 5, 167-174.

Tánago, I.G., Urquijo, J., Blauhut, V., Villarroya, F., De Stefano, L., 2016. Learning from experience: a systematic review of assessments of vulnerability to drought. Natural Hazards 80, 951-973.

The Vietnam Academy for Water Resources, 2015. Periodic reports on salinity intrusion forecast in the Mekong River Delta (in Vietnamese), The Southern Institute of Water Resouces Research Ho Chi Minh city (http://www.siwrr.org.vn/?id=news&nhom=93&page=2).

Thong, P.L., 2014. Willingness to pay for rice price insurance of households in Can Tho city (in Vietnmese), Socio-Economics development for Mekong River Delta. School of Economics and Business Administration, Can Tho University.

Toan, T.Q., 2014. 9 - Climate Change and Sea Level Rise in the Mekong Delta: Flood, Tidal Inundation, Salinity Intrusion, and Irrigation Adaptation Methods, in: Esteban, N.D.T.T. (Ed.), Coastal Disasters and Climate Change in Vietnam. Elsevier, Oxford, pp. 199-218.

Trinh, T.Q., Rañola, R.F., Camacho, L.D., Simelton, E., 2018. Determinants of farmers' adaptation to climate change in agricultural production in the central region of Vietnam. Land Use Policy 70, 224-231.

Vagias, W.M., 2006. Likert-type Scale Response Anchors. Clemson International Institute for Tourism. & Research Development, Department of Parks, Recreation and Tourism Management, Clemson University.

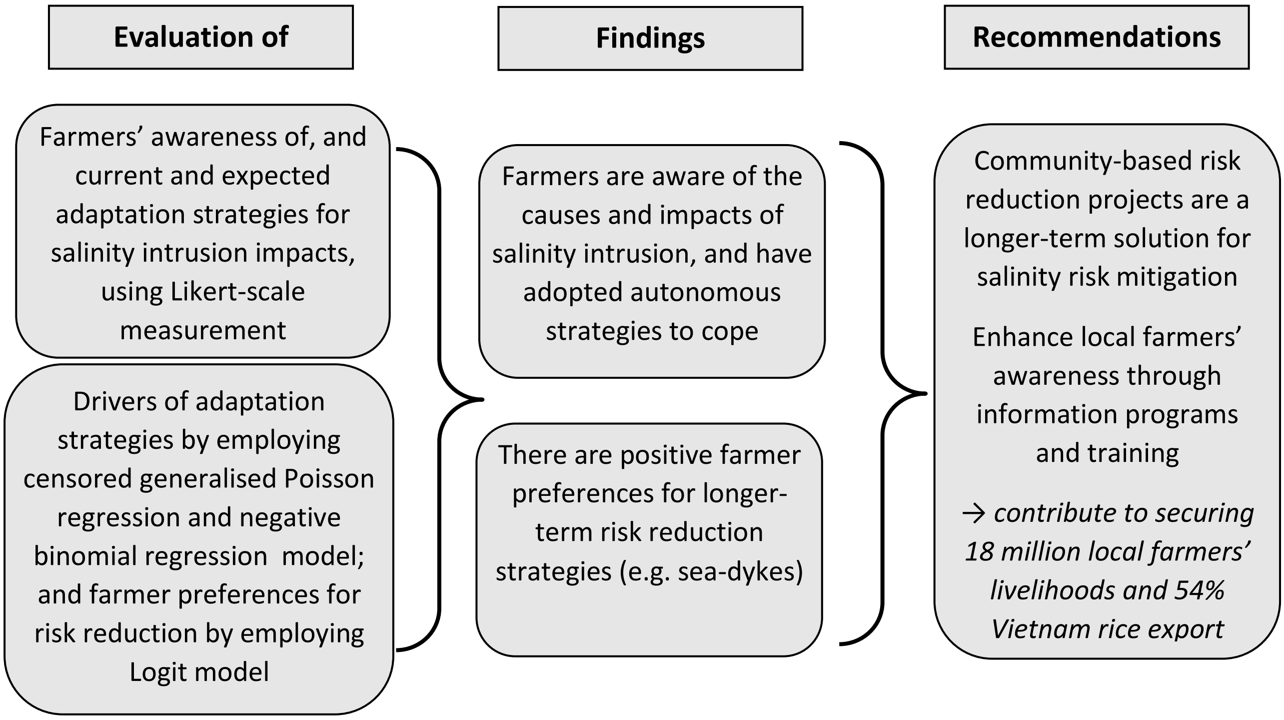
Van, S.T., Boyd, W., Slavich, P., Van, T.M., 2015. Perception of Climate Change and Farmers' Adaptation: A Case Study of Poor and Non-Poor Farmers in Northern Central Coast of Vietnam. Journal of Basic & Applied Sciences 11, 323.

Weijters, B., Cabooter, E., Schillewaert, N., 2010. The effect of rating scale format on response styles: The number of response categories and response category labels. International Journal of Research in Marketing 27, 236-247.

WHO - Regional Office for Europe, 2002. Floods: Climate change and adaptation strategies for human health, EUR/02/5036813, London, United Kingdom.

World Bank Group, 2010. Vietnam: Economics of Adaptation to Climate Change, Washington, DC 20433.

*Graphical Abstract



*Highlights (for review : 3 to 5 bullet points (maximum 85 characters including spaces per bullet point)

Highlights

- Salinity intrusion is reducing agricultural productivity in the Mekong River Delta
- In response, farm households are adapting to salinity intrusion autonomously
- Data suggests farmers understanding is variable and current responses likely flawed
- Understanding farmers' perceptions improves risk-reduction program implementation
- Results can be used to inform strategic policy and long-term investment choices

Perceptions and responses to rising salinity intrusion in the Mekong River Delta: what drives a long-term community-based strategy?

Abstract

This study analyses data on perceptions of the adverse impacts of salinity intrusion on rice farming in the Mekong River Delta. Collected from interviews with the head of 441 households and several focus group meetings, the data is used to provide an understanding of current adaptation or coping strategies and, from the insights gained make recommendations for the management of this increasing challenge. We find that most households are concerned about the impact of salinity intrusion on their livelihood and their capacity to cope in the future. Some strategies are already failing and many many farmers will struggle to adapt in the medium-term. Censored generalised Poisson regression and negative binomial regression models are used to identify and test the effectiveness of alternative management strategies. The results suggest that farmers have a preference for the construction of dykes as a means to prevent salinity intrusion. We conclude that farmer willingness to support the construction and improvement of dykes can be improved by providing more information and training.

Keywords salinity, adaptation measures, smallholder farmers, Mekong River Delta

JEL classification Q54, Q59

1 Introduction

Vietnam's Mekong River Delta (MRD) is experiencing rising levels of salinity intrusion in a manner that is significantly reducing agricultural production and farm income. There are three causes of this salinity intrusion First, sea-level rise is changing MRD hydrological conditions and increasing the pressure on the Delta (Khong et al., 2019). Second, the development of dams and reservoirs upstream of the MRD has reduced freshwater flows in a manner that has further altered the hydrologic properties of the Delta (Kondolf et al., 2018). Third, farmers have been increasing water extraction within the Delta so that they can support annual three-rice crop agricultural systems. When all three of these processes come together the rate of freshwater flows to the sea necessary to stop the sea from intruding is significant (Dan, 2015; Khong et al., 2019).

The MRD covers an area of 4 million ha, 78% of which is used annually for rice production. It contributes more than 55% of Vietnam's rice production and more than 85% of national rice exports (General Statistics Office of Vietnam, 2018). Under salinity intrusion impacts, rice yield loss estimates vary from 2.5 tons to 4 tons per hectare (or 18 to 30 percent loss of total yield) depending on the area and level of impact (Khai et al., 2018). Salinity intrusion impacts have increased since the 2014-2016 period, especially during the dry season, enabling saltwater to intrude further inland to cause significant negative impacts on rice yields. In total, nine out of 13 provinces in the MRD are now affected (The Vietnam Academy for Water Resources, 2015). In response to salinity intrusion, MRD farmers have adopted various strategies based on their own knowledge of farming and/or based on neighbour suggestions. These include changes to planting times, adjustments to fertilizer and chemical use, and accessing alternative sources of freshwater (e.g. groundwater) (Smajgl et al., 2015; Toan, 2014). However, while these strategies may provide some short-term mitigation, long-term adaptation benefits remain uncertain. Alternatively, infrastructure such as coastal sea dikes and sluice gates have been identified as a viable strategy for salinity intrusion risk reduction. Recent studies by Danh (2012) and Danh and Khai (2014) performed benefit-cost analysis to calculate the net present value of concrete sea dikes in the MRD. The analyses concluded that salinity intrusion mitigation benefits from concrete sea dikes would exceed the total costs, including construction and on-going operation and maintenance costs, with farmers as the principal beneficiaries. However, sea dike infrastructure construction, operation and maintenance would require significant public investment; which Vietnam would struggle to achieve (Danh and Khai, 2014; Khong et al., 2018).

As the primary beneficiaries of sea dike construction, MRD farmers could be called upon to contribute to fully fund its upfront and ongoing costs (Khong et al., 2019; Khong et al., 2018). To assess the potential for MRD farmer contributions toward this mitigation project, it will be useful to better understand their current salinity impact perceptions, as adaptation strategies are typically not effective without information about farmers' awareness and perceptions (Alam et al., 2017), and very few smallholder farms are able to adapt to climate variability impacts individually (Nyamadzawo et al., 2013). Further, successful policy implementation depends on the specific context in which mitigation is to occur (Dost, 2010; Hoornweg, 2011). A better understanding of current and intended adaptation strategies may positively inform program implementation and policy decision-making. For Vietnam, any lack of information about farm household perceptions of salinity intrusion risk may lead to ineffective individual and/or group adaptation measures (Alam et al., 2017).

Research on climate change adaptation behaviour and responses have been emerging in recent years. However, there is insufficient information and findings in the context of salinity intrusion (Ho and Ubukata, 2017; Khong et al., 2018). Moreover, private adaptation strategies are typically short-term in nature (Dubey et al., 2017), may be insufficient for reliable mitigation into the future (Ayanlade et al., 2017), and dependent upon the specific country context (Margulis et al., 2010). It has been suggested that more data about farmer perceptions and adaptation strategies are needed in Southeast Asia (Schad et al., 2012), together with accurate information for each farming season (Mamba et al., 2015). In addition, few previous studies have approached climate issues in details, while even less have identified empirical evidence about the determinants of farmers' adaptation behaviour which is essential for vulnerability assessment design (Tánago et al., 2016). It is therefore also recognised that data improvements are required with respect to smallholder farmers, particularly the information and resources that they will need to adapt and cope with future conditions (Ayanlade et al., 2017).

We are ultimately interested in: (1) whether farm households are aware of the causes and impacts of salinity intrusion on their livelihood and farming activities; (2) what independent strategies and measures farm households are currently adopting in response to salinity intrusion; (3) what salinity intrusion adaptation strategies (if any) farmers are intending to adopt in future; (4) what future planned public salinity intrusion mitigation strategies farm households would prefer by analyzing farmers' preferences on the introduction of concrete sea dyke long-term measures; and (5) what drives those decisions/preferences in order to propose relevant recommendations prior to the introduction of any large projects? It is expected that this study will contribute to the existing literature on climate risk response adaptations in developing countries by understanding how local farmers have tried to adapt to salinity intrusion and provide insights about what adaptation strategies the Vietnamese national and local governments might explore for long-term salinity mitigation solutions.

2 Materials and methods

2.1 Data collection

We used available data from the Vietnam Academy for Water Resources and maps of rice crop vulnerability to sea-level rise (Khang et al., 2008) to identify three survey areas. Two areas with different levels of salinity impact (*currently affected* and *at high risk*), and one area unaffected by salinity intrusion (*control group*). The area currently affected by salinity intrusion is the Cau Ke district located close to the coast of the MRD. The “at high risk of future salinity intrusion impact” area includes part of Cau Ke district and the Tra On district which is located further inland from the coast. Finally, the control-group area where there is very limited risk of salinity intrusion at present—or in the immediate future—is the Vinh Thanh district (Figure 1).

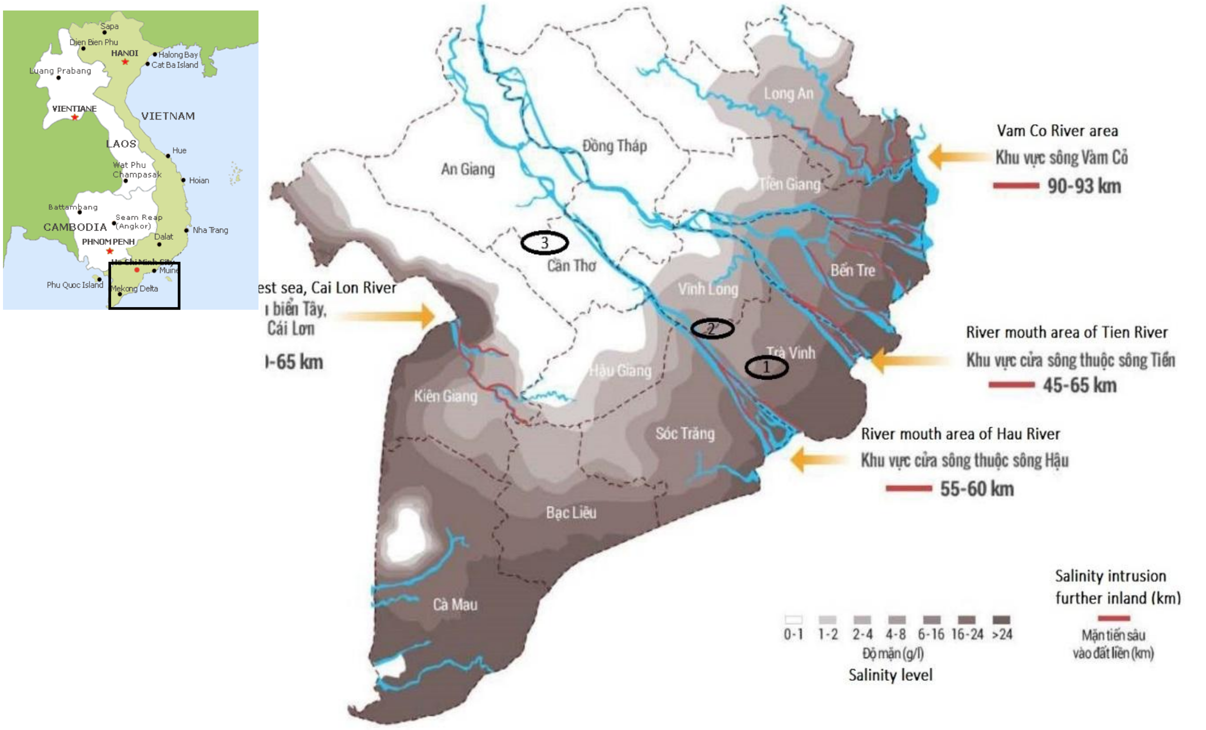


Figure 1. Mekong River Delta salinity intrusion levels in 2015 and the study area locations (1-Cau Ke district, 2-Cau Ke and Tra On districts, and 3-Vinh Thanh district)

Source: Adapted from Khong et al. (2018), cited from the Vietnam Academy for Water Resources (2015)

These districts were also recommended by local officials from the Department of Agriculture and Rural Development who are knowledgeable about, and familiar with, the local characteristics of MRD farm households. Using a random sampling procedure, this study surveyed 441 farm households from the study districts listed above. A list of farm households was provided by government officers from the Department of Agriculture and Rural Development. Survey respondents were chosen randomly from these lists.

Before the official survey was implemented, the questionnaire was pilot tested with 30 farm household-heads to ascertain whether or not farmers could understand the questions and information provided. The opportunity was also taken to test enumerator comprehension of technical notes attached to questionnaire in a manner that would help to explain concepts to the farmers' in local/everyday language. Enumerators for the study were carefully chosen from staff and final year students with prior experience of farm household surveys at the Department of Agricultural Economics, Can Tho University.

2.2 Survey instrument

Based on the range of adaptation drivers specified in the previous section, open-ended categories were first used to identify perceptions of salinity intrusion drivers and to classify any private adaptation strategies adopted by farm households. The survey instrument was focused on (1) farmers' awareness of salinity intrusion causes and impacts, (2) current individual adaptation measures, (3) farmers' intention to adapt to salinity intrusion, and (4) perceptions of proposed public intervention strategies/measures.

However, farmers were not expected to be fully knowledgeable about future adaptation options, especially at the public-provision level. To identify possible future adaptation strategies and mitigation options focus group discussions (FGDs) were employed in advance of pilot-testing the survey instrument. This involved consultations with local experts (one in each district) from the Department of Rural Development in each survey area, and experienced rice farmers (three in each district). The outputs from these FGDs were then used to formulate a series of close-ended questions focused on future adaptation options in the farm household survey.

The FGD approach resulted in a total of four adaptation strategy groups identified for use in the survey: i) non-engineering adaptations (e.g. crop changes); ii) engineering adaptations (e.g. earthen dikes); iii) hydro-management adaptations (e.g. new water sources); and iv) other adaptation measures (e.g. off-farm employment). The classification in this study is consistent with definitions from World Bank Group (2010), WHO - Regional Office for Europe (2002), and a recent study in America (Barlow and Reichard, 2010).

Ultimately, a series of seven-point Likert scales were employed to collect responses for perceptions about to salinity intrusion impacts (i.e. 1=No effect to 7=Extreme effect), drivers of salinity intrusion in the MRD (i.e. 1=Strongly disagree to 7=Strongly agree), the effectiveness of adopted strategies (i.e. 1=Very ineffective to 7=Very effective), and proposed future salinity mitigation programs (i.e. 1=Strongly disagree to 7=Strongly agree).

2.3 Data analysis

Likert scales are widely employed by marketing researchers for examining consumer behaviour, commercial market indicator evaluations, and public attitudes (Cabooter et al., 2016; Dawes, 2008; Green and Rao, 1970; Weijters et al., 2010). To date, a number of risk perception and attitudinal studies have also adopted/modified Likert-scale measurement in their field research (e.g. Le Dang et al., 2014). Different formats are often employed by different researchers, depending on the respondents and the research categories (Cabooter et al., 2016; Harpe, 2015). Researchers often find similar results using five- and seven-point scales (Dawes, 2008), and it has been suggested that the appropriate scale depends on the population survey and analysis target (Harpe, 2015; Weijters et al., 2010). In terms of a standard methodological recommendation, however, the seven-point scale appears to be widely preferred because it contains a neutral position that enhances measurement quality (Nowlis et al., 2002) and avoids poor information recovery without overburdening respondents (Cabooter et al., 2016). Hence, the dimensions in this analysis were measured based on the seven-point Likert-type scale suggested by Vagias (2006)). An *ex-post* calibration was also employed to improve the certainty of farm household answers and the reliability of the findings. To do this, the perception and awareness questions were followed by a question asking farm household-heads to rank how certain they were about this choice on a scale of 1 to 3 (where 1=Not confident, 2=Confident, and 3=Very confident). Any farm household-head who reported a certainty level of one was asked to review their perception/awareness answer.

To estimate coefficients for drivers of adaptation strategy adoption regression models for count data were employed to examine the extent of farm household adaptation strategy uptake. The Poisson, hurdle Poisson, truncated Poisson and the negative binomial models are considered appropriate statistical techniques for modelling count data (Famoye and Wang, 2004; Mahmoud and Alderiny, 2010; Ozonur et al., 2017). A detailed discussion of Poisson models can be found in Ozonur et al. (2017) where the response variable $Y_j(j=1,....,n)$ has a Poisson distribution with mean of λ_i and the covariates are included in the parameter $\lambda_i = \exp(x_i^{'}\beta)$

$$f_{Y_i}(y_i) = \frac{e^{-\lambda_i}\lambda_i^{y_i}}{y_i\,!}$$

However, the Poisson model is appropriate only when the dependent variable follows the Poisson distribution with the conditional mean and conditional variance are the same, which is known as equi-dispersion (Mahmoud and Alderiny, 2010). In practical applications, when the data is over-dispersed or a restrictive assumption that the variance is equal to the mean made by the Poisson model is loosened, negative binomial regression models (NBRM)

(Caudill and Mixon, 1995) and/or censored generalized Poison regression models (CGPR) are more appropriate. In our data set, the variance of the dependent variable (67.58) is nearly five times larger than the mean (13.44) signalling over-dispersion. Moreover, a Pearson goodness-of-fit statistic indicates that the distribution of dependent variable differs significantly from that of a Poisson distribution (Chi-square value of 453.0845 with a Prob > chi2p value of 0.000 which falls below the 0.05 threshold). Therefore, we conclude that CGPR and NBRM models are more appropriate for our data set (Famoye and Wang, 2004) and employ both to identify determinants of adaptation measures. In the CGPR and NBRM models our dependent variable will take numeric form denoting how many private adaptation actions have been adopted by farm households. The modelled independent variables include farm household characteristics and farmer perceptions about salinity intrusion risk impacts on their farming, livelihoods and related aspects.

Finally, an ordered logit regression model was used to estimate specific drivers of MRD farm household preferences for the implementation and heightening of sea dike systems in the area. This adaptation strategy is proposed as a potential long-term public adaptation strategy investment and revealed as one with strong farmer investment preferences (see Figure 6). Other dependent variables comprised strategies not currently included in the planned approach to salinity intrusion mitigation (e.g. training, implementing and heightening sea dike systems), selected based on the number of Strongly Agree responses provided by farm household survey respondents. We also expanded the vector of predicted salinity intrusion impacts across all observations in the three groups rather than focusing on farm household perceptions during the last three years. Our selection of an ordered logit regression model was based on a discussion by Clogg and Shihadeh (1994). This regression is suitable for modelling Likert scale dependent variables, and can also be estimated with censored dependent variables. Other detailed discussions related to applications of this model can be found in (Guagnano et al., 2016) and Hill and Fomby (2010). The results of these models are discussed in the following section.

3 Results

3.1 Farm household perceptions of salinity intrusion impact

The demographic characteristics of our respondents suggest that our sample was drawn from households with sufficient farm experience to respond meaningfully to questions about salinity intrusion perceptions and awareness. Importantly for survey finding generalizability and policy guidance purposes the farm/er characteristics present in our survey sample—together with the survey household size and household income results—are broadly consistent with data metrics from the national Vietnam Household Living Standard Survey (VHLSS) which is a national survey of the Vietnamese population conducted every two years by the Viet Nam General Statistics Office (GSO).

3.1.1 Perceptions of salinity impacts

For the district where salinity intrusion had already occurred, we first asked farm household-heads how salinity intrusion had affected their family and region by asking *"For your worst affected plot, to what extent do you think salinity intrusion has affected your household to date?"* The results reveal that over 60% of respondents rated salinity intrusion as having negative influences on their agricultural output/productivity and farm income. Since freshwater provides essential functions for rice paddy farming, nearly 50% of respondents also perceived that salinity intrusion had had negative effects on their water supplies for agricultural activities—although far fewer were concerned about impacts on daily water supplies (Figure 2). Noticeably, the fourth-highest observed perceived impact of salinity intrusion in our survey results was mental health, which we elaborate on later.

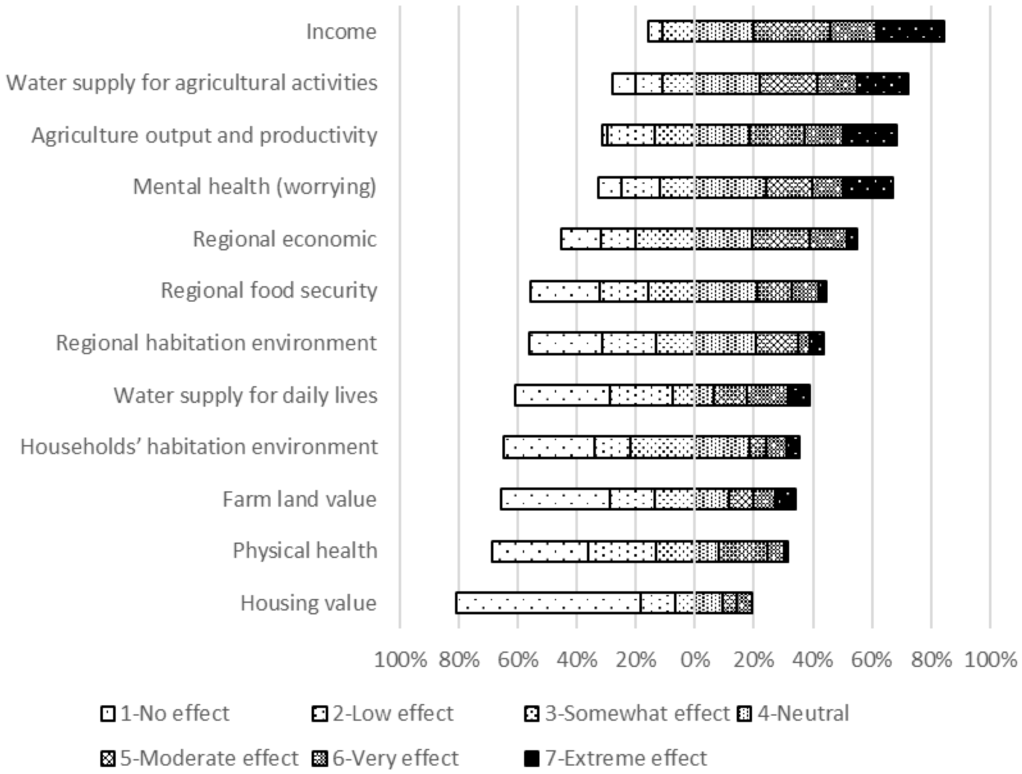


Figure 2. Distribution of perceived salinity intrusion impacts on farm household and regional issues (n=146 - Only included Group One where salinity intrusion has occurred)

3.1.2 Future perceived salinity impacts

Next, household-heads were asked to indicate their perceived salinity intrusion impacts if nothing were done over the next three years to mitigate its effects. Again, more than half of the respondents indicated that salinity intrusion would be expected to have an extreme effect on their agricultural output, productivity and income as well as negative impacts for water supply and farmland values in the long-term. Interestingly, the expected future impacts of salinity intrusion on income were less than those for agricultural output, possibly suggesting an intention by farm households to explore income diversification within that period (Figure 3). A set of Kruskal-Wallis H tests was conducted to determine if farm households' perceptions about salinity intrusion impacts were different across the three groups and even different areas. Unsurprisingly, the test showed that there was a statistically significant difference in each dimension between the three groups, with significant levels (p-value of $\chi^2(2)$) below the standard threshold of 0.05. This result suggests that farm household perceptions were shaped by their location and exposure to salinity intrusion risk, which is consistent with other adaptation research (Alam et al., 2017).

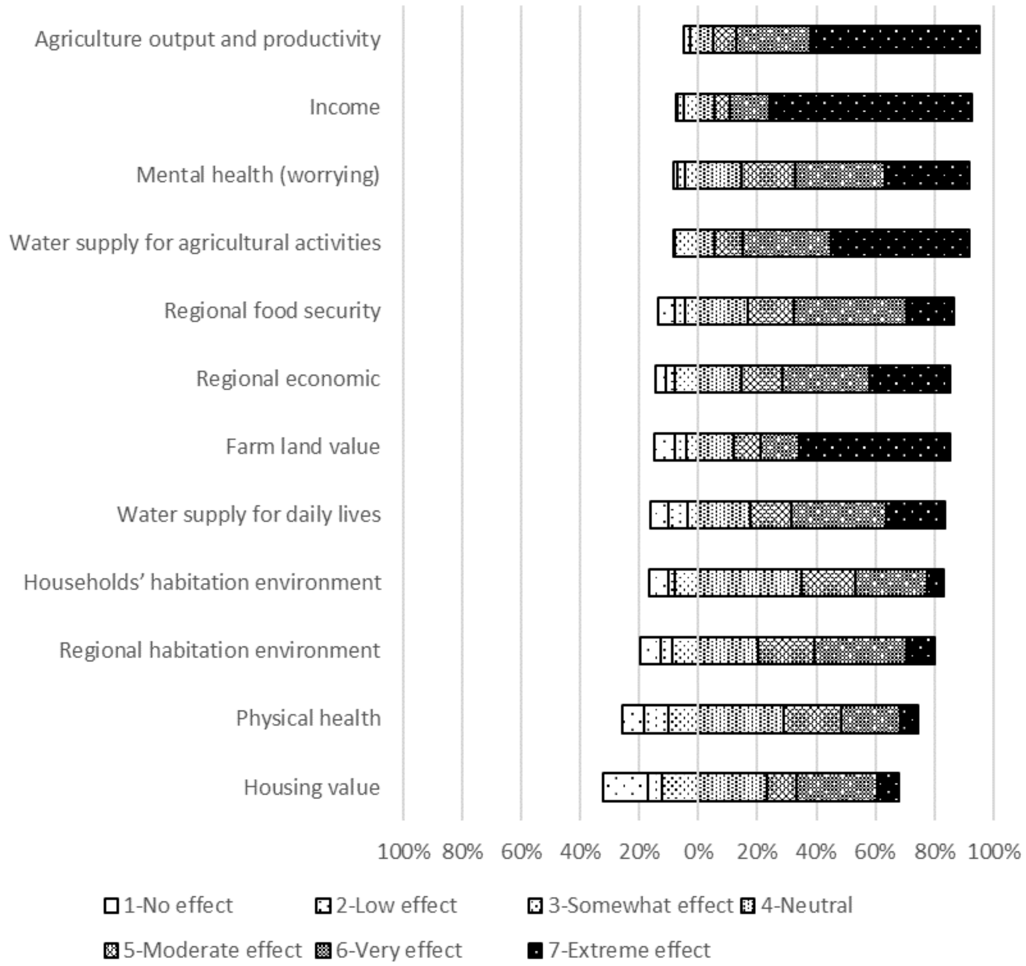


Figure 3. Distribution of expected salinity intrusion impacts on farm households' and regions over the next 3 years (n=441)

3.1.3 Perceived causes of salinity impacts

Each farm household head was then asked to identify their perceived causes of salinity intrusion in the MRD, ranging from 1=Less important to 4=Most important. In general, most farm households are very aware of the major causes of MRD salinity intrusion, with ≥50% of respondents identifying that sea-level rise, upstream development impacts on river flows and drought are the main causes. More than 70% of farm household-heads in the MRD viewed increasing water demand (e.g. to support three-crop rice production) as a less important reason for salinity intrusion. We, therefore, looked to identify current and intended autonomous adaptation responses at the farm and regional levels.

3.2 Private and public responses to salinity intrusion

3.2.1 Farm household autonomous responses

Those farm households located in the current salinity intrusion affected area were asked to indicate any adaptation strategies they had adopted and its effectiveness. Only a small number of farm households had failed to adapt in any way. The majority of farm households had adopted at least one autonomous strategy over the last three years, consistent with other studies that find farmers generally apply more than one adaptive strategy to cope with adverse impacts (Alam, 2015; Trinh et al., 2018).

The most popular non-engineering adaptation measures were changes to farming systems through altered planting times, shifting to other crop varieties, changed irrigation schedules and altered uses of farm inputs (e.g. fertilizer). Again, this supports studies which find that changed planting times are a popular adaptation strategy in the MRD (Van et al., 2015). Farm households also indicated the successful adoption of engineering strategies such as independent dike structures, dredging of local canals, increased water storage in farm dams or ponds, and water-saving techniques; all with reasonable perceptions of effectiveness (Figure 4).

Figure 4. Distribution of the effectiveness of salinity adaptation strategies adopted by farm households (n=146)

For farm households that explored shifting from rice to aquaculture or livestock and/or sought off-farm employment activities the strategy-effectiveness, however, results were relatively lower, suggesting limited success. This may be due to the fact that changes of this nature require new skillsets and training, which may be challenging for farmers with low levels of education and limited non-farming experience. Notably, many of the autonomous strategies listed appear to score mixed effectiveness results, which may be an indication of their short-term nature depending on the location of the farm and relevant exposure to salinity impacts.

3.2.2 Intended adaptation responses

Following our exploration of current adaptation strategies, we asked all respondents to identify any adaptive strategies that they intended to adopt in future. Most reported an intention to continue with autonomous adaptation strategies such as changes to planting times, irrigation schedules, and input usage. However, as indicated by the darkest colour areas (Figure 5), the strongest future adaptation strategy adoption preferences were for salt-tolerant crop varieties and engineering measures such as canal dredging and dike maintenance/heightening. Increased access to information from local and national authorities also rated quite strongly. By way of example, salt-tolerant varieties are only suitable in areas where salinity is moderate, but many farmers remain unaware of this limitation.

Many farm households also believed that agricultural insurance could be an effective future strategy to salinity impacts (25% strongly agree) which we also return to later. Finally, the very low intended migration of farm households away from the MRD should be carefully noted, along with its implications for the importance of future policy/programs to mitigate salinity intrusion impacts. Farmers do not seem willing to leave the area, and therefore careful attention may be needed to ensure effective public interventions in support of those intentions (Figure 5).

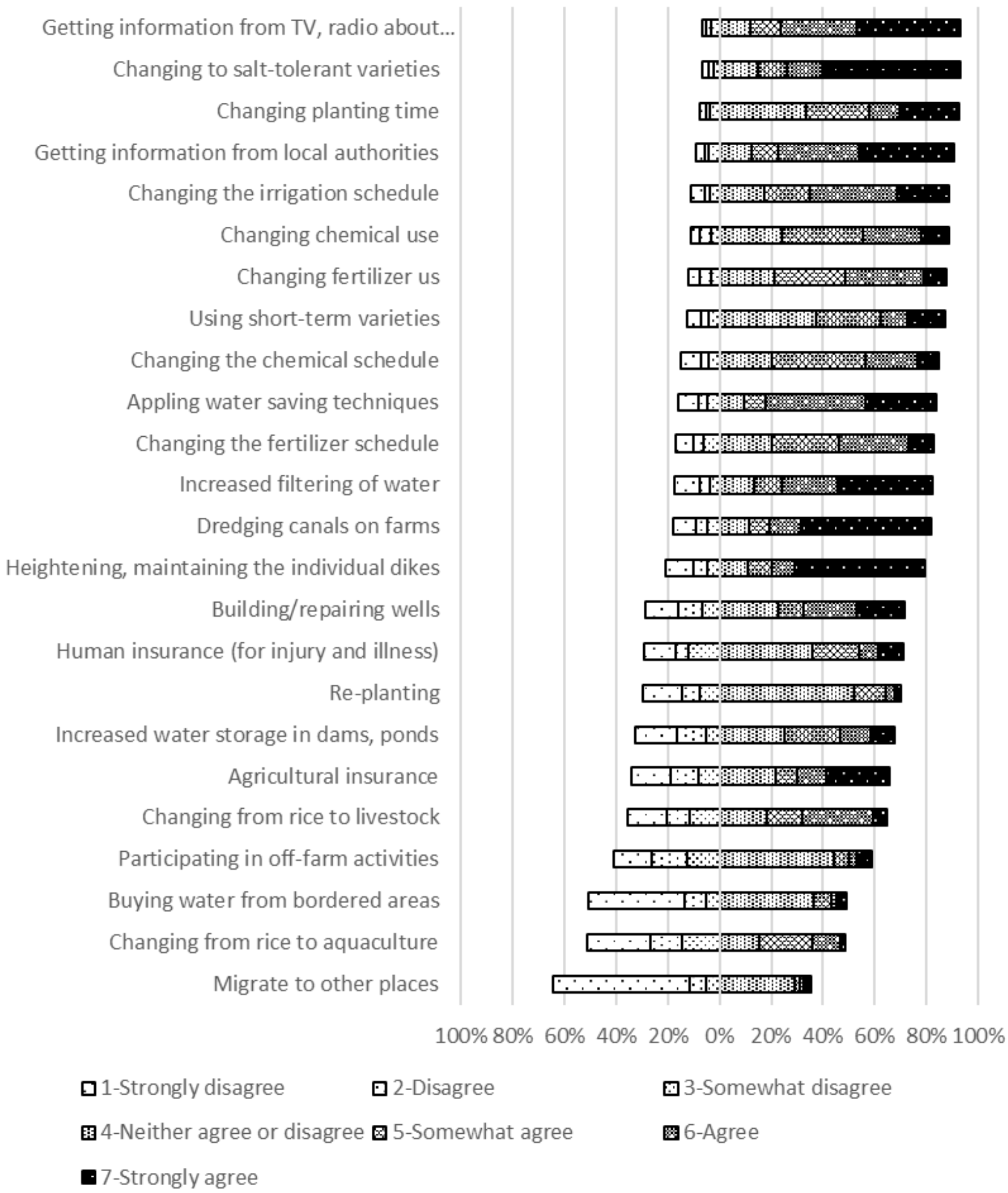


Figure 5. Distribution of intended future salinity adaptation strategies (n=441)

Note: The aggregate percentage in some is less than 100 per cent since several households did not apply any adaptation measures/strategies, and observations are only included farm households where salinity intrusion is already present.

3.2.3 Public responses to salinity intrusion risks

With regard to current public responses to salinity intrusion, farm households in three districts in the survey area were asked to identify relevant programs/strategies and evaluate the perceived effectiveness of those options. Only four strategies were reported, all with reasonable levels of effectiveness as far as farmers were concerned. Of those, training programs enjoyed relatively low levels of effectiveness perception which is of some concern as training for risk mitigation has been recommended as an important driver of farmers' adaptation decisions (Trinh et al., 2018). Overall, however, the support by farmers for current MRD mitigation strategies appears solid.

Finally, farm households were asked to indicate alternative salinity intrusion mitigation options for future public planned adaptation strategies (Figure 6). In addition to the current strategies identified above farmers stated their short-term preference for additional salt-tolerant crop varieties and increased information-communication programs (~50% Strongly agree). In terms of longer-term adaptation, the implementation of early-warning systems, updated freshwater supply systems, river-mouth sluice gate construction, and sea dike heightening/changes to concrete construction were the most popular strategies (>60% strongly agree)—with sea dike heightening recording the highest overall Strongly agree response (Figure 6).

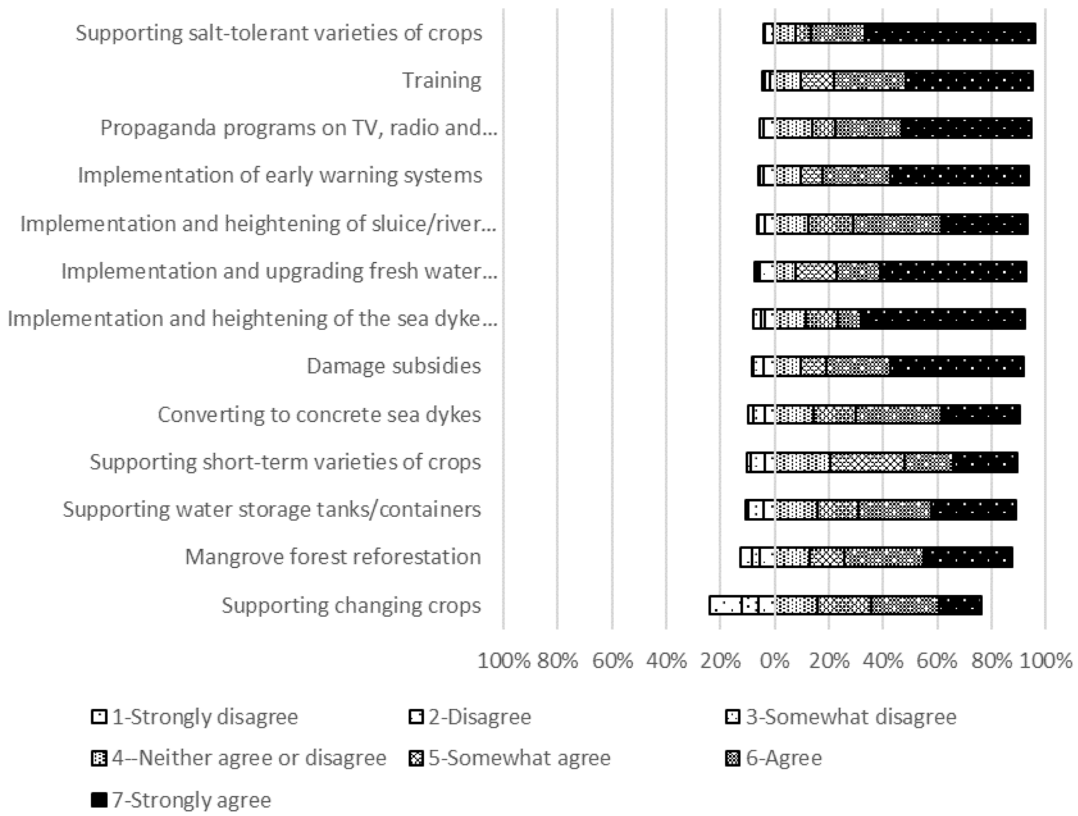


Figure 6. Distribution of farmers' responses for future public strategies (n=441)

3.3 Determinants of farm household adaptation preferences

Table 1 illustrates the determinants of 24 different adaptations made by farm households' based on a range of socio-demographic characteristics (i.e. the gender of the household head, number of household members, education level, the age of the household head, experience working on farms and household income), and farm household perceptions about salinity intrusion impacts at individual and regional levels. Initial tests for multicollinearity were undertaken using the Variance Inflation Factor (VIF) checks, with the resultant values indicating no significant multicollinearity issues (i.e. all VIF less than 5.0). The parameter estimates and their significance level using both NBRM and CGPR models are shown, with both models returning largely similar estimates. Slight differences include the impact on housing value which is less significant in the NBRM at the 10% level than the CGPR model at 5%. This supports our earlier view that modelling under-dispersed data using both NBRM and CGPR is appropriate given our capacity to check the reliability of determinants across the two models. A test for the over-dispersion parameter alpha was also performed using the Pearson likelihood-ratio test. The result indicates that alpha is significantly different from zero, confirming our use of both NBRM and CGPR models. The results also provide broad confirmation for the research hypothesis by indicating that the model is well-explained by the independent variables (Prob>chi2=0.0000), while identifying some critical variables influencing farmer adaptation decisions.

Seven factors have a statistically significant positive influence on increased numbers of adaptation strategies including increased willingness-to-pay for collective salinity mitigation programs, age, salinity intrusion impacts on housing and farmland values, water supply, physical health, impacts on regional economy, and habitation environment. On the other hand, six indicators were found to be statistically significant and negatively associated with greater adaptation strategy adoption including increased farming experience, larger household sizes, larger impacts on mental health, higher changes to local habitation or environment, and concerns about regional food security. Noticeably, for those who have already tried to adopt more strategies over the last three years, the level of willingness-to-pay for risk reduction increases—which is expected where higher private adaptation would be viewed as offsetting any future public interventions from international agencies or the Vietnamese central government. This result is also consistent with recent research by Khong et al. (2018; 2019).

In addition, these drivers are all broadly consistent with other studies into climate change adaptation in Vietnam (Nguyen et al., 2017); although other drivers such as off-farm experience and income were found to be relevant for different study areas (Ayanlade et al., 2017). Experienced farmers have a greater understanding of salinity intrusion impacts, and exercise caution when adopting new strategies in response. Further, farm households with higher membership have more opportunities (and incentives) to seek alternative income sources, which leads to fewer adaptation strategies. This point is supported by the fact that in this study there are only slight differences in annual income among the currently affected, high future risk, and control group districts (Table 1).

Table 1. Estimation results of the NBRM and CGPR models of adaptation strategy choices for Group 1: Currently affected area (n=146)

Indicators	Description	Mean	Min	Max
Dependent variable				
Strategies adopted	Numeric variable	13.445 (8.19)	0[1]	24
Independent variables	Description	NBRM	CGPR	VIF
Willingness to pay[2]	1=Yes, 0=No	0.407***	0.357***	1.25
Household head's age	Numeric variable	0.026***	0.024***	4.87
Household head's gender	1: Female, 0: male	-0.008	0.026	1.46
Household head's education	From 0 to 5	0.012	0.018	1.31
Household head's farming experience	Numeric variable	-0.019***	-0.017***	4.50
Farm household size	Numeric variable	-0.102**	-0.064***	1.17
Farm household income	Numeric variable	-6.40e-07	-4.66e-07*	1.28
Impact on income	7 point scale	-0.009	0.011	1.97
Impact on housing value	7 point scale	0.044	0.047*	2.58
Impact on farm land value	7 point scale	0.068**	0.055***	2.46
Impact on agricultural output and productivity	7 point scale	0.024	0.016	2.48
Impact on water supply for agricultural activities	7 point scale	-0.006	-0.001	1.50
Impact on water supply for daily lives	7 point scale	0.032	0.026*	1.85
Impact on physical health	7 point scale	0.127***	0.123***	3.01
Impact on mental health	7 point scale	-0.136***	-0.122***	2.02
Impact on households' habitation environment	7 point scale	-0.121**	-0.104***	3.24
Impact on regional food security	7 point scale	-0.079*	-0.059***	2.59
Impact on regional economics	7 point scale	0.096*	0.091***	3.64
Impact on regional habitation environment	7 point scale	0.104*	0.054*	4.74
Cons		1.732***	1.593***	
/lnalpha		-1.682		
Alpha		0.186		
Log-likelihood		-472.729	-534.459	
LR chi2		79.20	355.58	
Prob>chi2		0.000	0.000	
Pseudo R2		0.077	-	
N (sample size)			146	

Likelihood-ratio test of alpha=0: chibar2(01)=123.46 Prob>=chibar2=0.000
Notes: ***, **, and * are statistically significant at 1%, 5% and 10% levels, respectively. Numbers in parentheses are Standard deviation.

[(1)] Zero values for the dependent variable here indicates that, although some farm households are currently affected by salinity intrusion, they have not adopted any adaptation strategies or measures.
[(2)] Since this research is part of wider research conducted by the authors, this value indicates farmers' willingness-to-pay level for a salinity intrusion risk reduction fund which was discussed and published in Khong et al. (2018)

3.4 Determinants of farm household preferences for planned adaptation

We estimated a second model to gain additional insight into the drivers of farm household preferences for a long-term public adaptation strategy. Table 2 presents the results for sea dike construction projects as one of the most effective mitigation options currently offered in this area (Danh, 2012; Danh and Khai, 2014; Khong et al., 2018). Once again, the VIF scores for each independent variables were less than five, indicating no serious multicollinearity. The coefficients and marginal effects (average marginal effects) of the determinants of farmers' preferences of long-term public adaptation measure are presented. It should be noted that in the ordered logit model instead of coefficients, marginal effects are used to interpret the influences of the variance of the independent variables per unit on the dependent variable. The likelihood ratio Chi-square of 126.78 with a P-value of 0.0000 indicates that this model as a whole is statistically significant.

Table 2. Ordered logit regression estimates of the determinants of farm household preferences for sea dikes as a long-term public adaptation measure

Dependent variable: Public strategies preference (7-point scale agreement level)			
Independent variables	Coefficients	Marginal effects (dy/dx)	P-value
Willingness to pay	-0.543	0.008**	0.031
Group	0.177	-0.002	0.294
Household head's age	-0.012	0.001	0.526
Household head's gender	-0.412	0.006	0.215
Household head's education	0.025	-0.001	0.800
Household head's farming experience	0.013	-0.001	0.450
Farm household size	-0.135	0.002	0.149
Farm household income	2.02e-06	-2.80e-08	0.126
Impact on income	0.147	-0.002	0.204
Impact on housing value	0.218	-0.003**	0.032
Impact on farm land value	-0.138	0.002	0.197
Impact on agricultural output and productivity	0.194	-0.003	0.163
Impact on water supply for agricultural activities	-0.231	0.003*	0.051
Impact on water supply for daily lives	0.069	-0.001	0.400
Impact on physical health	0.139	-0.002	0.204
Impact on mental health	-0.046	0.001	0.619
Impact on households' habitation environment	-0.559	0.008***	0.005
Impact on regional food security	-0.154	0.002	0.283
Impact on regional economics	0.648	-0.009**	0.004
Impact on regional habitation environment	0.099	-0.001	0.366
Log-likelihood		-509.09192	
LR Chi2		126.78	
Prob>Chi2		0.0000	
Pseudo R2		0.1107	
N (sample size)		441	

Notes: ***, **, and * are statistically significant at 1%, 5% and 10% levels, respectively.

The results indicate that five determinants including willingness-to-pay, housing value impact, impact on water supply for agricultural activities, households' habitation environment and regional economics were significant determinants of farmers' preferences. As we might expect, MRD farm households' willingness-to-pay for planned interventions to mitigate salinity intrusion impacts are positively associated with a proposed long-term strategy, suggesting a tendency for farmers to contribute financially to support this strategy. It is also interesting and important to note that the explanatory ‘Group’ factor does not affect farmers’ preferences. Recall that this represents the spatially-differentiated groups to which farmers were classified based on salinity intrusion impact levels. It suggests that almost all farmers in this area realized some negative impacts of saltwater intrusion on their agricultural activities and daily lives, leading to preferences that are not significantly different across the groups.

4 Discussion

In this section, we discuss results and their implications based on a grouped-assessment of perceived salinity impacts (Figure 7). As can be seen from the graph, key impacts are similar across the three groups including income, agricultural output, water supply and mental health. However, the level of anticipated impacts perceived by farmers are different. The highest score was high-risk group (Group 2) and the smallest score was affected group (Group 1).

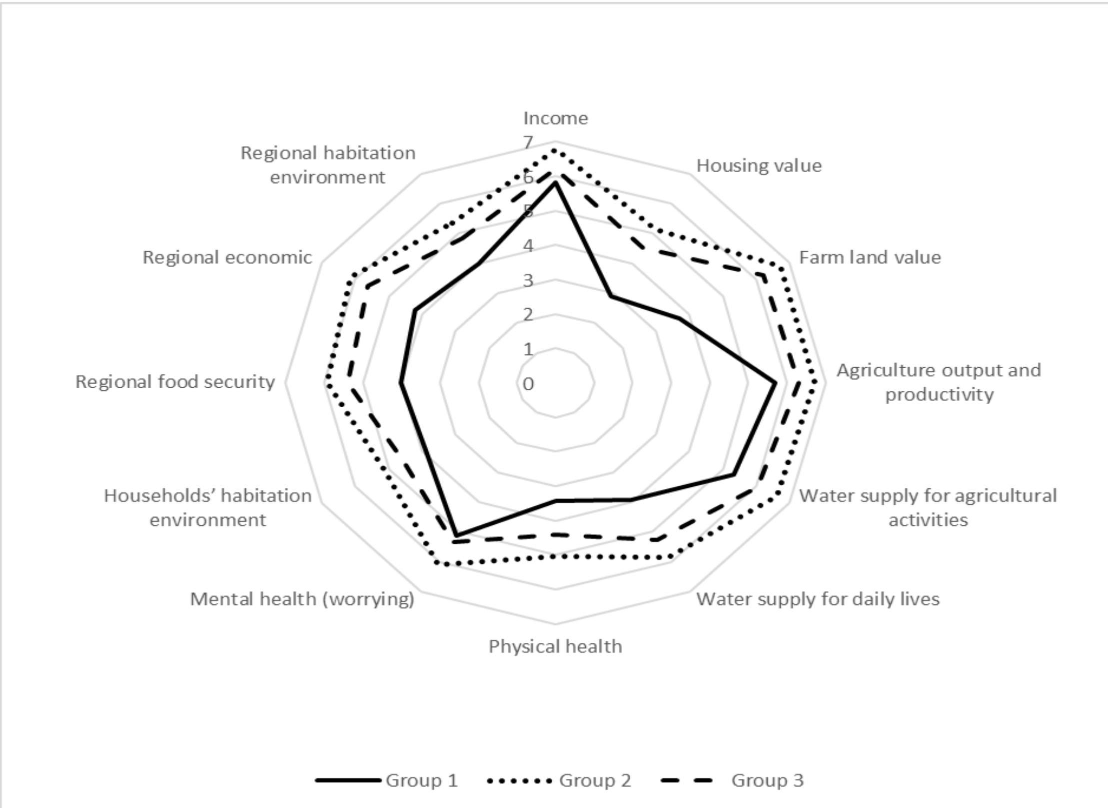


Figure 7. Farmers' perception of future salinity intrusion impacts on farm households' and regions over the next 3 years by group

With respect to reported mental health issues, a plausible explanation may be that physical impacts of flood or drought events are more immediate, manifesting as sickness or famine over shorter periods (i.e. months), while the impacts of salinity intrusion take longer to manifest (i.e. years) with an attendant mental toll. Our findings are consistent with other studies of broader issues suggesting that climate change-related issues affect both physical and mental health (Berry et al., 2011). However, since the data related to mental problems in this study stem from one Likert scale answer it is necessary to conduct more research before drawing any wider policy implications.

Temporal aspects to salinity intrusion may also explain the roughly equal split between farmer perceptions of regional economic impacts. While some are experiencing problems at present, other districts would have less familiarity with regional changes. This suggests a need for more data collection with regard to health impacts, as well as improved information from local authorities to farmers in currently/future affected districts about salinity intrusion.

MRD farmers also did not necessarily equate productivity or livelihood impacts with increased salinity. For example, although changes to three-crop rice production systems in recent years has required increased water usage in the MRD, few farm households appear to have made the connection between that and increasing salinity levels. This may drive both a continued reliance on private short-term autonomous adaptation strategies, as well as a requirement for public planned adaptation interventions if the effectiveness of these strategies reduces over time. Interestingly, recent evidence suggests that third-rice cropping strategies are already becoming less effective, with lower productive returns and higher chemical costs (Dan, 2015). In addition, while crop insurance may be viewed as a mitigation strategy in other contexts, in Viet Nam this option is not very effective (Khoi, 2014; Thong, 2014). Most farmers do not participate in agricultural insurance schemes due to low affordability and availability from insurance providers.

Finally, the statistically significant drivers of adaptation strategies presented in our models would seem to suggest that if autonomous adaptation strategies reduce overtime—or begin to fail with individual (physical/mental health), private asset (house/land value), community (habitat/environment), and/or regional (food security/economy) impacts—a rise in planned public-policy interventions may be sought as an alternative strategy.

Drivers of preferences for public investment include impacts on water supply and habitation environment which increases the level of proposed strategy agreement. However, the impact on housing value and regional economics lowers this level of agreement. These results may be explained by noting that farm household preferences for long-term measure are also controlled by factors directly related to their farming activities. Thus, these drivers of preferences need more careful testing before any final recommendations for adaptation strategies can be made. However, insights provided by the analysis discussed in this paper offer a useful starting point for that further study, which will be the objective of the research team. Finally, it is clear that our hypothesised expectation of mixed private and public adaptation strategies in response to salinity intrusion impacts will play an important future role, highlighting possible future intervention by the Vietnamese government in the form of support/guidance of adaptation behaviour and outcomes via a range of policies and/or programs.

5 Conclusion

This paper examines farm household perceptions of salinity intrusion impacts, as well as current/intended adaptation strategies in the MRD in an effort to assist policymakers to develop and implement effective future planned public adaptation strategies. The approach taken is to focus on farm household awareness and the extent of autonomous private adaptation to salinity intrusion and, also, the risk that the adverse effects of salinity intrusion could worsen. The empirical findings presented here show that farm households in the MRD have a clear perception of the existing salinity intrusion risk, as well as the future risks associated with the unchecked spread of saline water. One of the important findings from this study is that most farmers in this study area realize the causes and impacts of salinity intrusion—without necessarily linking the two. The findings also indicate farmers' perceptions and attitudes to salinity intrusion do not depend on the level of salinity intrusion impacts.

To date, when the data is examined, it is clear that predominantly short-term adaptation measures have been applied, with varying levels of effectiveness. One of the novel findings from this study is that farm households believe it is hard for them to adapt to the issue by themselves. Moreover, it appears likely that the effectiveness of autonomous farm household strategies will reduce over time and that, if the adverse effects of salinity intrusion are to be avoided, publicly funded programs will be necessary. At present, as Vietnam can do little to increase flows into the MRD, the only option is to construct sea dikes.

If Vietnam is required to invest in public interventions, such as sea dikes, then the findings from this study can be used to guide policy choices and develop implementation guidelines. Our results suggest that time can be bought by using local awareness and information programs. This could be achieved using media such as television, newspaper and radio to increase salinity knowledge about the problem and provide the training needed to expedite improvement. The findings from this study also indicate that engineering adaptation strategies such as sea dike construction are preferred by farm households as long-term planned public interventions and that they are willing to contribute to the cost of such an intervention. If this policy pathway is chosen, then further research on options for the collection of this money and its use would be necessary.

5. References

Alam, G.M.M., Alam, K., Mushtaq, S., 2017. Climate change perceptions and local adaptation strategies of hazard-prone rural households in Bangladesh. Clim. Risk Manag. 17, 52-63. https://doi.org/10.1016/j.crm.2017.06.006

Alam, K., 2015. Farmers' adaptation to water scarcity in drought-prone environments: A case study of Rajshahi District, Bangladesh. Agric. Water Manag. 148, 196-206. http://dx.doi.org/10.1016/j.agwat.2014.10.011

Ayanlade, A., Radeny, M., Morton, J.F., 2017. Comparing smallholder farmers' perception of climate change with meteorological data: A case study from southwestern Nigeria. Weather and Climate Extremes 15, 24-33. https://doi.org/10.1016/j.wace.2016.12.001

Barlow, P.M., Reichard, E.G., 2010. Saltwater intrusion in coastal regions of North America. Hydrogeol. J. 18, 247-260.

Berry, H.L., Hogan, A., Owen, J., Rickwood, D., Fragar, L., 2011. Climate Change and Farmers' Mental Health: Risks and Responses. Asia-Pac J. of Public He. 23, 119S-132S.

Cabooter, E., Weijters, B., Geuens, M., Vermeir, I., 2016. Scale format effects on response option interpretation and use. J. Bus. Res. 69, 2574-2584. https://doi.org/10.1016/j.jbusres.2015.10.138

Caudill, S.B., Mixon, F.G., 1995. Modelling household fertility decisions: Estimation and testing of censored regression models for count data. Empir. Econ. 20, 183-196.

Clogg, C.C., Shihadeh, E.S., 1994. Statistical models for ordinal data. Thousand Oakes: Sage Publications.

Dan, T.Y., 2015. A Cost-Benefit Analysis of Dike Heightening in the Mekong Delta.

Danh, V.T., 2012. Adaptation to sea-level rise in the Vietnamese Mekong River Delta: Should a sea dike be built?, No. 2011-RR13.

Danh, V.T., Khai, H.V., 2014. Using a Risk Cost-Benefit analysis for a sea Dike to adapt to the sea level in the Vietnamese Mekong River delta. Climate 2, 78-102. https://doi.org/10.3390/cli2020078

Dawes, J., 2008. Do data characteristics change according to the number of scale points used? Int. J. Market Res. 50, 61-77. https://doi.org/10.1177/147078530805000106

Dost, S., 2010. Development and climate change: a strategic framework for the World Bank Group.

Dubey, S.K., Trivedi, R.K., Chand, B.K., Mandal, B., Rout, S.K., 2017. Farmers' perceptions of climate change, impacts on freshwater aquaculture and adaptation strategies in climatic change hotspots: A case of the Indian Sundarban delta. Environ. Dev. 21, 38-51. https://doi.org/10.1016/j.envdev.2016.12.002

Famoye, F., Wang, W., 2004. Censored generalized Poisson regression model. Computational statistics & data analysis 46, 547-560.

General Statistics Office of Vietnam, 2018. 2018 Vietnam Statistics Data https://www.gso.gov.vn/Default.aspx?tabid=706&ItemID=13412.

Green, P.E., Rao, V.R., 1970. Rating Scales and Information Recovery - How Many Scales and Response Categories to Use? J. Mark. 34, 33-39.

Guagnano, G., Santarelli, E., Santini, I., 2016. Can Social Capital Affect Subjective Poverty in Europe? An Empirical Analysis Based on a Generalized Ordered Logit Model. Social Indicators Research 128, 881-907.

Harpe, S.E., 2015. How to analyze Likert and other rating scale data. Currents in Pharmacy Teaching and Learning 7, 836-850. https://doi.org/10.1016/j.cptl.2015.08.001

Hill, C., Fomby, T., 2010. Maximum simulated likelihood methods and applications. Emerald Group Publishing.

Ho, T.T., Ubukata, F., 2017. Climate change in Vietnam's Mekong Delta: Soc Trang rice farmers' perceptions and adaptive behaviors. Journal of Environmental Science for Sustainable Society 8, 1-14. https://doi.org/10.3107/jesss.8.1

Hoornweg, D., 2011. Cities and climate change: responding to an urgent agenda. World Bank Publications.

Khai, H.V., Dang, N.H., Yabe, M., 2018. Impact of Salinity Intrusion on Rice Productivity in the Vietnamese Mekong Delta. 九州大学大学院農学研究院紀要 63, 143-148.

Khang, N.D., 小寺昭彦, 坂本利弘, 横沢正幸, 2008. Sensitivity of salinity intrusion to sea level rise and river flow change in Vietnamese Mekong Delta-impacts on availability of irrigation water for rice cropping. 農業気象 64, 167-176.

Khoi, P.D., 2014. The determinants of shrimp farmers' decision to participate into shrimp insurance at Bac Lieu province (in Vietnamese), Socio-Economic development at Mekong River Delta. School of Economics and Business Administration, Can Tho University.

Khong, T.D., Loch, A., Young, M.D., 2019. Inferred valuation versus conventional contingent valuation: A salinity intrusion case study. J. Environ. Manag. 243, 95-104. https://doi.org/10.1016/j.jenvman.2019.05.009

Khong, T.D., Young, M.D., Loch, A., Thennakoon, J., 2018. Mekong River Delta farm-household willingness to pay for salinity intrusion risk reduction. Agr. Water Manag. 200, 80-89. https://doi.org/10.1016/j.agwat.2017.12.010

Kondolf, G.M., Schmitt, R.J., Carling, P., Darby, S., Arias, M., Bizzi, S., Castelletti, A., Cochrane, T.A., Gibson, S., Kummu, M., 2018. Changing sediment budget of the Mekong: Cumulative threats and management strategies for a large river basin. Sci. Total Environ. 625, 114-134. https://doi.org/10.1016/j.scitotenv.2017.11.361

Le Dang, H., Li, E., Bruwer, J., Nuberg, I., 2014. Farmers' perceptions of climate variability and barriers to adaptation: lessons learned from an exploratory study in Vietnam. Mitig Adapt Strateg Glob Change 19, 531-548.

Mahmoud, M.M., Alderiny, M.M., 2010. On estimating parameters of censored generalized Poisson regression model. Appl. Math. Sci. 4, 623-635.

Mamba, S.F., Salam, A., Peter, G., 2015. Farmers' Perception of Climate Change a Case Study in Swaziland. J. Food Secur. 3, 47-61.

Margulis, S., Narain, U., Chinowsky, P., Cretegny, L., Hughes, G., Kirshen, P., Kuriakose, A., Lange, G., Nelson, G., Neumann, J., 2010. Cost to developing countries of adapting to climate change: New methods and estimates.

Nguyen, T.L.H., Yao, S.B., Shah, F., 2017. Farmers' perception, awareness and adaptation to climate change: evidence from northwest Vietnam. Int. J. Clim. Chang. Str. 9, 555-576. https://doi.org/10.1108/IJCCSM-02-2017-0032

Nowlis, S.M., Kahn, B.E., Dhar, R., 2002. Coping with Ambivalence: The Effect of Removing a Neutral Option on Consumer Attitude and Preference Judgments. J. Consumer Res. 29, 319-334.

Nyamadzawo, G., Wuta, M., Nyamangara, J., Gumbo, D., 2013. Opportunities for optimization of in-field water harvesting to cope with changing climate in semi-arid smallholder farming areas of Zimbabwe. SpringerPlus 2, 100.

Ozonur, D., Akdur, H.T.K., Bayrak, H., 2017. Comparisons of tests of distributional assumption in Poisson regression model. Communications in Statistics-Simulation and Computation 46, 6197-6207. https://doi.org/10.1080/03610918.2016.1202267

Schad, I., Schmitter, P., Saint-Macary, C., Neef, A., Lamers, M., Nguyen, L., Hilger, T., Hoffmann, V., 2012. Why do people not learn from flood disasters? Evidence from Vietnam's northwestern mountains. Natural hazards 62, 221-241.

Smajgl, A., Toan, T.Q., Nhan, D.K., Ward, J., Trung, N.H., Tri, L.Q., Tri, V.P.D., Vu, P.T., 2015. Responding to rising sea levels in the Mekong Delta. Nature Clim. Change 5, 167-174.

Tánago, I.G., Urquijo, J., Blauhut, V., Villarroya, F., De Stefano, L., 2016. Learning from experience: a systematic review of assessments of vulnerability to drought. Natural Hazards 80, 951-973.

The Vietnam Academy for Water Resources, 2015. Periodic reports on salinity intrusion forecast in the Mekong River Delta (in Vietnamese), The Southern Institute of Water Resouces Research Ho Chi Minh city (http://www.siwrr.org.vn/?id=news&nhom=93&page=2).

Thong, P.L., 2014. Willingness to pay for rice price insurance of households in Can Tho city (in Vietnmese), Socio-Economics development for Mekong River Delta. School of Economics and Business Administration, Can Tho University.

Toan, T.Q., 2014. 9 - Climate Change and Sea Level Rise in the Mekong Delta: Flood, Tidal Inundation, Salinity Intrusion, and Irrigation Adaptation Methods, in: Esteban, N.D.T.T. (Ed.), Coastal Disasters and Climate Change in Vietnam. Elsevier, Oxford, pp. 199-218.

Trinh, T.Q., Rañola, R.F., Camacho, L.D., Simelton, E., 2018. Determinants of farmers' adaptation to climate change in agricultural production in the central region of Vietnam. Land Use Policy 70, 224-231. https://doi.org/10.1016/j.landusepol.2017.10.023

Vagias, W.M., 2006. Likert-type Scale Response Anchors. Clemson International Institute for Tourism. & Research Development, Department of Parks, Recreation and Tourism Management, Clemson University.

Van, S.T., Boyd, W., Slavich, P., Van, T.M., 2015. Perception of Climate Change and Farmers' Adaptation: A Case Study of Poor and Non-Poor Farmers in Northern Central Coast of Vietnam. J. Basic & Appl. Sci. 11, 323.

Weijters, B., Cabooter, E., Schillewaert, N., 2010. The effect of rating scale format on response styles: The number of response categories and response category labels. Int. J. Res. Mark. 27, 236-247. https://doi.org/10.1016/j.ijresmar.2010.02.004

WHO - Regional Office for Europe, 2002. Floods: Climate change and adaptation strategies for human health, EUR/02/5036813, London, United Kingdom.

World Bank Group, 2010. Vietnam: Economics of Adaptation to Climate Change, Washington, DC 20433.