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1 **A framework for identifying and selecting long term adaptation policy directions for deltas**

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3 Hutton<sup>1</sup>, Katharine Vincent<sup>3</sup>, Andrew Allan<sup>4</sup>, Alex Chapman<sup>2</sup>, Rezaur Rahman<sup>5</sup>, Tuhin Ghosh<sup>6</sup>,  
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5

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18

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21

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24 *and Adaptation (DECCMA) project (IDRC 107642) under the Collaborative Adaptation Research*

25 *Initiative in Africa and Asia (CARIIA) programme with financial support from the UK Government's*

26 *Department for international Development (DFID) and the International Development Research*  
27 *Centre (IDRC), Canada. The views expressed in this work are those of the creators and do not*  
28 *necessarily represent those of DFID and IDRC or its Boards of Governors.*

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54 *Abstract*

55 Deltas are precarious environments experiencing significant biophysical, and socio-economic  
56 changes with the ebb and flow of seasons (including with floods and drought), with infrastructural  
57 developments (such as dikes and polders), with the movement of people, and as a result of climate  
58 and environmental variability and change. Decisions are being taken about the future of deltas and  
59 about the provision of adaptation investment to enable people and the environment to respond to  
60 the changing climate and related changes. The paper presents a framework to identify options for,  
61 and trade-offs between, long term adaptation strategies in deltas. Using a three step process, we:  
62 (1) identify current policy-led adaptations actions in deltas by conducting literature searches on  
63 current observable adaptations, potential transformational adaptations and government policy; (2)  
64 develop narratives of future adaptation policy directions that take into account investment cost of  
65 adaptation and the extent to which significant policy change/ political effort is required; and (3) explore  
66 trade-offs that occur within each policy direction using a subjective weighting process developed  
67 during a collaborative expert workshop. We conclude that the process of developing policy  
68 directions for adaptation can assist policy makers in scoping the spectrum of options that exist, while  
69 enabling them to consider their own willingness to make significant policy changes within the delta  
70 and to initiate transformative change.

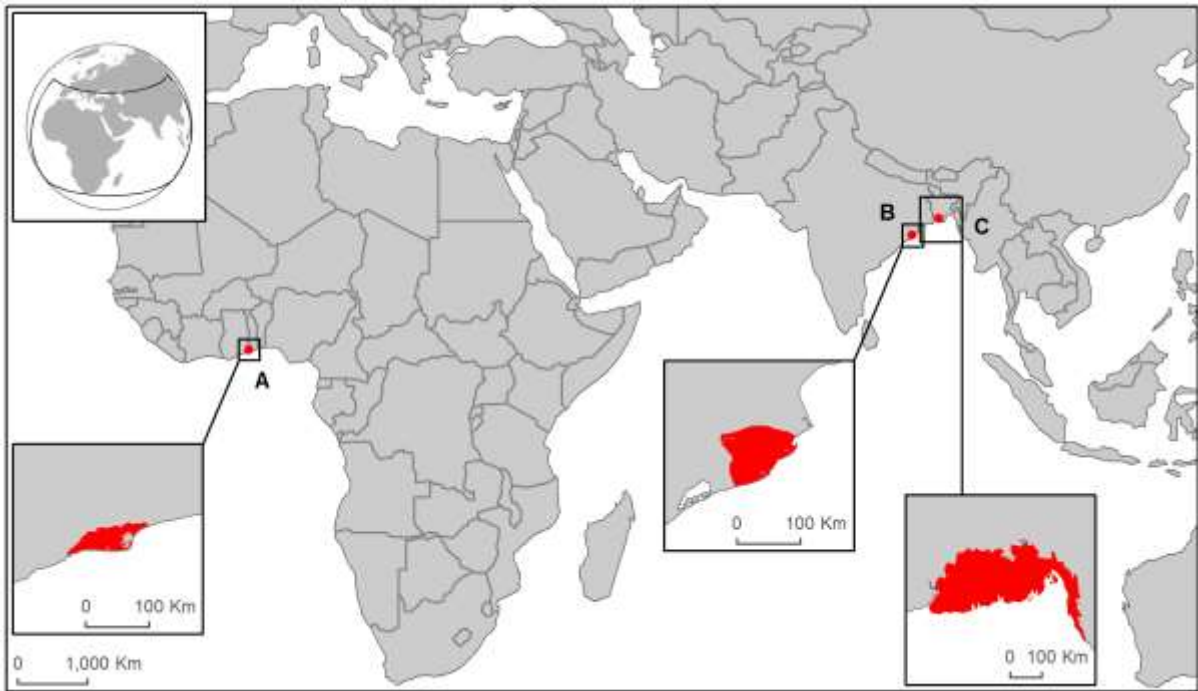
71

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## 73 1. Introduction

74 Deltas are dynamic, stressed and often densely populated environments. They are especially  
75 vulnerable to the impacts of climate change and variability, including sea-level rise, erosion, land loss,  
76 increased soil salinity, and changing storms { ADDIN EN.CITE { ADDIN EN.CITE.DATA }}. These factors  
77 combined with subsidence and sediment starvation are rapidly changing the coastal landscape {  
78 ADDIN EN.CITE { ADDIN EN.CITE.DATA }}. This has implications for deltaic populations who rely on  
79 the economic activities and ecosystems services that deltas provide { ADDIN EN.CITE  
80 <EndNote><Cite><Author>Ericson</Author><Year>2006</Year><RecNum>641</RecNum><DisplayT  
81 ext>(Ericson et al., 2006)</DisplayText><record><rec-number>641</rec-number><foreign-  
82 keys><key app="EN" db-id="vx99swex92xxtwettvxxzpt2edff2zwe0a2">641</key></foreign-  
83 keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Ericson,  
84 Jason P</author><author>Vörösmarty, Charles J</author><author>Dingman, S  
85 Lawrence</author><author>Ward, Larry G</author><author>Meybeck,  
86 Michel</author></authors></contributors><titles><title>Effective sea-level rise and deltas: causes  
87 of change and human dimension implications</title><secondary-title>Global and Planetary  
88 Change</secondary-title></titles><periodical><full-title>Global and Planetary Change</full-  
89 title></periodical><pages>63-  
90 82</pages><volume>50</volume><number>1</number><dates><year>2006</year></dates><isbn>  
91 0921-8181</isbn><urls></urls></record></Cite></EndNote>}. Without adaptation measures to  
92 address these multiple stresses, deltas could struggle to attain the Sustainable Development Goals  
93 (SDGs) and become unsafe locations. Human interventions have a long history in deltas through  
94 efforts to enhance livelihoods and reduce hazards. Engineered adaptation interventions, where they  
95 have occurred, have arguably had a major impact on delta evolution { ADDIN EN.CITE  
96 <EndNote><Cite><Author>Welch</Author><Year>2017</Year><RecNum>678</RecNum><DisplayTe  
97 xt>(Welch et al., 2017)</DisplayText><record><rec-number>678</rec-number><foreign-keys><key

98 app="EN" db-id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">678</key></foreign-keys><ref-type  
99 name="Journal Article">17</ref-type><contributors><authors><author>Welch,  
100 AC</author><author>Nicholls, RJ</author><author>Lázár,  
101 AN</author></authors></contributors><titles><title>Evolving deltas: Coevolution with engineered  
102 interventions</title><secondary-title>Elem Sci Anth</secondary-title></titles><periodical><full-  
103 title>Elem Sci Anth</full-  
104 title></periodical><volume>5</volume><dates><year>2017</year></dates><isbn>2325-  
105 1026</isbn><urls></urls></record></Cite></EndNote>}. However, these adaptations have not been  
106 systematically planned, assessed or documented to date. Consequently, there is a pressing need for  
107 information about what deltaic communities and their governments can do to adapt. Drawing on  
108 evidence of policy-led adaptations collected through a five year IDRC funded project ('Deltas,  
109 Vulnerability & Climate Change: Migration and Adaptation' - DECCMA) this paper aims to provide  
110 policy makers with insight into plausible adaptation policy directions in deltas. DECCMA's  
111 geographical focus is on three deltas in Africa and Asia: the Volta in Ghana, the Mahanadi in India,  
112 and the Ganges-Brahmaputra-Meghna (GBM) spanning India and Bangladesh (Figure 1). However,  
113 this paper has a wider relevance, especially for large ecosystems, as we seek to generate a method  
114 for understanding adaptation in complex social and physical environments.



115

116 **Figure 1: Map of the DECCMA study deltas (A: Volta Delta, Ghana; B: Mahanadi Delta, India; C:**  
 117 **Ganges-Brahmaputra-Meghna (GBM), India and Bangladesh)**

118

119 Adaptation policy is a newly emerging area for most countries where it is becoming an increasingly  
 120 important challenge to meet. Adaptation is all the more pertinent in the context of the Paris  
 121 Agreement 2015, the global agreement to address climate change, adopted under the United  
 122 Nations Framework Convention on Climate Change (UNFCCC). The Paris Agreement introduces an  
 123 ‘ambition mechanism’ requiring countries to strengthen their commitments to adaptation and  
 124 mitigation. Many countries are grappling with the possible contents of adaptation policy, and this is  
 125 especially challenging in large interconnected and transboundary ecosystems, such as deltas,  
 126 mountains or coasts, where adaptation policies do not exist. Using deltas as an example, we reflect  
 127 on the challenges affecting large ecosystems, that often have both upstream and downstream areas,  
 128 and that may span national or regional borders. The aim of this paper is therefore to explore long  
 129 term adaptation policy choices for deltas. To do this we ask: (1) what adaptations are occurring in

130 deltas?; (2) what are possible future directions for adaptation policy?; and (3) what are the trade-  
131 offs associated with each policy direction?

132 This paper first reviews the theoretical literature on framing adaptation, and considers the key  
133 drivers underpinning adaptation policy development (section 2). Drawing on data collected by  
134 DECCMA researchers during literature searches, inventory analysis and policy analysis, we then  
135 outline the planned, policy-led adaptations that are currently occurring in deltas, as well as  
136 presenting a method to create and populate four discrete directions for adaptation policy, which  
137 considers the trade-offs between different aspects of adaptation (section 3). Section 4 describes  
138 specific adaptation actions in DECCMA's three deltas, in the context of the four directions for policy,  
139 which range from a minimum intervention approach to radical transformational adaptation.

## 140 2. Adaptation theory

141 Broadly defined, adaptation is "an adjustment in natural or human systems in response to actual or  
142 expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities"

143 { ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>Intergovernmental Panel on Climate  
144 Change (IPCC)</Author><Year>2007</Year><RecNum>679</RecNum><Prefix>IPCC`,  
145 </Prefix><DisplayText>(IPCC, 2007)</DisplayText><record><rec-number>679</rec-  
146 number><foreign-keys><key app="EN" db-

147 id="vx99swex92xxtwettvxxzpt2edff2zwe0a2">679</key></foreign-keys><ref-type  
148 name="Book">6</ref-type><contributors><authors><author>Intergovernmental Panel on Climate  
149 Change (IPCC),</author></authors><secondary-authors><author>Parry, Martin  
150 L</author><author>Canziani, OF</author><author>Palutikof, Jean P</author><author>van der  
151 Linden, Paul J</author><author>Hanson, Clair E</author></secondary-  
152 authors></contributors><titles><title>Contribution of Working Group II to the Fourth Assessment  
153 Report of the Intergovernmental Panel on Climate Change,



154 2007</title></titles><dates><year>2007</year></dates><urls></urls></record></Cite></EndNote> }.

155 However, debates surrounding more precise definitions as well as the content of adaptation  
156 continue unabated adding to the perceived complexity of understanding adaptation { ADDIN EN.CITE  
157 <EndNote><Cite><Author>Lesnikowski</Author><Year>2016</Year><RecNum>5560</RecNum><Di  
158 splayText>(Lesnikowski et al., 2016)</DisplayText><record><rec-number>5560</rec-  
159 number><foreign-keys><key app="EN" db-id="552vavf0m5009dezrviv5909wperzvd9at9"  
160 timestamp="1510134691">5560</key></foreign-keys><ref-type name="Journal Article">17</ref-  
161 type><contributors><authors><author>Lesnikowski, Alexandra</author><author>Ford,  
162 James</author><author>Biesbroek, Robbert</author><author>Berrang-Ford,  
163 Lea</author><author>Heymann, S. Jody</author></authors></contributors><titles><title>National-  
164 level progress on adaptation</title><secondary-title>Nature Clim. Change</secondary-  
165 title></titles><periodical><full-title>Nature Clim. Change</full-title></periodical><pages>261-  
166 264</pages><volume>6</volume><number>3</number><dates><year>2016</year><pub-  
167 dates><date>03//print</date></pub-dates></dates><publisher>Nature Publishing  
168 Group</publisher><isbn>1758-678X</isbn><work-type>Letter</work-type><urls><related-  
169 urls><url>http://dx.doi.org/10.1038/nclimate2863</url></related-urls></urls><electronic-resource-  
170 num>10.1038/nclimate2863&#xD;http://www.nature.com/nclimate/journal/v6/n3/abs/nclimate28  
171 63.html#supplementary-information</electronic-resource-num></record></Cite></EndNote> }.

172 Despite the lack of consensus in answering questions about the relationship between adaptation  
173 and other variables e.g. coping and adapting, or adaptation and development, progress has been  
174 made on agreeing its broad aims. It is generally agreed that adaptation aims to: (1) address drivers of  
175 vulnerability; (2) reduce disaster risk (DRR); and, (3) build landscape/ecosystem resilience { ADDIN  
176 EN.CITE { ADDIN EN.CITE.DATA } }. These three broad aims allow a simpler categorisation of  
177 adaptation options and an easier communication to stakeholders. We are thus developing and  
178 organising our policy adaptation scenarios around these categories.

179 Well-developed theoretical constructs already exist to allow us to explore the three aims of  
180 adaptation in more detail. To better understand the first aim, addressing the drivers of vulnerability,  
181 the sustainable livelihoods approach (SLA) builds on decades of work on entitlements and  
182 endowments. It has been widely used to document poverty and wellbeing in the context of shocks  
183 and stresses { ADDIN EN.CITE  
184 <EndNote><Cite><Author>Chambers</Author><Year>1992</Year><RecNum>2772</RecNum><Disp  
185 layText>(Carney, 1998; Chambers and Conway, 1992)</DisplayText><record><rec-  
186 number>2772</rec-number><foreign-keys><key app="EN" db-  
187 id="552vavf0m5009dezrviv5909wperzvd9at9" timestamp="1343720948">2772</key></foreign-  
188 keys><ref-type name="Report">27</ref-type><contributors><authors><author>Chambers,  
189 R.</author><author>Conway, G. </author></authors></contributors><titles><title>Sustainable rural  
190 livelihoods: practical concepts for the 21st  
191 century</title></titles><dates><year>1992</year></dates><pub-location>Brighton</pub-  
192 location><publisher>Institute of Development  
193 Studies.</publisher><urls></urls></record></Cite><Cite><Author>Carney</Author><Year>1998</Ye  
194 ar><RecNum>873</RecNum><record><rec-number>873</rec-number><foreign-keys><key  
195 app="EN" db-id="552vavf0m5009dezrviv5909wperzvd9at9"  
196 timestamp="1334223875">873</key></foreign-keys><ref-type name="Edited Book">28</ref-  
197 type><contributors><authors><author>Diana Carney</author></authors><secondary-  
198 authors><author>DFID Natural Resources Department,</author></secondary-  
199 authors></contributors><titles><title>Sustainable rural livelihoods: What contributions can we  
200 make?</title></titles><dates><year>1998</year></dates><pub-location>London</pub-  
201 location><publisher>Department for International Development  
202 (DfID)</publisher><urls></urls></record></Cite></EndNote>}. The SLA offers a visual and practical  
203 framework to categorise adaptations around the different forms of capitals that are used to  
204 generate income and support livelihoods { ADDIN EN.CITE

205 <EndNote><Cite><Author>DfID</Author><Year>1999</Year><RecNum>599</RecNum><DisplayText  
206 >(DfID, 1999)</DisplayText><record><rec-number>599</rec-number><foreign-keys><key app="EN"  
207 db-id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">599</key></foreign-keys><ref-type  
208 name="Journal Article">17</ref-type><contributors><authors><author>DfID,  
209 UK</author></authors></contributors><titles><title>Sustainable livelihoods guidance  
210 sheets</title><secondary-title>London: DFID</secondary-title></titles><periodical><full-  
211 title>London: DFID</full-  
212 title></periodical><dates><year>1999</year></dates><urls></urls></record></Cite></EndNote>}.  
213 The five capitals used in the SLA relate to people's stocks of / access to: i) the natural environment  
214 (*natural capital*); ii) health, education and physical wellbeing (*human capital*); iii) financial resources  
215 (*financial capital*); iv) physical assets and infrastructure, such as houses, cars, phones (*physical*  
216 *capital*); and v) access to social networks and community support (*social capital*).

217 The Hyogo and Sendai Frameworks { ADDIN EN.CITE  
218 <EndNote><Cite><Author>UNISDR</Author><Year>2005</Year><RecNum>600</RecNum><Display  
219 Text>(UNISDR, 2005; UNISDR, 2015)</DisplayText><record><rec-number>600</rec-  
220 number><foreign-keys><key app="EN" db-  
221 id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">600</key></foreign-keys><ref-type name="Web  
222 Page">12</ref-  
223 type><contributors><authors><author>UNISDR</author></authors></contributors><titles><title>H  
224 yogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to  
225 Disasters. 22 (International Strategy for Disaster Reduction  
226 www.unisdr.org)</title></titles><dates><year>2005</year></dates><pub-location>Geneva</pub-  
227 location><urls></urls></record></Cite><Cite><Author>UNISDR</Author><Year>2015</Year><RecN  
228 um>601</RecNum><record><rec-number>601</rec-number><foreign-keys><key app="EN" db-  
229 id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">601</key></foreign-keys><ref-type name="Web  
230 Page">12</ref-

231 type<<contributors><authors><author>UNISDR</author></authors></contributors><titles><title>Se  
232 ndai Framework for Disaster Risk Reduction 2015-2030. 37 (International Strategy for Disaster  
233 Reduction www.unisdr.org)</title></titles><dates><year>2015</year></dates><pub-  
234 location>Geneva</pub-location><urls></urls></record></Cite></EndNote>} categorise actions that  
235 address the second aim of adaptation, DRR. These frameworks respond to decades of research into  
236 DRR that finds that disasters do not happen on their own – they are created through people’s  
237 susceptibility and exposure to hazards { ADDIN EN.CITE <EndNote><Cite><Author>World  
238 Bank</Author><Year>2010</Year><RecNum>4938</RecNum><DisplayText>(Pelling, 2001; World  
239 Bank and United Nations, 2010)</DisplayText><record><rec-number>4938</rec-number><foreign-  
240 keys><key app="EN" db-id="552vavf0m5009dezrviv5909wperzvd9at9"  
241 timestamp="1343720960">4938</key></foreign-keys><ref-type name="Report">27</ref-  
242 type><contributors><authors><author>World Bank,</author><author>United  
243 Nations,</author></authors></contributors><titles><title>Natural Hazards, UnNatural Disasters.  
244 The Economics of Effective  
245 Prevention</title></titles><pages>254</pages><dates><year>2010</year></dates><pub-  
246 location>Washington D.C.</pub-location><publisher>The International Bank for Reconstruction and  
247 Development / The World  
248 Bank</publisher><urls></urls></record></Cite><Cite><Author>Pelling</Author><Year>2001</Year>  
249 <RecNum>4206</RecNum><record><rec-number>4206</rec-number><foreign-keys><key  
250 app="EN" db-id="552vavf0m5009dezrviv5909wperzvd9at9"  
251 timestamp="1343720956">4206</key></foreign-keys><ref-type name="Book Section">5</ref-  
252 type><contributors><authors><author>Pelling, M. </author></authors><secondary-  
253 authors><author>Castree, N.</author><author>Braun, B.</author></secondary-  
254 authors></contributors><titles><title>Natural Disasters?</title><secondary-title>Social  
255 Nature</secondary-title></titles><pages>170-  
256 188</pages><dates><year>2001</year></dates><pub-location>Oxford</pub-

257 location><publisher>Blackwell</publisher><urls></urls></record></Cite></EndNote>}. The  
258 frameworks acknowledge that susceptibility and exposure arises from a lack of action in four time  
259 steps: i) *long term risk mitigation*, such as managing land or infrastructure to reduce risk; ii) *hazard*  
260 *preparedness*, i.e. preparing for specific hazards, for example through developing risk management  
261 plans; iii) *response*, timely action taken immediately before, during or immediately after a hazardous  
262 event, e.g. evacuation or going to a shelter; and iv) *recovery and rehabilitation*, i.e. returning to  
263 normality after a disaster, such as search and rescue, or rebuilding post disaster.

264 A third framework, the Millennium Ecosystem Assessment { ADDIN EN.CITE <EndNote><Cite  
265 ExcludeAuth="1"><Author>MEA (Millennium Ecosystem  
266 Assessment)</Author><Year>2005</Year><RecNum>602</RecNum><Prefix>MEA  
267 </Prefix><DisplayText>(MEA 2005)</DisplayText><record><rec-number>602</rec-  
268 number><foreign-keys><key app="EN" db-  
269 id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">602</key></foreign-keys><ref-type  
270 name="Report">27</ref-type><contributors><authors><author>MEA (Millennium Ecosystem  
271 Assessment),</author></authors></contributors><titles><title>Millennium ecosystem  
272 assessment</title><secondary-title>Ecosystems and human wellbeing: a framework for assessment  
273 Washington, DC: Island Press</secondary-title></titles><periodical><full-title>Ecosystems and  
274 human wellbeing: a framework for assessment Washington, DC: Island Press</full-  
275 title></periodical><dates><year>2005</year></dates><urls></urls></record></Cite></EndNote>},  
276 categorises actions that address the third aim of adaptation, building social-ecological resilience. The  
277 MEA recognises the value of ecosystems and the services that they provide. Following CGIAR {  
278 ADDIN EN.CITE <EndNote><Cite ExcludeAuth="1"><Author>CGIAR Research Program on Water Land  
279 and Ecosystems  
280 (WLE)</Author><Year>2014</Year><RecNum>595</RecNum><DisplayText>(2014)</DisplayText><r  
281 ecord><rec-number>595</rec-number><foreign-keys><key app="EN" db-  
282 id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">595</key></foreign-keys><ref-type

283 name="Report">27</ref-type><contributors><authors><author>CGIAR Research Program on Water  
284 Land and Ecosystems (WLE),</author></authors></contributors><titles><title>Ecosystem services  
285 and resilience framework. </title><secondary-title>Colombo, Sri Lanka: International Water  
286 Management Institute (IWMI). CGIAR Research Program on Water, Land and Ecosystems (WLE). 46p.  
287 doi: 10.5337/2014.229</secondary-  
288 title></titles><dates><year>2014</year></dates><urls></urls></record></Cite></EndNote>} and {  
289 ADDIN EN.CITE <EndNote><Cite  
290 AuthorYear="1"><Author>Walker</Author><Year>2012</Year><RecNum>604</RecNum><DisplayT  
291 ext>Walker and Salt (2012</DisplayText><record><rec-number>604</rec-number><foreign-  
292 keys><key app="EN" db-id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">604</key></foreign-  
293 keys><ref-type name="Book">6</ref-type><contributors><authors><author>Walker,  
294 Brian</author><author>Salt, David</author></authors></contributors><titles><title>Resilience  
295 thinking: sustaining ecosystems and people in a changing  
296 world</title></titles><dates><year>2012</year></dates><publisher>Island  
297 Press</publisher><isbn>1597266221</isbn><urls></urls></record></Cite></EndNote>}} we define  
298 ecosystems services as the combined actions of natural processes that perform functions of value to  
299 society. Since the MEA, ecosystems are broadly recognised as delivering four main types of services:  
300 i) provision of food, water, building materials and protection of direct use to people (*provisioning*  
301 *services*); ii) maintenance of a diversity of species (e.g. bee and bird populations to fertilise plants) to  
302 support other ecosystems (*habitat services*); iii) maintenance of healthy planetary systems e.g. trees  
303 to regulate the climate and air quality (*regulating services*); and iv) aesthetic, spiritual, mental health,  
304 and cognitive development services (*cultural services*). By using the MEA in conjunction with the SLA,  
305 the interrelationships between natural resources and human wellbeing are recognised. As such, this  
306 approach addresses criticisms of the SLA that relate to the concept of 'natural capital', notably, that  
307 by suggesting ecological processes are a form of capital, trading them for another form of capital, for  
308 monetary or other gain, is without consequence { ADDIN EN.CITE

309 <EndNote><Cite><Author>Sneddon</Author><Year>2000</Year><RecNum>635</RecNum><Display  
310 Text>(Sneddon, 2000)</DisplayText><record><rec-number>635</rec-number><foreign-keys><key  
311 app="EN" db-id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">635</key></foreign-keys><ref-type  
312 name="Journal Article">17</ref-type><contributors><authors><author>Christopher S.  
313 Sneddon</author></authors></contributors><titles><title>'Sustainability' in ecological economics,  
314 ecology and livelihoods: a review</title><secondary-title>Progress in Human  
315 Geography</secondary-title></titles><periodical><full-title>Progress in Human Geography</full-  
316 title></periodical><pages>521-  
317 549</pages><volume>24</volume><number>4</number><keywords><keyword>ecological  
318 economics,ecology,sustainability,sustainable development,sustainable  
319 livelihoods</keyword></keywords><dates><year>2000</year></dates><urls><related-  
320 urls><url><http://journals.sagepub.com/doi/abs/10.1191/030913200100189076></url></related-  
321 urls></urls><electronic-resource-num>10.1191/030913200100189076</electronic-resource-  
322 num></record></Cite></EndNote>.

323 Collectively, these three theoretical frameworks allow us to consider adaptation options at multiple  
324 spatial scales, across multiple environments (from human to natural), and at multiple administrative  
325 scales (household to national). To allow us to identify and document adaptations we use all three  
326 frameworks (Figure 2), recognising 13 classes of adaptation. Although we document adaptations  
327 using deltas as an example, these classes of adaptation could apply anywhere.

328

329

# Adaptation to climate variability/change and related drivers

## Vulnerability Reduction

1. Human capital

2. Financial capital

3. Social capital

4. Physical capital

5. Natural capital

## Disaster Risk Reduction

6. Risk mitigation

7. Hazard preparedness

8. Disaster response

9. Post disaster recovery

## Social-Ecological Resilience

10. Provisioning services

11. Regulating services

12. Habitat services

13. Cultural services

330

331 **Figure 2: Classes of adaptation**

332 As with any typology, there are inevitably overlaps between categories. To address this issue, we  
333 have slightly modified the focus of some of the 13 classes, which are outlined in greater detail in  
334 Table 1. For example, to address areas of potential duplication between 'natural capital' and  
335 'provisioning services', we include 'natural capital' adaptations only where the adaptation actively  
336 influences livelihoods and relates to land access and ownership. For example, natural capital  
337 adaptations may include land reclamation and redistribution (to the poor or other groups) or fishing  
338 zones with associated fishing rights. In contrast, adaptations included in 'provisioning services' relate  
339 to the production of goods and services by the land. These adaptations may include the use of  
340 climate tolerant crops or the provision of seed banks. The following section applies this framework  
341 to first identify current adaptation actions in deltas, and then to create directions for policy that  
342 explicitly show the trade-offs between the 13 different classes.

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345



346 **Table 1: Description of the 13 classes of adaptation**

<b>Broad objective of adaptation</b>	<b>Class of adaptation</b>	<b>Description of plausible adaptations</b>
Addressing drivers of vulnerability	1. Financial Capital	Changes in flows of money and savings that households have available, including loans and insurance
	2. Human Capital	Changes in skills, health and ability to labour of members of a household
	3. Social Capital	Changes in networks, relationships and membership of groups that households can use
	4. Natural Capital	Changes in land ownership and access to natural resources and storage facilities
	5. Physical Capital	Changes in infrastructure and goods such as tools and equipment that households can use to increase productivity and non-productive assets of the households (e.g. house material)
Disaster Risk Reduction	6. Managing long term risk	Efforts to build physical and social infrastructure that mitigate the worst impacts of an event. These can be one off activities, for example, building a sea wall, cyclone shelters, or on-going initiatives, e.g. developing flood risk management plans or relocating communities.
	7. Preparedness	Efforts to ensure communities are ready to respond to an event. These activities take place cyclically, for example, ensuring sea walls are maintained, practicing evacuation drills, or testing early warning systems.
	8. Response	Efforts to ensure affected households, communities, business and services receive appropriate assistance during and immediately following an event, e.g. evacuation support, first aid medical supplies, emergency responders
	9. Post disaster recovery and rehabilitation	Efforts to ensure affected households, communities, business and services are able to rebuild following an event, e.g. rehousing, reconstruction, etc.
Landscape/ecosystem resilience	10. Provisioning services	Changes in ecosystem goods, quality or productivity that can be directly consumed, such as food, water, raw materials (e.g. fibre, biofuel, ornamental items), but also adaptations that enhance these services such as the use of irrigation and fertiliser
	11. Regulating services	Changes in the services that keep the wider planetary systems (such as the atmosphere, cryosphere, oceans) functioning and include the regulation of climate, air, nutrient cycles and water flows; moderation of extreme events; treatment of waste – including water purification; preventing erosion; maintaining soil fertility; pollination; and biological controls, such as pests and diseases.
	12. Habitat services	Changes in the habitats that maintain the life cycles of species or maintain genetic diversity, through quality and quantity of suitable habitats. In turn, these habitats underpin the health of provisioning and regulating services.

	13. Cultural services	Changes in aesthetic, recreational and tourism, inspirational, spiritual, cognitive development and mental health services provided by ecosystems.
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348 **3. Identifying long term adaptation policy directions for deltas**

349 With a view to creating a set of adaptation policy directions for deltas, a three step process was  
 350 adopted: i) identify current policy-led adaptation actions in deltas in Ghana, India, and Bangladesh  
 351 (using the framing method in section 2); ii), create narratives of adaptation policy directions; and iii)  
 352 highlight adaptation trade-offs inherent in each policy direction.

353 *3.1. Step 1: Identify current policy-led adaptation actions in deltas*

354 Adaptation actions were identified using an inventory of observed adaptations, delta-wide  
 355 adaptation policy analyses, and a literature search on transformational adaptation. First, to generate  
 356 evidence of observed adaptations, we conducted a keyword search using ISI Web of Science. Each  
 357 delta team employed specific search terms appropriate to the type of hazard they experienced. For  
 358 example, Bangladesh used terms such as “Climat\*”, “Adapt\*”, “Cyclon\*”, “Flood\*”, “Salin\*”  
 359 coupled with the term “Bangladesh”. Papers were deemed suitable for inclusion if they documented  
 360 observed (and not theoretical) examples of adaptation, included a study area that was within the  
 361 boundaries of the DECCMA deltas, had been peer-reviewed, and were published in English. To  
 362 identify articles from the grey literature (e.g. NGO reports) we used a snowballing method where  
 363 we discussed the findings of the peer-reviewed literature search with country experts who then  
 364 sought out relevant grey literature { ADDIN EN.CITE <EndNote><Cite><Author>Hagen-  
 365 Zanker</Author><Year>2013</Year><RecNum>718</RecNum><DisplayText>(Hagen-Zanker and  
 366 Mallett, 2013)</DisplayText><record><rec-number>718</rec-number><foreign-keys><key  
 367 app="EN" db-id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">718</key></foreign-keys><ref-type  
 368 name="Journal Article">17</ref-type><contributors><authors><author>Hagen-Zanker,  
 369 Jessica</author><author>Mallett, R</author></authors></contributors><titles><title>How to do a

370 rigorous, evidence-focused literature review in international development, A Guidance  
371 Note</title><secondary-title>London: Overseas Development Institute</secondary-  
372 title></titles><periodical><full-title>London: Overseas Development Institute</full-  
373 title></periodical><dates><year>2013</year></dates><urls></urls></record></Cite></EndNote>}.  
374 The output of these searches generated an inventory of 122 adaptations that included strategies  
375 such as post disaster mobile water treatment plants or training on new farming methods. Of these,  
376 93 documents relate to the GBM delta (85 from Bangladesh and 8 from the Indian Bengal Delta), 14  
377 refer to the Mahanadi, and 15 to the Volta.

378 Second, each DECCMA country team conducted a review of current and proposed adaptation policy  
379 in the study areas { ADDIN EN.CITE { ADDIN EN.CITE.DATA }}. Thirty-one policy documents from the  
380 GBM were included in the review (21 from Bangladesh and 10 from the Indian Bengal Delta); 21  
381 policy documents from the Mahanadi were included; and 18 from Ghana. Third, a literature search  
382 was undertaken on transformative adaptation to document the types of adaptations that could be  
383 considered radical, new and of a scale or intensity so the whole deltaic system is transformed, either  
384 socially, physically, or both { ADDIN EN.CITE  
385 <EndNote><Cite><Author>Vincent</Author><Year>2017</Year><RecNum>5617</RecNum><Display  
386 Text>(Kates et al., 2012; Vincent, 2017)</DisplayText><record><rec-number>5617</rec-  
387 number><foreign-keys><key app="EN" db-id="552vavf0m5009dezrviv5909wperzvdf9at9"  
388 timestamp="1512399975">5617</key></foreign-keys><ref-type name="Report">27</ref-  
389 type><contributors><authors><author>Vincent, K. </author></authors><secondary-  
390 authors><author>DECCMA</author></secondary-authors><tertiary-authors><author>DECCMA,  
391 University of Southampton</author></tertiary-  
392 authors></contributors><titles><title>Transformational adaptation: A review of examples from 4  
393 deltas to inform the design of DECCMA's Adaptation Policy Trajectories</title><secondary-  
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398 </Year><RecNum>31</RecNum><record><rec-number>31</rec-number><foreign-keys><key  
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402 J</author></authors></contributors><titles><title>Transformational adaptation when incremental  
403 adaptations to climate change are insufficient</title><secondary-title>Proceedings of the National  
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406 7161</pages><volume>109</volume><number>19</number><dates><year>2012</year></dates><  
407 isbn>0027-8424</isbn><urls></urls></record></Cite></EndNote>}.  
408 All data were analysed consistently within the three DECCMA deltas using a data collection and  
409 analysis template, developed by { ADDIN EN.CITE <EndNote><Cite  
410 AuthorYear="1"><Author>Tompkins</Author><Year>2010</Year><RecNum>2119</RecNum><Displ  
411 ayText>Tompkins et al. (2010</DisplayText><record><rec-number>2119</rec-number><foreign-  
412 keys><key app="EN" db-id="552vavf0m5009dezrviv5909wperzvdf9at9"  
413 timestamp="1334223947">2119</key></foreign-keys><ref-type name="Journal Article">17</ref-  
414 type><contributors><authors><author>Emma L. Tompkins</author><author>Emily  
415 Boyd</author><author>Sophie Nicholson-Cole</author><author>W Neil  
416 Adger</author><author>Keith Weatherhead</author><author>Nigel W  
417 Arnell</author></authors></contributors><titles><title>Observed adaptation to climate change: UK  
418 evidence of transition to a well-adapting society?</title><secondary-title>Global Environmental  
419 Change</secondary-title></titles><periodical><full-title>Global Environmental Change</full-  
420 title></periodical><pages>627-  
421 635</pages><volume>20</volume><dates><year>2010</year></dates><urls></urls></record></Cit

422 e></EndNote>}} and described in { ADDIN EN.CITE <EndNote><Cite  
 423 AuthorYear="1"><Author>Tompkins</Author><Year>2017</Year><RecNum>605</RecNum><Displa  
 424 yText>Tompkins et al. (2017</DisplayText><record><rec-number>605</rec-number><foreign-  
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 427 </author><author>Suckall, N., </author><author>Vincent, K., </author><author>Rahman, R.,  
 428 </author><author>Mensah, A., </author><author>Ghosh,  
 429 T.,</author></authors></contributors><titles><title>Observed adaptation in deltas. DECCMA  
 430 Working Paper, Deltas, Vulnerability and Climate Change: Migration and Adaptation, IDRC Project  
 431 Number 107642. Available online at: www.deccma.com, Accessed 27 November  
 432 2017</title></titles><dates><year>2017</year></dates><urls></urls></record></Cite></EndNote>}  
 433 ). For each adaptation found in the literature, information categorised based on five core questions  
 434 asked by { ADDIN EN.CITE  
 435 <EndNote><Cite><Author>Smit</Author><Year>2001</Year><RecNum>719</RecNum><DisplayText  
 436 >(Smit and Pilifosova, 2001)</DisplayText><record><rec-number>719</rec-number><foreign-  
 437 keys><key app="EN" db-id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">719</key></foreign-  
 438 keys><ref-type name="Book Section">5</ref-type><contributors><authors><author>Smit,  
 439 B</author><author>Pilifosova, O</author></authors><secondary-authors><author>McCarthy,  
 440 J.J</author><author>Canziani, O</author><author>Leary, N. A</author><author>Dokken, D.  
 441 J</author><author>White, K. S</author></secondary-authors></contributors><titles><title>Chapter  
 442 18, Adaptation to climate change in the context of sustainable development and  
 443 equity</title><secondary-title>Climate Change 2001: Impacts, Adaptation, Vulnerability.  
 444 Contribution of Working Group II. Third Assessment Report of the Intergovernmental Panel on  
 445 Climate Change</secondary-title></titles><pages>877-  
 446 912</pages><dates><year>2001</year></dates><pub-location>Cambridge University Press,  
 447 Cambridge</pub-location><urls></urls></record></Cite></EndNote>}: Form: what does the

448 adaptation look like?; Purposefulness: why is the adaptation being undertaken?; Provider  
 449 /beneficiary: who is providing the adaptation and who is benefiting from it?; Timing: is the  
 450 adaptation occurring in response to or in anticipation of climate change?; Function / effects: what is  
 451 the broad aim of in terms of addressing drivers of vulnerability, reduce disaster risk, and/or building  
 452 landscape/ecosystem resilience. As with all methods, this approach has its limitations, notably, only  
 453 published works are included and as such, adaptations that have not been reported in the literature  
 454 may have been missed. The list of adaptation interventions therefore may not reflect all the  
 455 adaptations that are currently happening in deltas.

456 The adaptations identified included actions undertaken autonomously by households, non-  
 457 governmental organisations (NGOs) and governments. As the focus of this method is on policy-led  
 458 adaptation the household adaptations were removed, and the remaining government and NGO-led  
 459 adaptations were grouped into 67 discrete types, using the high level categorisation of adaptations  
 460 set out in Table 2. The next step describes the four different policy directions that policymakers may  
 461 choose to follow. For each of the four policy directions, the adaptations in Table 2 are either  
 462 more/less important, or do not feature at all.

463

464 **Table 2: Current or planned policy-led adaptations in DECCMA deltas**

<b>Broad objective of adaptation</b>	<b>Adaptation actions</b>
Addressing drivers of vulnerability	<ol style="list-style-type: none"> <li>1. Promote livelihood diversification (farming)</li> <li>2. Switch livelihoods (from farming to off-farm) and develop non-farm industry</li> <li>3. Promote livelihood diversification (fishing)</li> <li>4. Promote livelihood diversification - off-farm activity</li> <li>5. Livelihood diversification – fishing</li> <li>6. Education for non-farm livelihoods, based within the delta (e.g. STEM livelihoods)</li> <li>7. Education for non-farm livelihoods, based outside the delta (e.g. STEM livelihoods)</li> <li>8. Agricultural extension to provide training on how to increase income at the household level, e.g. by providing new farming or fishing techniques.</li> <li>9. Availability of business and household loans at government level</li> <li>10. Incentives for migration to economic expansion areas</li> <li>11. Financial incentives to relocate outside of the worst affected parts of the delta</li> </ol>

	<ul style="list-style-type: none"> <li>12. Promote private sector investments in eco-tourism through economic incentives</li> <li>13. Establish agriculture and fisheries based insurance schemes</li> <li>14. Post-harvest production and storage at local level (e.g. farmer level)</li> <li>15. Develop and use open spaces, green belts and other ecologically sensitive areas for alternative livelihoods such as urban farming</li> <li>16. Use of climate resilient farming techniques</li> <li>17. Farmer led cooperatives that reduce the cost of production/distribution</li> <li>18. Improving access to markets for all, including infrastructure and training</li> <li>19. Fishing zones/rights for small-scale fishers</li> <li>20. Land reclamation and redistribution (to the poor or other groups)</li> </ul>
Disaster Risk Reduction	<ul style="list-style-type: none"> <li>21. All-Risk-changing-modifications to homes (e.g., height of foundations/walls/floors, climate resilient cluster housing) and local facilities (e.g., raise water sources and sanitation facilities above flood levels) through funding, loans and new building standards and codes</li> <li>22. Raise land using controlled sedimentation</li> <li>23. Beach nourishment</li> <li>24. Land zoning, including no build zones</li> <li>25. Education at school level re. responsibilities for DRR management e.g. evacuation training</li> <li>26. Active stakeholder engagement in design and delivery of DRR</li> <li>27. Communication and information re. individual roles and responsibilities re DRR</li> <li>28. Readiness of emergency services to distribute medicines, food and potable water</li> <li>29. Availability of DRR insurance</li> <li>30. Rehabilitation and upgrading of reservoirs for water storage (e.g. dredging, raising spillway levels)</li> <li>31. Funding to reduce risks to agriculture (Government-run Agriculture Disaster Mitigation Fund)</li> <li>32. Multipurpose shelters including flood and cyclone shelters used in conjunction with early warning systems</li> <li>33. River/coastal management defence infrastructure (including sea walls, groynes, dikes and polders)</li> <li>34. Climate-proof grain silos/storage (at national and local level)</li> <li>35. Ensure food availability during floods (e.g. Floating gardens and hanging vegetable garden)</li> <li>36. Train community in DRR management</li> <li>37. Train community in water management</li> <li>38. Maintain existing infrastructure</li> <li>39. Initiatives to promote economy recovery, e.g. funding to rebuild damaged economic assets such as ports, roads and grain stores</li> <li>40. Temporary evacuation</li> <li>41. Use of emergency responders</li> <li>42. Secondment of army or national resources</li> <li>43. Post disaster mobile water treatment plants</li> <li>44. Post disaster house construction</li> <li>45. Managed/forced relocation of households from disaster-affected areas</li> </ul>
Landscape/ ecosystem resilience	<ul style="list-style-type: none"> <li>46. Climate tolerant crops</li> <li>47. Changing crop varieties</li> <li>48. Seed bank for crop diversification</li> <li>49. Climate tolerant aquaculture (e.g. brackish shrimp)</li> <li>50. Alternative climate proof grasses for cattle</li> <li>51. Mixed land use (e.g. polder and freshwater shrimp farm with rice)</li> </ul>

	<ul style="list-style-type: none"> <li>52. Changing irrigation and water level management practices to improve agriculture</li> <li>53. Potable water management</li> <li>54. Promote saline tolerant trees to prevent erosion around farms and homes</li> <li>55. Use of agro-chemicals to boost agricultural productivity and treat salinity</li> <li>56. River course management</li> <li>57. Mangrove forest planting</li> <li>58. Agroforestry</li> <li>59. Afforestation - Promote ecological restoration of degraded and poorly stocked forests</li> <li>60. Tree planting in public areas</li> <li>61. Create incentives for investor in tree crops and plantation (tax relief for private sector investment in research and development)</li> <li>62. Reduce the pressure on forests for wood-fuels by encouraging use of renewable energy</li> <li>63. No commercial mining in forested areas</li> <li>64. Afforestation – climate tolerant bamboo</li> <li>65. Create biological corridors between existing conservation areas to maintain gene flows</li> <li>66. Promote establishment of protected green spaces with native grass along waterways</li> <li>67. Conserve wildlife and biodiversity in natural heritage sites including sacred groves, protected areas</li> </ul>
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467 *3.2 Step 2: Creating narratives of the adaptation policy directions*

468 In creating the directions for policy, we note two key limiting variables that influence adaptation

469 policy choice: the investment cost of the adaptation, and the extent to which significant policy

470 change, and hence political effort, is required { ADDIN EN.CITE { ADDIN EN.CITE.DATA }}. The

471 adaptations in Table 2 reflect a diversity of costs and effort required. They range from minimal to

472 high cost, and from requiring a small or incremental change to a significant change from the status

473 quo. This spectrum of cost, and willingness to commit to substantial change from the status quo

474 have been recognised in earlier research on infrastructure systems { ADDIN EN.CITE

475 <EndNote><Cite><Author>Hall</Author><Year>2016</Year><RecNum>598</RecNum><DisplayText

476 >(Hall et al., 2016; Hickford et al., 2015)</DisplayText><record><rec-number>598</rec-

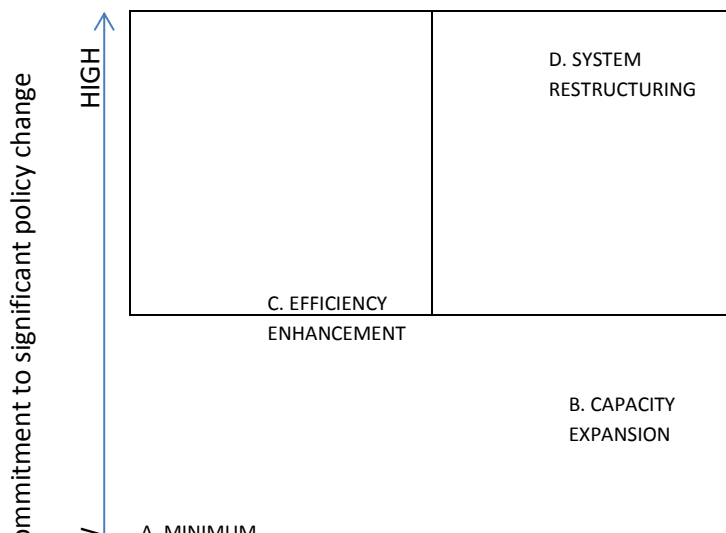
477 number><foreign-keys><key app="EN" db-

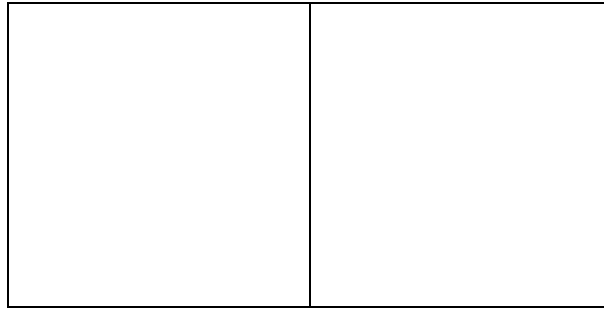
478 id="vx99swex92xxtwettvxxzpt2edff2zwe0a2">598</key></foreign-keys><ref-type name="Book

479 Section">5</ref-type><contributors><authors><author>Hall, Jim, </author><author>Otto,



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481 </author><author>Tran, Martino, </author></authors><secondary-authors><author>Hall, M. Tran,  
482 </author><author>A. Hickford,</author><author>R. Nicholls ,</author></secondary-  
483 authors></contributors><titles><title>A framework for analysing the long-term performance of  
484 interdependent infrastructure systems</title><secondary-title>The future of national infrastructure:  
485 A system-of-systems approach (p. 338)</secondary-  
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487 Cambridge University Press.</pub-  
488 location><isbn>1316558657</isbn><urls></urls></record></Cite><Cite><Author>Hickford</Author  
489 ><Year>2015</Year><RecNum>680</RecNum><record><rec-number>680</rec-number><foreign-  
490 keys><key app="EN" db-id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">680</key></foreign-  
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492 Adrian J</author><author>Nicholls, Robert J</author><author>Otto,  
493 Alexander</author><author>Hall, Jim W</author><author>Blainey, Simon P</author><author>Tran,  
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495 Pranab</author></authors></contributors><titles><title>Creating an ensemble of future strategies  
496 for national infrastructure provision</title><secondary-title>Futures</secondary-  
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498 24</pages><volume>66</volume><dates><year>2015</year></dates><isbn>0016-  
499 3287</isbn><urls></urls></record></Cite></EndNote>} and the same approach was used here to  
500 consider what might drive governments to adopt different adaptation actions (Figure 3).





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504 **Figure 3: Drivers of government-led adaptation policy choice**

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506 Drawing on this four quadrant categorisation, a set of distinctly different cost and effort sets of  
507 plausible adaptation directions are developed for deltas.

508 A. *Minimum Intervention (low investment/low commitment to policy change)* is a no-regrets

509 strategy where the lowest cost adaptation policies are pursued to protect citizens from some

510 climate impacts. This strategy addresses those areas where maximum impact can be achieved

511 for the lowest cost, requires low levels of commitment to policy change and promotes

512 adaptations that require little investment. This direction reflects either a fundamental

513 preference for a non-interventionist government, or a government lacking ambition or the

514 capacity to act. It may also reflect the position of a government that feels that no further action

515 is required. There is little planning for climate events, instead, the government provides a basic

516 emergency response.

517 B. *Capacity Expansion (high investment/low commitment to policy change)* encourages climate-

518 proof economic growth, but does not seek to make significant change to the current structure of

519 the economy. A high level of investment is required to prepare the economy for future change,

520 but adaptation policy does not aim to reorient the economy, or create significant change.

521 Instead, the focus is on climate proofing industry and enhancing ability to adapt to changes.

522 C. *Efficiency Enhancement (medium investment/medium commitment to policy change)* is an  
523 ambitious strategy that promotes adaptation consistent with the most efficient management  
524 and exploitation of the current system, looking at ways of distributing labour, balancing  
525 livelihood choices, and best utilising ecosystem services to enhance livelihoods and wellbeing  
526 under climate change. As this policy direction is about efficiency, it requires less investment than  
527 other interventionist approaches (i.e. capacity enhancement and system restructuring).  
528 However, there is a reasonable commitment to significant policy change as the system moves  
529 toward supporting people to adapt to long term change.

530 D. *System Restructuring (high investment/high commitment to change)* embraces pre-emptive  
531 fundamental change at every level in order to completely transform the current social and  
532 ecological system, and change the social and physical functioning of the delta system. There is a  
533 guiding belief that significant/radical landscape modifications are justified to create long term  
534 system restructuring despite the short term costs that may be accrued, among some social  
535 groups, or economic sectors. Within this broad policy direction are three possible sub-directions  
536 which each seek a different end goal. The first is 'protect', broadly following the Dutch model  
537 with use of extensive protective infrastructure and significant landscape changes to protect the  
538 current status quo in terms of livelihoods { ADDIN EN.CITE  
539 <EndNote><Cite><Author>VanKoningsveld</Author><Year>2008</Year><RecNum>675</RecNu  
540 m><DisplayText>(VanKoningsveld et al., 2008)</DisplayText><record><rec-number>675</rec-  
541 number><foreign-keys><key app="EN" db-  
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543 name="Journal Article">17</ref-type><contributors><authors><author>VanKoningsveld,  
544 Mark</author><author>Mulder, JPM</author><author>Stive,  
545 MJF</author><author>VanDerValk, L</author><author>VanDerWeck,  
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547 change: a case study of the Netherlands</title><secondary-title>Journal of Coastal

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549 title></periodical><pages>367-379</pages><dates><year>2008</year></dates><isbn>1551-  
550 5036</isbn><urls></urls></record></Cite></EndNote>}. Under this policy, land is protected  
551 from any further change so that communities can continue to maintain traditional livelihoods  
552 such as farming or fishing. The second is 'accommodate', as is evolving in the Mississippi delta  
553 where livelihoods have significantly changed in order to 'live with nature' and there is an  
554 aspiration to 'work with nature' to adapt to changes to the natural environment { ADDIN EN.CITE  
555 <EndNote><Cite><Author>Day</Author><Year>2014</Year><RecNum>683</RecNum><Display  
556 Text>(Day et al., 2014)</DisplayText><record><rec-number>683</rec-number><foreign-  
557 keys><key app="EN" db-id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">683</key></foreign-  
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559 W</author><author>Kemp, G Paul</author><author>Freeman, Angelina  
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562 restoration of the Mississippi Delta</title><secondary-title>Perspectives on the Restoration of  
563 the Mississippi Delta</secondary-title></titles><pages>1-  
564 7</pages><dates><year>2014</year></dates><publisher>Springer</publisher><urls></urls></r  
565 ecord></Cite></EndNote>}. The third is 'retreat' or abandonment of the delta in terms of  
566 population, for example, through a policy of population and infrastructural relocation { ADDIN  
567 EN.CITE  
568 <EndNote><Cite><Author>Dun</Author><Year>2011</Year><RecNum>684</RecNum><Display  
569 Text>(Dun, 2011)</DisplayText><record><rec-number>684</rec-number><foreign-keys><key  
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571 type name="Journal Article">17</ref-type><contributors><authors><author>Dun,  
572 Olivia</author></authors></contributors><titles><title>Migration and displacement triggered  
573 by floods in the Mekong Delta</title><secondary-title>International Migration</secondary-

574 title</titles><periodical><full-title>International Migration</full-  
575 title></periodical><volume>49</volume><number>s1</number><dates><year>2011</year></d  
576 ates><isbn>1468-2435</isbn><urls></urls></record></Cite></EndNote>}. All three  
577 restructuring policies require a high level of investment and a high commitment to significant  
578 policy change.

### 579 3.3 Step 3: Exploring adaptation trade-offs

580 Having developed a conceptualisation of adaptation, collated evidence of adaptation, and designed  
581 a contrasting set of adaptation policy directions, the next step is to allocate specific adaptation  
582 measures to each direction. To do this, a more nuanced understanding of each policy direction is  
583 required where each of the 13 adaptation classes are given relative weights to reflect the relative  
584 levels of investment, and political willingness to change. In the context of finite resources, this  
585 approach also identifies the trade-offs that occur between the 13 adaptation classes. Due to the  
586 complexity of the task, and following { ADDIN EN.CITE <EndNote><Cite  
587 AuthorYear="1"><Author>Brooks</Author><Year>2005</Year><RecNum>1243</RecNum><DisplayT  
588 ext>Brooks et al. (2005</DisplayText><record><rec-number>1243</rec-number><foreign-keys><key  
589 app="EN" db-id="552vavf0m5009dezrviv5909wperzvd9at9"  
590 timestamp="1334223897">1243</key></foreign-keys><ref-type name="Journal Article">17</ref-  
591 type><contributors><authors><author>Nick Brooks</author><author>W. Neil  
592 Adger</author><author>P. M. Kelly</author></authors></contributors><titles><title>The  
593 determinants of vulnerability and adaptive capacity at the national level and the implications for  
594 adaptation</title><secondary-title>Global Environmental Change</secondary-  
595 title></titles><periodical><full-title>Global Environmental Change</full-  
596 title></periodical><pages>151-  
597 163</pages><volume>15</volume><number>2</number><dates><year>2005</year><pub-  
598 dates><date>July 2005</date></pub-dates></dates><urls></urls></record></Cite></EndNote>}},  
599 an expert interdisciplinary group of eight delta research scientists (in the fields of climate change

600 adaptation, engineering, systems modelling, population and development, and geography) were  
 601 asked to deliberate on the relative investment availability under each policy direction, and to assign  
 602 weights to reflect this investment (Table 3). Low, medium and high levels of investment were  
 603 represented by three weights allocated out of 40. Hence direction A (the least costly) is weighted  
 604 20; B is weighted 40; C is weighted 30; and, D is weighted 40. These weights constrain the quantities  
 605 and focus of adaptation under each direction, thus highlighting the investment directions under each  
 606 scenario. This however, also means that some adaptation measures may be ignored altogether.

607

608 **Table 3: Weights assigned to policy directions**

Broad objective of adaptation	Class of adaptation	Policy direction					
		A. Minimum intervention	B. Capacity expansion	C. System efficiency	D. System restructuring		
					Protect	Accommo- date	Retreat
Addressing drivers of vulnerability	1. Financial capital	0	8	0	3	15	10
	2. Human capital	5	7	6	3	15	10
	3. Social capital	0	0	6	0	0	0
	4. Natural capital	0	0	4	3	0	0
	5. Physical capital	0	5	0	0	0	0
DRR	6. Managing long term risk	1	4	4	20	10	0
	7. Preparedness	0	2	3	0	0	0
	8. Response	4	2	0	0	0	0
	9. Post disaster recovery and rehabilitation	4	2	0	0	0	20
Landscape/ ecosystem resilience	10. Provisioning	6	5	3	10	0	0
	11. Regulating	0	5	1	1	0	0
	12. Habitat	0	0	1	0	0	0
	13. Cultural	0	0	2	0	0	0
	Total investment	20	40	30	40	40	40

609

610 The expert group also determined how 'significant policy change' could be represented by allocating  
 611 the points within each policy direction across the 13 adaptation classes. The points within each  
 612 adaptation class were allocated using a two stage subjective weighting process. First, for each

613 policy direction, each expert was asked to rank the 13 classes in order of importance. Then, in a  
614 collaborative workshop, the experts deliberated on the order of the classes for each policy direction  
615 until consensus was achieved. Second, the experts were asked to assign the points available under  
616 each policy direction to each of the classes based on their importance. Again, this was done through  
617 an open process of deliberation until consensus was achieved. As with any subjective decision  
618 making process, the outcome is informed by the knowledge, perceptions and experience of the  
619 decision makers. Thus a potential limitation arises.

620 Using this approach, the least costly policy direction, Minimum Intervention spreads limited  
621 resources across six of the 13 classes of adaptation. However, one of the three most ambitious  
622 directions, System Restructuring (Retreat) divides more substantial resources across just three  
623 classes of adaptation and uses half of its significant resources on post disaster recovery and  
624 rehabilitation alone. Using this weighting system it is possible to constrain the relative scope and  
625 types of adaptation present in each policy direction to understand where trade-offs occur.

626

#### 627 4. Understanding adaptation policy choices in deltas

628 Using the methods described in section three, this section explores more deeply the nature and  
629 structure of the adaptation policy directions. The policy directions offer a vision of some of the  
630 feasible adaptation futures within deltas, taking into account the main objectives of adaptation, and  
631 the adaptation actions that currently occur in deltas. The impacts of each direction can only be  
632 understood through an analysis of the specific adaptation choices that it promotes. To populate the  
633 four policy directions, the 67 adaptation types in Table 2 were categorised using the 13 classes of  
634 adaptation (see Tables 4-7). Each adaptation can appear in more than one of the policy directions.  
635 For example, the adaptation intervention to ‘promote private sector investments in eco-tourism  
636 through economic incentives’, was categorised under “1. *Financial capital – addressing drivers of*

637 *vulnerability*". It was then assigned to the Capacity Expansion policy direction as it offers a non-farm  
638 income generating activity, which sits alongside traditional farm based livelihoods. It was also  
639 assigned to the System Restructuring (Accommodate) policy direction as it may enable a complete  
640 shift from farm-based to non-farm-based livelihood activities that are more suited to a changed  
641 environment. For each of the four policy directions, we detail the adaptation options that might  
642 occur within them, highlighting areas that are less important, or that are ignored all together.

643

#### 644 4.1. *The Minimum Intervention adaptation choices*

645 *Vulnerability* is reduced through investing in human capital. There is little or no investment in other  
646 forms of capital. Investment in *human capital* may include basic training on how to increase income  
647 at the household level, such as learning new farming or fishing techniques. For example, India's  
648 Central Rice Research Institute (CRRI) provide support and training to farmers to develop integrated  
649 rice-fish farming systems on flood prone land in Odisha { ADDIN EN.CITE <EndNote><Cite  
650 ExcludeAuth="1"><Author>Regional Centre for Development Cooperation  
651 (RCDC)</Author><Year>2011</Year><RecNum>642</RecNum><Prefix>RCDC`,  
652 </Prefix><DisplayText>(RCDC, 2011)</DisplayText><record><rec-number>642</rec-  
653 number><foreign-keys><key app="EN" db-  
654 id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">642</key></foreign-keys><ref-type  
655 name="Serial">57</ref-type><contributors><authors><author>Regional Centre for Development  
656 Cooperation (RCDC),</author></authors></contributors><titles><title>Integrated Rice Fish Culture  
657 Climate Change Adaptation Option Paribartan Project in Kendrapara and  
658 Jagatsinghpur</title></titles><dates><year>2011</year></dates><publisher>Available online at  
659 [https://www.rcdcindia.org/PbDocument/995fd0d595e6ccf-173e-455b-a9f9-  
660 796e461137e6IRFC%20as%20CC%20Adaptation%20Option.pdf](https://www.rcdcindia.org/PbDocument/995fd0d595e6ccf-173e-455b-a9f9-796e461137e6IRFC%20as%20CC%20Adaptation%20Option.pdf). Accessed 18 December  
661 2017</publisher><urls></urls></record></Cite></EndNote>} The CRRI also provide training so



662 farmers can grow new varieties of fruit, vegetables and trees. Other similar schemes were reported  
663 { ADDIN EN.CITE { ADDIN EN.CITE.DATA }}.

664 DRR is delivered in three ways. First, through simple measures to *address long term risk*, such as  
665 training farmers to create floating gardens on flooded land { ADDIN EN.CITE

666 <EndNote><Cite><Author>Action</Author><Year>2011</Year><RecNum>647</RecNum><DisplayText>(Practical Action, 2011)</DisplayText><record><rec-number>647</rec-number><foreign-

667 keys><key app="EN" db-id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">647</key></foreign-  
668 keys><ref-type name="Report">27</ref-type><contributors><authors><author>Practical

669 Action,</author></authors></contributors><titles><title>Floating gardens in  
670 Bangladesh</title></titles><dates><year>2011</year></dates><pub-location>Available online at:

671 <http://www.fao.org/climatechange/17849-0e277b46b31f98942e6bc81bb22319243.pdf>. Last  
672 accessed 18 December 2017</pub-location><urls></urls></record></Cite></EndNote>}. Second,

673 through *disaster response* such as temporary evacuation, emergency responders and the  
674 secondment of the army or national resources. For example, WWF-India has helped train disaster

675 management teams in West Bengal who receive state support to help the community during  
676 extreme events { ADDIN EN.CITE

677 <EndNote><Cite><Author>Danda</Author><Year>2010</Year><RecNum>648</RecNum><DisplayText>(Danda, 2010)</DisplayText><record><rec-number>648</rec-number><foreign-keys><key

678 app="EN" db-id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">648</key></foreign-keys><ref-type  
679 name="Journal Article">17</ref-type><contributors><authors><author>Danda,

680 A</author></authors></contributors><titles><title>Sundarbans: Future Imperfect–Climate  
681 Adaptation Report. New Delhi: World Wide Fund for Nature–India. Available at ht

682 [tp</title><secondary-title>assets. wwfindia.  
683 org/downloads/sundarbans\\_future\\_imperfect\\_\\_climate\\_adaptation\\_report.pdf</secondary-](http://www.wwfindia.org/downloads/sundarbans_future_imperfect__climate_adaptation_report.pdf)

684 [title></titles><periodical><full-title>assets. wwfindia.  
685 org/downloads/sundarbans\\_future\\_imperfect\\_\\_climate\\_adaptation\\_report.pdf</full-](http://www.wwfindia.org/downloads/sundarbans_future_imperfect__climate_adaptation_report.pdf)

688 title</periodical><dates><year>2010</year></dates><urls></urls></record></Cite></EndNote>}.  
689 Third, basic services are provided during post *disaster recovery and rehabilitation*, such as post  
690 disaster mobile water treatment plants and post disaster house construction for the worst affected  
691 households. For example, following Cyclone Komen (2015) the Bangladesh Red Crescent Society  
692 (BDRCS) distributed cash grants, 3,000 tarpaulins, 30,000 packets of oral rehydration solution and  
693 installed two mobile water treatment plants in the worst affected areas { ADDIN EN.CITE  
694 <EndNote><Cite ExcludeAuth="1"><Author>International Federation of Red Cross and Red Crescent  
695 Societies (IFRC)</Author><Year>2015</Year><RecNum>649</RecNum><Prefix>IFRC`,  
696 </Prefix><DisplayText>(IFRC, 2015)</DisplayText><record><rec-number>649</rec-  
697 number><foreign-keys><key app="EN" db-  
698 id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">649</key></foreign-keys><ref-type  
699 name="Report">27</ref-type><contributors><authors><author>International Federation of Red  
700 Cross and Red Crescent Societies (IFRC),</author></authors></contributors><titles><title>Emergency  
701 appeal operations update Bangladesh: Cyclone  
702 Komen</title></titles><dates><year>2015</year></dates><pub-location>Available online at  
703 [https://reliefweb.int/sites/reliefweb.int/files/resources/MDRBD015\\_OU2%20%281%29.pdf](https://reliefweb.int/sites/reliefweb.int/files/resources/MDRBD015_OU2%20%281%29.pdf). Last  
704 accessed 19 December 2017</pub-location><urls></urls></record></Cite></EndNote>}.  
705 *Ecosystem resilience* is delivered through some basic *provisioning services*, which are partially  
706 supported through training services such as potable water management. For example, in Bangladesh,  
707 UNICEF and the Department of Public Health have introduced pond sand filters (PSFs) along the  
708 coastal belt { ADDIN EN.CITE  
709 <EndNote><Cite><Author>Ahmed</Author><Year>2010</Year><RecNum>651</RecNum><DisplayT  
710 ext>(Ahmed, 2010)</DisplayText><record><rec-number>651</rec-number><foreign-keys><key  
711 app="EN" db-id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">651</key></foreign-keys><ref-type  
712 name="Report">27</ref-type><contributors><authors><author>Ahmed,  
713 AU</author></authors></contributors><titles><title>Reducing vulnerability to climate change: the

714 pioneering example of community based adaptation in  
715 Bangladesh</title></titles><pages>156</pages><dates><year>2010</year></dates><pub-  
716 location>Centre for Global Change (CGC) and CARE Bangladesh, Dhaka</pub-  
717 location><isbn>9843322347</isbn><urls></urls></record></Cite></EndNote>}. There is no support  
718 for other ecosystem services. See Table 4, for details of the specific adaptation interventions.

#### 719 4.2 The Capacity Expansion adaptation choices

720 *Vulnerability* reduction is the main focus of this policy direction with the prime focus is on improving  
721 *financial capital*. This is done at the household level, for example training on post-harvest production  
722 and storage { ADDIN EN.CITE

723 <EndNote><Cite><Author>Chowdhury</Author><Year>2011</Year><RecNum>655</RecNum><Disp

724 layText>(Chowdhury et al., 2011)</DisplayText><record><rec-number>655</rec-number><foreign-

725 keys><key app="EN" db-id="vx99swex92xxtwettvxxzpt2edff2zwe0a2">655</key></foreign-

726 keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Chowdhury,

727 Ataharul Huq</author><author>Van Mele, Paul</author><author>Hauser,

728 Michael</author></authors></contributors><titles><title>Contribution of Farmer-to-Farmer Video

729 to Capital Assets Building: Evidence from Bangladesh</title><secondary-title>Journal of Sustainable

730 Agriculture</secondary-title></titles><periodical><full-title>Journal of Sustainable Agriculture</full-

731 title></periodical><pages>408-

732 435</pages><volume>35</volume><number>4</number><dates><year>2011</year><pub-

733 dates><date>2011/04/04</date></pub-dates></dates><publisher>Taylor & amp;

734 Francis</publisher><isbn>1044-0046</isbn><urls><related-

735 urls><url>https://doi.org/10.1080/10440046.2011.562059</url></related-urls></urls><electronic-

736 resource-num>10.1080/10440046.2011.562059</electronic-resource-

737 num></record></Cite></EndNote>} and government and NGO provided loans { ADDIN EN.CITE

738 <EndNote><Cite><Author>Aveh</Author><Year>2013</Year><RecNum>653</RecNum><DisplayTex

739 t>(Aveh et al., 2013; Nukpezah and Blankson, 2017)</DisplayText><record><rec-number>653</rec-

740 number><foreign-keys><key app="EN" db-  
741 id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">653</key></foreign-keys><ref-type name="Journal  
742 Article">17</ref-type><contributors><authors><author>Aveh, FK</author><author>Dadzie,  
743 PS</author><author>Krah, RY</author></authors></contributors><titles><title>Success of  
744 microfinance institutions: the Ghanaian experience</title><secondary-title>International Business  
745 and Management</secondary-title></titles><periodical><full-title>International Business and  
746 Management</full-title></periodical><pages>91-  
747 97</pages><volume>6</volume><number>2</number><dates><year>2013</year></dates><isbn>1  
748 8428</isbn><urls></urls></record></Cite><Cite><Author>Nukpezah</Author><Year>2017</Year><  
749 RecNum>654</RecNum><record><rec-number>654</rec-number><foreign-keys><key app="EN"  
750 db-id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">654</key></foreign-keys><ref-type  
751 name="Journal Article">17</ref-type><contributors><authors><author>Nukpezah, Julius  
752 A.</author><author>Blankson,  
753 Charles</author></authors></contributors><titles><title>Microfinance Intervention in Poverty  
754 Reduction: A Study of Women Farmer-Entrepreneurs in Rural Ghana</title><secondary-title>Journal  
755 of African Business</secondary-title></titles><periodical><full-title>Journal of African  
756 Business</full-title></periodical><pages>457-  
757 475</pages><volume>18</volume><number>4</number><dates><year>2017</year><pub-  
758 dates><date>2017/10/02</date></pub-  
759 dates></dates><publisher>Routledge</publisher><isbn>1522-8916</isbn><urls><related-  
760 urls><url>https://doi.org/10.1080/15228916.2017.1336915</url></related-urls></urls><electronic-  
761 resource-num>10.1080/15228916.2017.1336915</electronic-resource-  
762 num></record></Cite></EndNote>}. For example, micro-credit based by the World Health  
763 Organization (WHO) in the Volta have shown a reduction in poverty among women farmer-  
764 entrepreneurs. Vulnerability reduction is also done at the government level, for example, by  
765

766 encouraging private sector investment in ecotourism, which is a policy goal in Ghana { ADDIN  
767 EN.CITE <EndNote><Cite><Author>Government of the Republic of  
768 Ghana</Author><Year>2013</Year><RecNum>656</RecNum><DisplayText>(Government of the  
769 Republic of Ghana, 2013)</DisplayText><record><rec-number>656</rec-number><foreign-  
770 keys><key app="EN" db-id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">656</key></foreign-  
771 keys><ref-type name="Report">27</ref-type><contributors><authors><author>Government of the  
772 Republic of Ghana,</author></authors></contributors><titles><title>National Tourism  
773 Development Plan (2013 – 2027)</title></titles><dates><year>2013</year></dates><pub-  
774 location>Available online at: [http://www.ghana.travel/wp-content/uploads/2016/11/Ghana-  
776 Tourism-Development-Plan.pdf](http://www.ghana.travel/wp-content/uploads/2016/11/Ghana-<br/>
775 Tourism-Development-Plan.pdf). Last accessed 19 December 2017</pub-  
777 location><urls></urls></record></Cite></EndNote>}. There is also an emphasis on *human capital* as  
778 the government invests in training that in turn will ensure households are able to better participate  
779 in the non-farm economy { ADDIN EN.CITE  
780 <EndNote><Cite><Author>Haggblade</Author><Year>2010</Year><RecNum>658</RecNum><Displ  
781 ayText>(Haggblade et al., 2010)</DisplayText><record><rec-number>658</rec-number><foreign-  
782 keys><key app="EN" db-id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">658</key></foreign-  
783 keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Haggblade,  
784 Steven</author><author>Hazell, Peter</author><author>Reardon,  
785 Thomas</author></authors></contributors><titles><title>The rural non-farm economy: Prospects  
786 for growth and poverty reduction</title><secondary-title>World Development</secondary-  
787 title></titles><periodical><full-title>World Development</full-title></periodical><pages>1429-  
788 1441</pages><volume>38</volume><number>10</number><dates><year>2010</year></dates><is  
789 bn>0305-750X</isbn><urls></urls></record></Cite></EndNote>} and on *physical capital* by  
790 ensuring that appropriate infrastructure exists to support economic growth e.g. roads, storage, rural  
791 electricity { ADDIN EN.CITE  
792 <EndNote><Cite><Author>Deichmann</Author><Year>2009</Year><RecNum>657</RecNum><Disp

792 layText>(Deichmann et al., 2009; Sharma, 2007)</DisplayText><record><rec-number>657</rec-  
793 number><foreign-keys><key app="EN" db-  
794 id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">657</key></foreign-keys><ref-type name="Journal  
795 Article">17</ref-type><contributors><authors><author>Deichmann, Uwe</author><author>Shilpi,  
796 Forhad</author><author>Vakis, Renos</author></authors></contributors><titles><title>Urban  
797 proximity, agricultural potential and rural non-farm employment: Evidence from  
798 Bangladesh</title><secondary-title>World Development</secondary-title></titles><periodical><full-  
799 title>World Development</full-title></periodical><pages>645-  
800 660</pages><volume>37</volume><number>3</number><dates><year>2009</year></dates><isbn  
801 >0305-  
802 750X</isbn><urls></urls></record></Cite><Cite><Author>Sharma</Author><Year>2007</Year><Re  
803 cNum>659</RecNum><record><rec-number>659</rec-number><foreign-keys><key app="EN" db-  
804 id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">659</key></foreign-keys><ref-type name="Journal  
805 Article">17</ref-type><contributors><authors><author>Sharma, Dinesh  
806 C</author></authors></contributors><titles><title>Transforming rural lives through decentralized  
807 green power</title><secondary-title>Futures</secondary-title></titles><periodical><full-  
808 title>Futures</full-title></periodical><pages>583-  
809 596</pages><volume>39</volume><number>5</number><dates><year>2007</year></dates><isbn  
810 >0016-3287</isbn><urls></urls></record></Cite></EndNote>}.  
811

811 *DRR focuses on long term risk mitigation* through hard and soft measures. For hard DRR there might  
812 be a focus on the provision of river/coastal infrastructure to protect economically important areas,  
813 for example, the World Bank recently invested USD 400 million to improve polder embankments in  
814 economically important areas of Bangladesh { ADDIN EN.CITE <EndNote><Cite><Author>World  
815 Bank</Author><Year>2013</Year><RecNum>660</RecNum><DisplayText>(World Bank,  
816 2013)</DisplayText><record><rec-number>660</rec-number><foreign-keys><key app="EN" db-  
817 id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">660</key></foreign-keys><ref-type

818 name="Report">27</ref-type><contributors><authors><author>World  
819 Bank,</author></authors></contributors><titles><title>Coastal Embankment Improvement Project -  
820 Phase I (CEIP-I)</title></titles><dates><year>2013</year></dates><pub-location>Available online at:  
821 [http://projects.worldbank.org/P128276/coastal-embankment-improvement-project-phase-1ceip-](http://projects.worldbank.org/P128276/coastal-embankment-improvement-project-phase-1ceip-1?lang=en&tab=overview)  
822 [1?lang=en&tab=overview](http://projects.worldbank.org/P128276/coastal-embankment-improvement-project-phase-1ceip-1?lang=en&tab=overview). Last accessed 19 December 2017</pub-  
823 location><urls></urls></record></Cite></EndNote>}. For soft DRR, preparedness and risk mitigation,  
824 for example through agriculture and fisheries based insurance schemes { ADDIN EN.CITE  
825 <EndNote><Cite><Author>Government of the People's Republic of  
826 Bangladesh</Author><Year>2009</Year><RecNum>652</RecNum><DisplayText>(Government of  
827 the People's Republic of Bangladesh, 2009)</DisplayText><record><rec-number>652</rec-  
828 number><foreign-keys><key app="EN" db-  
829 id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">652</key></foreign-keys><ref-type  
830 name="Report">27</ref-type><contributors><authors><author>Government of the People's  
831 Republic of Bangladesh,</author></authors></contributors><titles><title>Crop insurance as a risk  
832 management strategy in Bangladesh</title><secondary-title>Department of Environment. Ministry  
833 of Environment and Forests. Government of the People's Republic of Bangladesh,  
834 Dhaka</secondary-title></titles><periodical><full-title>Department of Environment. Ministry of  
835 Environment and Forests. Government of the People's Republic of Bangladesh, Dhaka</full-  
836 title></periodical><dates><year>2009</year></dates><urls></urls></record></Cite></EndNote>};  
837 *Post-disaster recovery* efforts focus on getting the economy functioning quickly after disasters and  
838 reducing the impact of natural hazards on economic sectors. For example, rapidly releasing funds to  
839 rebuild damaged economic resources such as ports, roads and key grain stores.

840 *Ecosystem resilience* is delivered through investment in *provisioning services*. This is to enable  
841 income from food and water production under future climate change, for example, by using saline  
842 tolerant crops that can withstand coastal flooding { ADDIN EN.CITE  
843 <EndNote><Cite><Author>Islam</Author><Year>2016</Year><RecNum>661</RecNum><DisplayTex

844 t>(Islam et al., 2016)</DisplayText><record><rec-number>661</rec-number><foreign-keys><key  
845 app="EN" db-id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">661</key></foreign-keys><ref-type  
846 name="Journal Article">17</ref-type><contributors><authors><author>Islam, M.  
847 R.</author><author>Sarker, M. R. A.</author><author>Sharma, N.</author><author>Rahman, M.  
848 A.</author><author>Collard, B. C. Y.</author><author>Gregorio, G. B.</author><author>Ismail, A.  
849 M.</author></authors></contributors><titles><title>Assessment of adaptability of recently released  
850 salt tolerant rice varieties in coastal regions of South Bangladesh</title><secondary-title>Field Crops  
851 Research</secondary-title></titles><periodical><full-title>Field Crops Research</full-  
852 title></periodical><pages>34-43</pages><volume>190</volume><number>Supplement  
853 C</number><keywords><keyword>Adaptability</keyword><keyword>Farmers'  
854 preferences</keyword><keyword>Genotype×environment  
855 analysis</keyword><keyword>Salinity</keyword><keyword>Stagnant  
856 floods</keyword></keywords><dates><year>2016</year><pub-  
857 dates><date>2016/04/01/</date></pub-dates></dates><isbn>0378-4290</isbn><urls><related-  
858 urls><url>http://www.sciencedirect.com/science/article/pii/S0378429015300563</url></related-  
859 urls></urls><electronic-resource-num>https://doi.org/10.1016/j.fcr.2015.09.012</electronic-  
860 resource-num></record></Cite></EndNote>}. There is also a focus on *regulating services*, for  
861 example, the use of agro-chemicals or creation of private sector incentives for tree planting. See  
862 Table 5, for more details of the specific adaptation interventions.

863

#### 864 4.3 *The Efficiency Enhancement adaptation choices*

865 *Vulnerability* is reduced by focusing on human and social capital at the household and community  
866 level. In terms of *human capital*, livelihood diversification in farming is promoted as is the teaching  
867 of climate resilient farming and post-harvest production methods { ADDIN EN.CITE

868 <EndNote><Cite><Author>White</Author><Year>2016</Year><RecNum>663</RecNum><DisplayTe



869 xt>(White et al., 2016)</DisplayText><record><rec-number>663</rec-number><foreign-keys><key  
 870 app="EN" db-id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">663</key></foreign-keys><ref-type  
 871 name="Journal Article">17</ref-type><contributors><authors><author>White,  
 872 Douglas</author><author>Quinney, Marie</author><author>Jarvis,  
 873 Andy</author></authors></contributors><titles><title>Climate-Smart Agriculture (CSA) within the  
 874 Feed the Future Project Portfolio of USAID-Bangladesh: A CCAFS Deep-Dive  
 875 Review</title></titles><dates><year>2016</year></dates><urls></urls></record></Cite></EndNote  
 876 >}. In terms of *social capital*, local farming and fishing cooperatives ensure maximum production  
 877 benefits. Finally, by improving access to *natural capital*, for example through fishing permits,  
 878 households are able to make the most efficient use of income generating resources { ADDIN EN.CITE  
 879 <EndNote><Cite><Author>Monirul  
 880 Islam</Author><Year>2014</Year><RecNum>662</RecNum><DisplayText>(Monirul Islam et al.,  
 881 2014)</DisplayText><record><rec-number>662</rec-number><foreign-keys><key app="EN" db-  
 882 id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">662</key></foreign-keys><ref-type name="Journal  
 883 Article">17</ref-type><contributors><authors><author>Monirul Islam, Md</author><author>Sallu,  
 884 Susannah</author><author>Hubacek, Klaus</author><author>Paavola,  
 885 Jouni</author></authors></contributors><titles><title>Limits and barriers to adaptation to climate  
 886 variability and change in Bangladeshi coastal fishing communities</title><secondary-title>Marine  
 887 Policy</secondary-title></titles><periodical><full-title>Marine Policy</full-  
 888 title></periodical><pages>208-216</pages><volume>43</volume><number>Supplement  
 889 C</number><keywords><keyword>Climate  
 890 change</keyword><keyword>Adaptation</keyword><keyword>Fishing  
 891 community</keyword><keyword>Barrier</keyword><keyword>Limit</keyword><keyword>Banglad  
 892 esh</keyword></keywords><dates><year>2014</year><pub-  
 893 dates><date>2014/01/01</date></pub-dates></dates><isbn>0308-597X</isbn><urls><related-  
 894 urls><url><http://www.sciencedirect.com/science/article/pii/S0308597X13001334></url></related-

895 <https://doi.org/10.1016/j.marpol.2013.06.007>

896 resource-num></record></Cite></EndNote>},

897 *DRR* is provided through investments in long term risk management using relatively low cost

898 interventions such as early warning systems and cyclone shelters { ADDIN EN.CITE

899 <EndNote><Cite><Author>Danda</Author><Year>2010</Year><RecNum>648</RecNum><DisplayTe

900 xt>(Danda, 2010; Roy et al., 2015)</DisplayText><record><rec-number>648</rec-number><foreign-

901 keys><key app="EN" db-id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">648</key></foreign-

902 keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Danda,

903 A</author></authors></contributors><titles><title>Sundarbans: Future Imperfect–Climate

904 Adaptation Report. New Delhi: World Wide Fund for Nature–India. Available at ht

905 tp</title><secondary-title>assets. wwfindia.

906 org/downloads/sundarbans\_future\_imperfect\_\_climate\_adaptation\_report.pdf</secondary-

907 title></titles><periodical><full-title>assets. wwfindia.

908 org/downloads/sundarbans\_future\_imperfect\_\_climate\_adaptation\_report.pdf</full-

909 title></periodical><dates><year>2010</year></dates><urls></urls></record></Cite><Cite><Author

910 >Roy</Author><Year>2015</Year><RecNum>664</RecNum><record><rec-number>664</rec-

911 number><foreign-keys><key app="EN" db-

912 id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">664</key></foreign-keys><ref-type name="Journal

913 Article">17</ref-type><contributors><authors><author>Roy, Chandan</author><author>Sarkar,

914 Saroje Kumar</author><author>Åberg, Johan</author><author>Kovordanyi,

915 Rita</author></authors></contributors><titles><title>The current cyclone early warning system in

916 Bangladesh: providers&apos; and receivers&apos; views</title><secondary-title>International

917 journal of disaster risk reduction</secondary-title></titles><periodical><full-title>International

918 journal of disaster risk reduction</full-title></periodical><pages>285-

919 299</pages><volume>12</volume><dates><year>2015</year></dates><isbn>2212-

920 4209</isbn><urls></urls></record></Cite></EndNote>} , development of building codes for

921 buildings in at risk areas and no build zones and government funds to reduce risks to agriculture,  
922 such as government run Agriculture Disaster Mitigation Funds. There is also a focus on *preparedness*.  
923 Communities are trained to prepare for events through relatively low cost initiative, such as DRR  
924 education at school evacuation training and stakeholder engagement in DRR plans { ADDIN EN.CITE  
925 <EndNote><Cite><Author>Sunderban Social Development  
926 Centre</Author><Year>2012</Year><RecNum>665</RecNum><DisplayText>(Sunderban Social  
927 Development Centre, 2012; WWF-India, 2010)</DisplayText><record><rec-number>665</rec-  
928 number><foreign-keys><key app="EN" db-  
929 id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">665</key></foreign-keys><ref-type  
930 name="Report">27</ref-type><contributors><authors><author>Sunderban Social Development  
931 Centre,</author></authors></contributors><titles><title>Process Document on LEGO Risk Mapping  
932 Pilot Project (LEGO-DRR & CCA)</title><secondary-title>Available online at:  
933 [http://www.ssdcindia.org.in/gallery/1374828232Process%20Documentation%20of%20%20LEGO-  
934 DRR%20&%20CCA.pdf](http://www.ssdcindia.org.in/gallery/1374828232Process%20Documentation%20of%20%20LEGO-DRR%20&%20CCA.pdf) Last accessed 19 December 2017</secondary-  
935 title></titles><dates><year>2012</year></dates><urls></urls></record></Cite><Cite><Author>WW  
936 F-India</Author><Year>2010</Year><RecNum>666</RecNum><record><rec-number>666</rec-  
937 number><foreign-keys><key app="EN" db-  
938 id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">666</key></foreign-keys><ref-type  
939 name="Report">27</ref-type><contributors><authors><author>WWF-India,  
940 </author></authors></contributors><titles><title>Sundarbans: Future Imperfect Climate Adaptation  
941 Report</title><secondary-title>Available online at:  
942 [http://awsassets.wwfindia.org/downloads/sundarbans\\_future\\_imperfect\\_climate\\_adaptation\\_rep  
943 ort\\_1.pdf](http://awsassets.wwfindia.org/downloads/sundarbans_future_imperfect_climate_adaptation_report_1.pdf). Last accssed 19 December 2017</secondary-  
944 title></titles><dates><year>2010</year></dates><urls></urls></record></Cite></EndNote>}. There  
945 is little emphasis on *response or recovery*.

946 *Ecosystem resilience* is a priority as it supports efficient management and exploitation of the delta  
947 system. All four ecosystem services are recognised as contributing to wider system efficiency and all  
948 are the focus of government interventions. The focus is on low cost interventions. In terms of  
949 *provisioning*, mixed land use and irrigation are promoted { ADDIN EN.CITE  
950 <EndNote><Cite><Author>UNDP  
951 Bangladesh</Author><Year>2011</Year><RecNum>667</RecNum><DisplayText>(UNDP Bangladesh,  
952 2011)</DisplayText><record><rec-number>667</rec-number><foreign-keys><key app="EN" db-  
953 id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">667</key></foreign-keys><ref-type  
954 name="Report">27</ref-type><contributors><authors><author>UNDP  
955 Bangladesh,</author></authors></contributors><titles><title>A New Land Use Model: Forest Fruit  
956 Fish</title><secondary-title>Available online at:  
957 [http://www.bd.undp.org/content/dam/bangladesh/docs/Publications/A%20New%20Land%20Use%  
959 20Model\\_Forest%20Fruit%20Fish.pdf?download](http://www.bd.undp.org/content/dam/bangladesh/docs/Publications/A%20New%20Land%20Use%<br/>958 20Model_Forest%20Fruit%20Fish.pdf?download). Last accssed 19 December 2017</secondary-  
960 title></titles><dates><year>2011</year></dates><urls></urls></record></Cite></EndNote>}. In  
961 terms of *regulating*, tree planting, including mangroves, is the main focus { ADDIN EN.CITE { ADDIN  
962 EN.CITE.DATA }}. In terms of *habitat*, biological corridors are created, as are green spaces with native  
963 grass along waterways. Finally, in terms of *cultural* services the conservation of wildlife and  
964 biodiversity including sacred groves is promoted. See Table 6, for more details of the specific  
965 adaptation interventions.

#### 966 4.4. The System Restructuring adaptation choices

##### 967 4.4.1 System restructuring – Protect

968 This policy direction aims to significantly change the natural system to make sure that traditional,  
969 agricultural based livelihoods are protected from climate impacts. *Vulnerability* is reduced by  
970 focusing on financial, human and natural capital. In terms of *financial capital* the green belt is used

971 for farming so productivity can be maximised. In terms of *human capital*, climate resilient farming  
972 techniques are promoted, and in terms of *natural capital*, land is redistributed to poorer farmers {  
973 ADDIN EN.CITE  
974 <EndNote><Cite><Author>Devine</Author><Year>2002</Year><RecNum>673</RecNum><DisplayT  
975 ext>(Devine, 2002)</DisplayText><record><rec-number>673</rec-number><foreign-keys><key  
976 app="EN" db-id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">673</key></foreign-keys><ref-type  
977 name="Journal Article">17</ref-type><contributors><authors><author>Devine,  
978 Joseph</author></authors></contributors><titles><title>Ethnography of a policy process: A case  
979 study of land redistribution in Bangladesh</title><secondary-title>Public Administration and  
980 Development</secondary-title></titles><periodical><full-title>Public Administration and  
981 Development</full-title></periodical><pages>403-  
982 414</pages><volume>22</volume><number>5</number><dates><year>2002</year></dates><isbn  
983 >1099-162X</isbn><urls></urls></record></Cite></EndNote>} and small-scale fishers receive fishing  
984 rights. *DRR* is the main focus with all emphasis on managing *long term risk* through, for example,  
985 raising of land elevation using controlled sedimentation { ADDIN EN.CITE  
986 <EndNote><Cite><Author>Schiermeier</Author><Year>2014</Year><RecNum>674</RecNum><Dis  
987 playText>(Schiermeier, 2014)</DisplayText><record><rec-number>674</rec-number><foreign-  
988 keys><key app="EN" db-id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">674</key></foreign-  
989 keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Schiermeier,  
990 Quirin</author></authors></contributors><titles><title>Holding back the tide</title><secondary-  
991 title>Nature</secondary-title></titles><periodical><full-title>Nature</full-  
992 title></periodical><pages>164</pages><volume>508</volume><number>7495</number><dates><  
993 year>2014</year></dates><isbn>0028-0836</isbn><urls></urls></record></Cite></EndNote>}, the  
994 creation of dikes to manage flood water, no build zones, land zoning and massive investment in  
995 river/coastal defence infrastructure. Specifically, there is significant investment in river/coastal  
996 defence infrastructure to protect the built environment including industry. This would attempt to

997 replicate the success of the Delta Project in the Netherlands { ADDIN EN.CITE  
998 <EndNote><Cite><Author>VanKoningsveld</Author><Year>2008</Year><RecNum>675</RecNum><  
999 DisplayText>(VanKoningsveld et al., 2008)</DisplayText><record><rec-number>675</rec-  
1000 number><foreign-keys><key app="EN" db-  
1001 id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">675</key></foreign-keys><ref-type name="Journal  
1002 Article">17</ref-type><contributors><authors><author>VanKoningsveld,  
1003 Mark</author><author>Mulder, JPM</author><author>Stive, MJF</author><author>VanDerValk,  
1004 L</author><author>VanDerWeck, AW</author></authors></contributors><titles><title>Living with  
1005 sea-level rise and climate change: a case study of the Netherlands</title><secondary-title>Journal of  
1006 Coastal Research</secondary-title></titles><periodical><full-title>Journal of Coastal Research</full-  
1007 title></periodical><pages>367-379</pages><dates><year>2008</year></dates><isbn>1551-  
1008 5036</isbn><urls></urls></record></Cite></EndNote>} *Ecosystem resilience* is a priority as the aim  
1009 of this policy direction is to allow traditionally based agricultural livelihoods to continue. In terms of  
1010 *provisioning*, significant land use changes and use of climate tolerant crops allow farming to  
1011 continue. In terms of *regulating*, river course management and strict rules around forest use also  
1012 allow farming to continue. See Table 7, for more details of the specific adaptation interventions in  
1013 the three sub directions.

#### 1014 4.4.2 System restructuring – Accommodate

1015 This policy direction aims to significantly change livelihoods (i.e. move away from traditional  
1016 agricultural activities) to ensure the population can remain in the delta despite environmental  
1017 change and sudden environmental shocks. *Vulnerability* is reduced by significantly focusing on  
1018 financial and human capital. In terms of *financial capital*, there is an effort to promote non-farm  
1019 industry within the delta, such as private sector investments in eco-tourism through economic  
1020 incentives. *DRR* focuses on *managing long term risk*. There is also a focus on infrastructure that  
1021 allows people to remain in potentially dangerous locations, such as early warning systems and

1022 cyclone/flood shelters { ADDIN EN.CITE

1023 <EndNote><Cite><Author>Paul</Author><Year>2009</Year><RecNum>676</RecNum><DisplayText

1024 >(Lumbroso et al., 2017; Paul, 2009)</DisplayText><record><rec-number>676</rec-

1025 number><foreign-keys><key app="EN" db-

1026 id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">676</key></foreign-keys><ref-type name="Journal

1027 Article">17</ref-type><contributors><authors><author>Paul, Bimal

1028 Kanti</author></authors></contributors><titles><title>Why relatively fewer people died? The case

1029 of Bangladesh's Cyclone Sidr</title><secondary-title>Natural Hazards</secondary-

1030 title></titles><periodical><full-title>Natural Hazards</full-title></periodical><pages>289-

1031 304</pages><volume>50</volume><number>2</number><dates><year>2009</year></dates><isbn

1032 >0921-

1033 030X</isbn><urls></urls></record></Cite><Cite><Author>Lumbroso</Author><Year>2017</Year><

1034 RecNum>632</RecNum><record><rec-number>632</rec-number><foreign-keys><key app="EN"

1035 db-id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">632</key></foreign-keys><ref-type

1036 name="Journal Article">17</ref-type><contributors><authors><author>Lumbroso, Darren

1037 M</author><author>Suckall, Natalie R</author><author>Nicholls, Robert J</author><author>White,

1038 Kathleen D</author></authors></contributors><titles><title>Enhancing resilience to coastal

1039 flooding from severe storms in the USA: international lessons</title><secondary-title>Natural

1040 Hazards and Earth System Sciences</secondary-title></titles><periodical><full-title>Natural Hazards

1041 and Earth System Sciences</full-

1042 title></periodical><pages>1357</pages><volume>17</volume><number>8</number><dates><year

1043 >2017</year></dates><isbn>1561-8633</isbn><urls></urls></record></Cite></EndNote>}.  
*Ecosystem resilience* is not a priority as land is not used for provisioning. There is no drive to protect  
current agriculture

1046 4.4.3 *System restructuring – Retreat*

1047 This policy direction aims to encourage population movement out of the more vulnerable parts of  
1048 the delta. *Vulnerability* is reduced by significantly focusing on *financial* and *human* capital. This may  
1049 include financial incentives to relocate outside of the delta and farmer investment in training for  
1050 new non-delta livelihoods. *DRR* focuses on *post disaster recovery and rehabilitation*, specifically, the  
1051 promotion of relocation outside of the delta following an event. *Ecosystem resilience* is not a  
1052 priority as land is not used for provisioning. However, new habitats may be created as an incidental  
1053 impact of the policy.

## 1054 5. Discussion and conclusion

1055 In this paper, we asked: what adaptations are currently occurring in deltas?; what are possible  
1056 future directions for adaptation policy?; and, what are the trade-offs associated with each policy  
1057 direction?

1058 For the first time, we have generated a set of observed adaptations that are occurring in three  
1059 distinct deltas, but which are also generalizable across deltas worldwide. Adaptations are grouped  
1060 around three main objectives: (1) actions to reduce socio-economic vulnerability; (2) actions that  
1061 address disaster risk reduction; and (3) actions that affect social-ecological resilience. In this analysis,  
1062 we do not reflect on the 'success', 'failure' or 'desirability' of the adaptations, but simply identify  
1063 what is happening. However, this raises an important research question: what are the short-term  
1064 and long-term impacts of these adaptations on households and the wider delta? And, are  
1065 adaptations that we are observing today suitable for the future when climatic and other conditions  
1066 may be very different? Understanding these questions is recommended for future research and  
1067 DECCMA will also try to provide a quantitative answer.

1068 Adaptation actions rarely occur in isolation. More often packages of adaptation measures developed,  
1069 implemented and evaluated in response to different needs and priorities of nations { ADDIN EN.CITE  
1070 <EndNote><Cite ExcludeAuth="1"><Author>European Environment Agency



1071 (EEA)</Author><Year>2014</Year><RecNum>677</RecNum><Prefix>EEA`,  
1072 </Prefix><DisplayText>(EEA, 2014)</DisplayText><record><rec-number>677</rec-number><foreign-  
1073 keys><key app="EN" db-id="vx99swex92xxtwettvxxzppt2edff2zwe0a2">677</key></foreign-  
1074 keys><ref-type name="Book">6</ref-type><contributors><authors><author>European Environment  
1075 Agency (EEA),</author></authors></contributors><titles><title>National adaptation policy  
1076 processes in European countries-2014</title></titles><dates><year>2014</year></dates><pub-  
1077 location>Luxembourg: Publications Office of the European Union</pub-  
1078 location><isbn>9292134841</isbn><urls></urls></record></Cite></EndNote>}, and these packages  
1079 of adaptations are likely to reflect policymakers' commitment to both investment and significant  
1080 change. In this paper, we have developed a method to identify suites of adaptation policies. By  
1081 recognising both the drivers and constraints on the development of policy (levels of investment and  
1082 political will to implement change), we have been able to define seven alternative sets of adaptation  
1083 policy choices that cover a range of possible future states in many deltas. These seven futures also  
1084 make explicit the trade-offs that occur when policymakers prioritise different aspects of adaptation.  
1085 As with any work that attempts to identify plausible and realistic bundles of future choices, this  
1086 research is constrained by current thinking about the nature and scope of adaptation present in  
1087 deltas today. Indeed, by basing the future policy directions on current and planned adaptation  
1088 choices we limit the adaptation set to what is known. However, we start to move beyond this by  
1089 exploring what transformative adaptation might look like in deltas. As a next step in this research,  
1090 these options can be taken to a range of delta stakeholders combined with other analysis of the  
1091 future. This will promote further insight on adaptation choices and their implications and refine the  
1092 choices presented here. This includes application to specific deltas and comparison with the policy  
1093 process where possible. For instance, the first Bangladesh Delta Plan 2100 (BDP2100) is under  
1094 preparation and the draft is now in circulation for expert comments { ADDIN EN.CITE  
1095 <EndNote><Cite ExcludeAuth="1"><Author>General Economics Division (GEC) of the Government of  
1096 the People&apos;s Republic of

1097 Bangladesh</Author><Year>2017</Year><RecNum>687</RecNum><Prefix>GEC`,  
1098 </Prefix><DisplayText>(GEC, 2017)</DisplayText><record><rec-number>687</rec-  
1099 number><foreign-keys><key app="EN" db-  
1100 id="vx99swex92xxtwettvxxzpt2edff2zwe0a2">687</key></foreign-keys><ref-type  
1101 name="Report">27</ref-type><contributors><authors><author>General Economics Division (GEC)  
1102 of the Government of the People's Republic of  
1103 Bangladesh,</author></authors></contributors><titles><title>Draft Bangladesh Delta Plan 2100  
1104 </title></titles><dates><year>2017</year></dates><pub-location>Available on line at:  
1105 [http://www.plancomm.gov.bd/wp-  
1107 content/uploads/2017/delta\\_plan/Bangladesh\\_Delta\\_Plan\\_2100\\_DRAFT.pdf](http://www.plancomm.gov.bd/wp-<br/>1106 content/uploads/2017/delta_plan/Bangladesh_Delta_Plan_2100_DRAFT.pdf). Last accessed 18  
1108 January 2018</pub-location><urls></urls></record></Cite></EndNote>}. As a living plan, the  
1109 methods described here can potentially provide a reflective approach to develop the BDP2100 into  
1110 the future.

1110 In answering these questions, we are able to reflect on the implications of adaptation policy choices  
1111 for deltas where there are uncertain future socio-economic development trajectories, to support  
1112 policymakers' decisions on the trade-offs necessary to follow their normative goals. This method  
1113 represents a possible way forward for the global stocktake of adaptation under the Paris Agreement,  
1114 as it identifies an approach to documenting observed adaptation, as well as giving a vision of  
1115 possible sets of future adaptation options. Instead of providing a silver bullet this is a way that  
1116 countries can consider adaptation in a way that suits their geopolitical context and can address their  
1117 normative goals, expressed as their development aspirations.

Table 4: Adaptation interventions under the minimum intervention direction

Broad objective of adaptation	Adaptation class	Example of adaptation intervention
Addressing drivers of vulnerability	1. Financial capital	<i>Not a priority / component not active</i>
	2. Human capital	<ul style="list-style-type: none"> <li>• Agricultural extension officer who provide basic training on how to increase income at the household level, such as learning new farming or fishing techniques.</li> </ul>
	3. Social capital	<i>Not a priority / component not active</i>
	4. Natural capital	<i>Not a priority / component not active</i>
	5. Physical capital	<i>Not a priority / component not active</i>
DRR	6. Managing long term risk	<ul style="list-style-type: none"> <li>• Ensure food availability during flood (e.g. Floating gardens and hanging vegetable garden)</li> </ul>
	7. Preparedness	<i>Not a priority / component not active</i>
	8. Response	<ul style="list-style-type: none"> <li>• Temporary evacuation</li> <li>• Use of emergency responders</li> <li>• Secondment of army or national resources</li> </ul>
	9. Post disaster recovery and rehabilitation	<ul style="list-style-type: none"> <li>• Post disaster mobile water treatment plants</li> <li>• Post disaster house construction</li> </ul>
Landscape/ ecosystem resilience	10. Provisioning	<ul style="list-style-type: none"> <li>• Potable water management</li> </ul>
	11. Regulating	<i>Not a priority / component not active</i>
	12. Habitat	<i>Not a priority / component not active</i>
	13. Cultural	<i>Not a priority / component not active</i>

Table 5: Adaptation interventions under the capacity expansion direction

Broad objective of adaptation	Adaptation class	Example of adaptation intervention
Addressing drivers of vulnerability	1. Financial capital	<ul style="list-style-type: none"> <li>Promote private sector investments in eco-tourism through economic incentives</li> <li>Post-harvest production and storage</li> <li>Develop and use open spaces, green belts and other ecologically sensitive areas for alternative livelihood such as urban farming</li> <li>Existence of loans at government level</li> <li>Incentives for migration to economic expansion areas</li> </ul>
	2. Human capital	<ul style="list-style-type: none"> <li>Education for non-farm livelihoods, based within the delta (e.g. STEM livelihoods)</li> <li>Education for non-farm livelihoods, based outside the delta (e.g. STEM livelihoods)</li> </ul>
	3. Social capital	<i>Not a priority / component not active</i>
	4. Natural capital	<i>Not a priority / component not active</i>
	5. Physical capital	<ul style="list-style-type: none"> <li>Access to markets for all, including infrastructure, training</li> </ul>
DRR	6. Managing long term risk	<ul style="list-style-type: none"> <li>Government funds to reduce risks to agriculture (Government run Agriculture Disaster Mitigation Fund)</li> <li>Establish agriculture and fisheries based insurance schemes</li> <li>Cyclone/flood shelters, including early warning systems</li> <li>River/coastal management defence infrastructure(including sea walls, groynes, dikes and polders)</li> <li>Climate proof grain silos/storage</li> <li>Ensure food availability during flood (e.g. Floating gardens and hanging vegetable garden)</li> </ul>
	7. Preparedness	<ul style="list-style-type: none"> <li>Maintain existing infrastructure (e.g., coastal embankments, river embankments and drainage systems, urban drainage systems)</li> </ul>
	8. Response	<ul style="list-style-type: none"> <li>Emergency aid provision</li> <li>Provision to ensure business and economic activities that support the economy receive immediate attention</li> <li>Critical infrastructure protection</li> </ul>
	9. Post disaster recovery and rehabilitation	<ul style="list-style-type: none"> <li>Initiatives to get the economy running quickly, e.g. funds available to rebuild damaged economic resources such as ports, roads and grain stores</li> </ul>
Landscape/ecosystem	10. Provisioning	<ul style="list-style-type: none"> <li>Potable water management</li> </ul>

resilience		<ul style="list-style-type: none"> <li>• Climate tolerant crops (Saline tolerant crops; Use of drought and heat resistant crop varieties – e.g. drought tolerant peppers )</li> <li>• Using different crop varieties</li> <li>• Climate tolerant aquaculture</li> <li>• Promote saline tolerant trees to prevent erosion around farms and homes</li> <li>• Seed bank for crop diversification</li> <li>• Alternative climate proof grasses for cattle</li> </ul>
	11. Regulating	<ul style="list-style-type: none"> <li>• Use of agro-chemicals</li> <li>• Create incentives for investor in tree crops and plantation (tax relief for private sector investment in research and development)</li> </ul>
	12. Habitat	<i>Not a priority / component not active</i>
	13. Cultural	<i>Not a priority / component not active</i>

Table 6: Adaptation interventions under the efficiency enhancement direction

Broad objective of adaptation	Adaptation class	Example of adaptation intervention
Addressing drivers of vulnerability	1. Financial capital	<i>Not a priority / component not active</i>
	2. Human capital	<ul style="list-style-type: none"> <li>• Use of climate resilient farming techniques</li> <li>• Livelihood diversification (farming)</li> <li>• Livelihood diversification (fishing)</li> <li>• Livelihood diversification - off-farm activity</li> <li>• Post-harvest production and storage at local level (e.g. farmer led)</li> </ul>
	3. Social capital	<ul style="list-style-type: none"> <li>• Farmer led cooperatives that reduce the cost of production/distribution</li> </ul>
	4. Natural capital	<ul style="list-style-type: none"> <li>• Fishing zones/rights for small-scale fishers</li> </ul>
	5. Physical capital	<i>Not a priority / component not active</i>
DRR	6. Managing long term risk	<ul style="list-style-type: none"> <li>• Cyclone/flood shelters, including early warning systems</li> <li>• All-Risk-changing-modifications to homes (walls/floors, etc.) - through funding and new building codes</li> <li>• Rehabilitation and upgrading of reservoirs for water (e.g. dredging, raising spillway levels)</li> <li>• Government funds to reduce risks to agriculture (Government run Agriculture Disaster Mitigation Fund)</li> <li>• Ensure food availability during flood (e.g. Floating gardens and hanging vegetable garden)</li> <li>• Land zoning/ no build zones</li> </ul>
	7. Preparedness	<ul style="list-style-type: none"> <li>• Education at school level re. responsibilities for DRR management e.g. evacuation training</li> <li>• Active stakeholder engagement in design and delivery of DRR</li> <li>• Communication and information re. individual roles and responsibilities re DRR</li> <li>• Readiness of emergency services to distribute medicines, food and potable water</li> </ul>
	8. Response	<i>Not a priority / component not active</i>
	9. Post disaster recovery and rehabilitation	<i>Not a priority / component not active</i>
Landscape/ecosystem resilience	10.Provisioning	<ul style="list-style-type: none"> <li>• Mixed land use (e.g. polder and shrimp farm with rice)</li> <li>• Changing irrigation and water level management practices to improve agriculture</li> </ul>

	11.Regulating	<ul style="list-style-type: none"> <li>• Mangrove forest planting</li> <li>• Promote the adoption of farm forestry practices, which include managing trees on farms, farm boundary planting and agroforestry systems (Ghana)</li> <li>• Promote ecological restoration of degraded and poorly stocked forests using appropriate reforestation/restoration techniques (ie enrichment planting, Assisted Natural Regeneration)</li> <li>• Tree planting in public areas</li> <li>• Reduce the pressure on forests for wood-fuels by encouraging use of renewable energy</li> <li>• Afforestation – climate tolerant bamboo</li> </ul>
	12.Habitat	<ul style="list-style-type: none"> <li>• Create biological corridors between existing of conservation areas to maintain gene flows</li> <li>• Promote establishment of protected green spaces with native grass along waterways</li> </ul>
	13.Cultural	<ul style="list-style-type: none"> <li>• Conservation of wildlife and biodiversity in natural heritage sites including sacred groves, protected areas</li> <li>• Protect sacred groves</li> </ul>

Table 7: Adaptation interventions under the system restructuring direction

Broad objective of adaptation	Adaptation class	Example of adaptation intervention		
		Protect	Accommodate	Retreat
Addressing drivers of vulnerability	1. Financial capital	<ul style="list-style-type: none"> <li>Develop and use open spaces, green belts and other ecologically sensitive areas for farming</li> </ul>	<ul style="list-style-type: none"> <li>Promote private sector investments in eco-tourism through economic incentives</li> <li>Development of non-farm industry</li> </ul>	<ul style="list-style-type: none"> <li>Financial incentives to relocate outside of the delta</li> </ul>
	2. Human capital	<ul style="list-style-type: none"> <li>Use of climate resilient farming techniques</li> </ul>	<ul style="list-style-type: none"> <li>Education for non-farm livelihoods, based within the delta</li> </ul>	<ul style="list-style-type: none"> <li>Education for non-farm livelihoods, based outside the delta</li> </ul>
	3. Social capital	<i>Not a priority / component not active</i>	<i>Not a priority / component not active</i>	<i>Not a priority / component not active</i>
	4. Natural capital	<ul style="list-style-type: none"> <li>Land redistribution (to the poor or other groups)</li> <li>Fishing zones/rights for small-scale fishers</li> </ul>	<i>Not a priority / component not active</i>	<i>Not a priority / component not active</i>
	5. Physical capital	<i>Not a priority / component not active</i>	<i>Not a priority / component not active</i>	<i>Not a priority / component not active</i>
DRR	6. Managing long term risk	<ul style="list-style-type: none"> <li>Raise land using controlled sedimentation</li> <li>Beach nourishment</li> <li>Land zoning, including no build zones</li> <li>River/coastal management defence infrastructure (including sea walls, groynes, dikes)</li> </ul>	<ul style="list-style-type: none"> <li>Cyclone/flood shelters, including early warning systems</li> <li>Train community in DRR management</li> <li>Train community in water management</li> <li>All-Risk-changing-modifications to homes (e.g., height of</li> </ul>	<i>Not a priority / component not active</i>



		and polders)	foundations/walls/floors , climate resilient cluster housing) and local facilities (e.g., raise water sources and sanitation facilities above flood levels) through funding, loans and new building standards and codes	
	7. Preparedness	<i>Not a priority / component not active</i>	<i>Not a priority / component not active</i>	<i>Not a priority / component not active</i>
	8. Response	<i>Not a priority / component not active</i>	<i>Not a priority / component not active</i>	<i>Not a priority / component not active</i>
	9. Post disaster recovery and rehabilitation	<i>Not a priority / component not active</i>	<i>Not a priority / component not active</i>	<ul style="list-style-type: none"> <li>• <i>Example absent from the data but could include government supported relocation of people outside the delta following an event</i></li> </ul>
Landscape/ecosystem resilience	10. Provisioning	<ul style="list-style-type: none"> <li>• Mixed land use (e.g. polder and shrimp farm with rice)</li> <li>• Changing irrigation and water level management practices to improve agriculture</li> <li>• Climate tolerant crops (Saline tolerant crops;</li> </ul>	<i>Not a priority / component not active</i>	<i>Not a priority / component not active</i>

		<p>Use of drought and heat resistant crop varieties – e.g. drought tolerant peppers )</p> <ul style="list-style-type: none"> <li>• Using different crop varieties</li> <li>• Climate tolerant aquaculture</li> </ul>		
	11. Regulating	<ul style="list-style-type: none"> <li>• River course management</li> <li>• Reduce the pressure on forests for wood-fuels by encouraging use of renewable energy</li> <li>• No commercial mining in forested areas</li> </ul>	<i>Not a priority / component not active</i>	<i>Not a priority / component not active</i>
	12. Habitat	<i>Not a priority / component not active</i>	<i>Not a priority / component not active (although new habitat may be created)</i>	<i>Not a priority / component not active(although new habitat may be created)</i>
	13. Cultural	<i>Not a priority / component not active</i>	<i>Not a priority / component not active</i>	<i>Not a priority / component not active</i>

## References

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