

1 **Title:**

2 Mobility endowment and entitlements mediate resilience in rural livelihood systems

3 **Abstract:**

4 In economically marginal rural areas, choice in livelihood strategy such as decisions to move location
5 mediates levels of individual and household resilience under conditions of environmental change. It is
6 widely recognised that endowments associated with mobility and the entitlement to mobility are unevenly
7 distributed across populations. This paper integrates these insights and conceptualises location choice as a
8 set of mobility endowments and mobility entitlements. Through focussing on endowments and
9 entitlements, the paper explores how choice affects the ability to be mobile and its role in mediating levels
10 of resilience to livelihood shocks associated with changing environmental conditions. The research design
11 involves measuring the impact of different climatic perturbations in rural locations in Anhui Province,
12 China. Mixed methods of rural appraisal, life history interviews, and a household survey generate objective
13 and perceived elements of individual and household responses to risks. These data are augmented by
14 biophysical observations on the nature of the climatic perturbations. The results show that mobility
15 endowments and mobility entitlements are important in determining the impact of mobility on resilience.
16 The life history interview data highlight significant individual agency within the structures that impact on
17 individual choices. Further, individuals and households who possess the ability to decide and to
18 subsequently enact decisions about mobility, are shown to be more resilient compared to other individuals
19 and households that lack such ability. Moreover, households practicing short-term, circular mobility are
20 more resilient than those households that practice long-term mobility. The study confirms that, in these
21 instances, choice and the ability to enact those choices mediates resilience and highlights the implications
22 of location decisions but also the conditions in which those decisions are made.

23 **Keywords:**

24 Mobility, choice, resilience, adaptation, China

1 **1. Introduction**

2 Responding to environmental change and other livelihood shocks and stresses is fundamentally about
3 adjusting to risks in response to or in anticipation of changing circumstances (Adger et al. 2013). Migration
4 is such a strategy and is widely used to spread risk and diversify livelihoods (Ellis 1998; Agrawal & Perrin.
5 2009). Migration is a widespread social phenomenon, more fundamentally, an adaptive response to all
6 social, political, cultural and environmental signals and an important means to reduce vulnerability (Tacoli
7 2009; Barnett & Adger 2018) . By contrast, in policy discourses, migration is often described as a failure to
8 adapt, and a problem to be addressed through practices that encourage people to stay in their locations of
9 residence (Geiger & Pécoud 2013). Recent research and evidence captures this apparent contradiction:
10 migration is shown to be heterogeneous and influenced by a range of drivers that work across spatial and
11 temporal scales (Black et al. 2011). Exposure to environmental risks and long-term change have diverse
12 impacts on residential location: for some populations, higher exposure to environmental risks reduces
13 mobility, while for others migration is an option of last resort once all other options have failed (Mcleman
14 2010). Migration has also been shown to be in anticipation of risk: as a precautionary adaptation due to
15 increased perceptions of the future state of environments (Bardsley & Hugo 2010).

16 Choice is an important element underpinning the courses of action people and populations consider
17 feasible. Specific responses to livelihood shocks and stresses ultimately come down to choice, or absence of
18 choice, between different options (Mcleman & Smit 2006: 46). Research on migration and environmental
19 change has tended to conceptualise choice through a continuum of migration outcomes from forced
20 migration at one extreme to voluntary migration at the other (Hugo 1996). More recently these mobility
21 outcomes have been expanded to include those who are unable to migrate or trapped populations
22 (Foresight 2011). That the decision to migrate is influenced by a range of factors operating at different
23 levels from the macro to the micro is well established (Massey et al. 1998; Samers 2010), yet the processes
24 through which the ability to choose are realised and the impact that this has on resilience are rarely
25 studied. In this paper, we seek to address the issues of choice and ask, firstly, what does choice in relation
26 to mobility look like and mean and how is the ability to enact it realised (as conceptualised through
27 endowments and entitlements)? Secondly, are those with greater ability to choose more resilient to
28 environmental shocks? The paper is structured as follows: in the next two sections, we review literature on
29 resilience and choice in relation to environmental change and detail the sampling approach, methods used
30 and the analytical strategy. The subsequent two sections present the results and discussion, specifically
31 drawing out the crucial role that choice plays in mediating resilience. The final section concludes by arguing
32 that the use of mobility can be considered an adaptive response with a positive impact on household
33 resilience.

1 **2. Literature review**

2 2.1. Resilience

3 Although the close links between resilience and adaptation as captured in adaptive capacity are widely
4 acknowledged (Folke 2006; Miller et al. 2010), they differ conceptually and practically. Adaptation
5 describes the processes through which people are able to use knowledge and experience and adjust
6 behaviour and modes of operating in response to external or internal processes to continue to exist within
7 a current stability domain. Adaptation is a key attribute of resilience but not the only attribute. Resilience
8 includes other characteristics in addition to adaptive capacity that are more or less visible depending on the
9 nature of the system at a specific point in time, and include the ability to learn, the perception of agency,
10 the real or imagined limits that structure choice, behaviour and responses and the ability to completely
11 transform a system into a new state (Carpenter et al. 2001; Walker et al. 2004; Jones & Tanner 2017).

12 Many studies that use adaptive capacity or adaptation to explore resilience, rely on assessment or
13 quantification of capital assets that underpin sustainable livelihoods. The underlying logic is that resilience
14 at various scales is partially constituted by adaptive capacity and can be measured through the presence
15 and availability of different types of capital at an individual, household or a larger unit of analysis (see
16 Deshingkar (2012); and Nawrotzki et al. (2012); Ayeb-Karlsson et al. (2016); Loebach (2016); Banerjee et al.
17 (2017)). Using capital assets as a proxy for resilience, however, downplays characteristics that are critical to
18 generate a more holistic understanding of a resilient system. A holistic approach incorporates factors such
19 as the ability to use knowledge and experience to adjust behaviour, sense of place, constraints associated
20 with marginalisation and disempowerment, and the self-perceived limits of what is considered possible
21 (Jones & Tanner 2017). Both resilience and adaptive capacity remain contested in terms of measurement
22 and operationalisation. But further, there is a major challenge to integrate measurement of resilience with
23 existing migration theories and the problems associated with working across spatial and temporal scales
24 (Walker et al. 2004; Turner 2014; Davies et al. 2015; Adams 2016).

25 Expansion of the key attributes of system resilience has led directly to consideration of perceived resilience
26 and its implications for action: so-called subjective resilience (Brown 2014). Subjective resilience
27 incorporates social, cultural and psychological elements that contribute to resilience (Béné et al. 2016;
28 Jones & Tanner 2017). That is, the measure of resilience is not externally imposed but self-generated
29 reflecting individual circumstances and lived experiences. Furthermore, self-generated measures of
30 resilience also offer greater potential to better reflect the perceived opportunities and constraints that
31 structure behaviour and reveal the processes through which individuals and households are or are not able
32 to gain the ability to make choices about mobility.

1 2.2. Choice

2 The presence or lack of choice is a key element that influences not only the way in which mobility is
 3 enacted but also the outcome of that mobility decision. Choice has been extensively addressed in research
 4 that explores migration ranging from the neoclassical approaches (that model the choices individuals make
 5 as rationale beings seeking to maximise returns on investment) through to more psychological and
 6 behavioural approaches (that focus on the cognitive processes through which people elect to move or not)
 7 as demonstrated in Table 1. In the specific arena of the role of environmental risk in migration, constraints
 8 on choice have been posited as mediating factors in the impact of environmental change on decisions to
 9 migrate, predominantly from areas at risk of, or experiencing, environmental shocks or stresses (Barnett &
 10 Adger 2018).

Name	Description	Citations
Neoclassical approaches	Focus on the individual as making rational and self-interested decisions	Lewis (1954); (Ranis & Fei 1961); Todaro (1969); Harris and Todaro (1970). See also Lilleör and Van Den Broeck (2011).
New economics of labour migration approaches	Set individual migration decisions within other decision-making units, such as the family or household	Stark and Levhari (1982); Stark and Bloom (1985); Stark and Lucas (1988); Taylor et al. (2003); Amare and Hohfeld (2016). See also Žičkutė and Kumpikaitė-Valiūnienė (2015).
Psychological and behavioural approaches	Focuses on decision-making processes and perceived value or utility of a place.	Wolpert (1965); Speare et al. (1974); De Jong and Fawcett (1981); Kniveton et al. (2011); Tabor and Milfont (2011); Martin et al. (2014). See also Adams (2016); Klabunde and Willekens (2016).
Environmental and climate change studies	Refocused attention on the links between changing environmental conditions and migration outcomes	Mcleman and Smit (2006); Hugo (2008); Afifi and Jäger (2010); Black et al. (2011); Warner and Afifi (2013). See also Piguët et al. (2011); Hastrup and Olwig (2012); Mcleman et al. (2016).
Forced migration and trapped populations	Emerging field exploring the processes through which people are forced to move or trapped in place	Cohen et al. (2013); Adams (2016); Foresight (2011). See also Morrissey (2009); Ottonelli and Torresi (2013).

11 Table 1: Theoretical approaches that incorporate choice and agency within studies of migration.

12
 13 Within the theoretical traditions in Table 1, and despite an either implicit or explicit focus on choice, the
 14 process through which this ability to choose is realised is under-researched. For example, neoclassical
 15 approaches suggest that people seek to gain the maximum utility in different places or that migration can
 16 be conceptualised as a risk-spreading technique (new economics approaches). However, whilst the
 17 outcome of the choice is clear, the means through which an individual or household is able to convert their
 18 resources into mobility, and the barriers and enablers that mediate that process, are unclear.

19 That environmental change leads to differentiated outcomes via social structures operating on individuals
 20 is widely accepted in thought and practice. The same event can have multiple outcomes depending on the
 21 characteristics of the individual and their social context. An individual's ability to manage stresses is not
 22 given, for example, it is produced by unequal access to resources, poverty and lack of representation
 23 (Langridge et al. 2006; Ribot 2010). In relation to mobility, some populations are mobile through choice,

1 whilst, at the other end of the spectrum, some are mobile because they have no other option (the same
2 applies to immobility). Yet, despite this knowledge, the processes, barriers and enablers that structure how
3 and if that choice is realised, and its outcomes in relation to resilience, are poorly understood.

4 Within China, much evidence suggests that migrants move for economic reasons although sub-regional
5 patterns are more complex and multi-faceted (Murphy 2002; Zhu 2003; Gaetano & Jacka 2004; Zhu 2007;
6 Zhang 2008; Whyte 2010; Zhu & Chen 2010). Despite ongoing reforms and greater freedoms (for some),
7 migration, as with many other aspects of people's lives, remains, to a certain extent, under the influence of
8 socialist era instruments of state control such as the *Hukou* system (Cai 2003; Fan 2004; Deshingkar 2005;
9 Zhang 2008; Chan 2010; Chan 2011). *Hukou* classification is divided into two types. The first classification is
10 the *Hukou suozaidi* (the place of *hukou* registration), based on a person's presumed regular residence and
11 is either rural or urban. The second classification, *Hukou leibie*, is based on status or type of *Hukou* and is
12 either agricultural (*nongye*) or non-agricultural (*feinongye* or *chengzhen*) (Chan & Zhang 1999).

13 Fan (2004) contends that the study of migration in China must include institutions owing to the legacy of
14 the socialist era control instruments such as the *Hukou* system that controlled the movement of
15 populations between rural and urban areas. Despite the gradual relaxation of controls the influence of the
16 *Hukou* system on mobility remains powerful especially when linked to other state institutions such as
17 welfare support and education access. Beyond these formal state-level institutions are those that operate
18 informally. For example, gender and intra-household structures are also highly salient. The roles that are
19 ascribed to individuals within the household, the norms and expectations of people to live up to and fulfil
20 those roles, are very important in influencing who is and is not mobile. These institutional arrangements
21 are likely to influence the choice of individuals to deploy mobility and by extension resilience.

22 In this paper, we address the issue of choice and the ability to enact it, and the consequences for resilience
23 to environmental shocks. To achieve this, we employ a novel conceptual framework to understand the
24 processes through which people exercise their mobility rights. Building on Leach *et al* (1999), we develop
25 the twin concepts of *mobility endowments* and *mobility entitlements* to explore the ways in which people
26 are or are not able to exert a legitimate, effective command to convert rights and resources to be mobile
27 into mobility itself. Mobility endowments are defined as the rights and resources that people have to be
28 able to be mobile and mobility entitlements are considered to be the legitimate, effective command to
29 convert your rights and resources to be mobile (mobility endowments) into mobility. Institutions are crucial
30 within the framework and influence who is mobile and which resources can be converted into mobility
31 endowments and thence to mobility entitlements. By breaking down the process through which resources
32 are mapped on to mobility endowment and thence on to mobility entitlements, we empirically explore the
33 nature and extent to which individuals and households have choice, how they use that choice and what it
34 means in terms of mobility outcomes. Moreover, the framework provides a means to express resilience
35 through an understanding of endowments and entitlements and draws on recent work that has sought to

1 integrate the concept with more actor-orientated approaches (Langridge et al. 2006; Nelson et al. 2007;
2 Miller et al. 2010; Béné et al. 2011; Armitage et al. 2012; Coulthard 2012).

3 **3. Methods**

4 3.1. Sites, sampling and methods

5 Anhui is the second largest (only Sichuan is larger) exporter of migrants of China's provinces, recording a
6 net out-migration of 11,108,000 people over a 20-year period (1990 – 2010) for the population aged five
7 and above (Chan 2012). Over the four five-year periods (1990 – 2010), Anhui has always ranked in the top
8 three for net exporting provinces indicating stability in trends between exporting provinces. Within Anhui,
9 two rural villages, Wanzhuang and Dongdian, located within Lixin County, one of four counties that
10 constitute Bozhou prefecture, are chosen as appropriate sites for the research. In 2011, Bozhou reported
11 above average levels of temporary migration (defined as leaving for six months or more but not changing
12 registration), with 35 per cent of the population taking this decision (the average the Anhui is 31 per cent).
13 Of these, 82 per cent relocated to other provinces with the majority going to Jiangsu (20 per cent), Zhejiang
14 (35 per cent) and Shanghai (33 per cent) (China Statistical Press 2012: 3-21 & 3-22).

15 The economy of both villages is agricultural: wheat, corn and soya are the dominant crops often practiced
16 alongside animal husbandry. The majority of the population in the case study sites has a local and
17 agricultural *Hukou* and there are no significant livelihood options outside of agriculture: underemployment
18 is acute. Dongdian (26m asl) and Wanzhuang (26m asl) are located in the low-lying plains of the Fei River, a
19 tributary of the Huai River. Significant improvements to the villages' infrastructure have occurred within
20 the last 20 years. Both villages now have near universal access to potable water, are electrified and
21 witnessed improvements to the local road network although travel to major urban centres remains time-
22 consuming. The Fei River constituted a major flood risk until a levee was built along its the banks. Low-lying
23 farmland (located towards the Fei) is particularly vulnerable to surface water flooding or ponding. In both
24 villages, the main roads also act as levees protecting parts of the settlements from surface water or fluvial
25 flooding.

26 Wanzhuang experienced a flood in 2007 and Dongdian experienced drought-like conditions from 2010 to
27 2011. These climatic phenomena are selected as they offer an interesting contrast in terms of speed of
28 onset (a drought event is typically categorised as a slow onset event whilst flooding is considerably more
29 rapid) and are likely to engender different human responses (Dun & Gemenne 2008; Renaud et al. 2011).
30 The data were collected through multiple trips to the research sites over a period of two years from 2011
31 to 2013. We employed a combination of social research methods: rapid rural appraisal (RRA), household
32 questionnaire surveys and semi-structured and life history interviews. The mixed methods approach
33 employed has been utilised in previous research (specifically the EACH-FOR and Rainfalls projects) on the
34 migration-climate change nexus (Warner et al. 2009; Piguet 2010; Warner 2011; Warner et al. 2012) and

1 interdisciplinary research more generally (Nuijten 2011). One of the key strengths of this sort of approach
2 are the different perspectives, layers of understanding and rigour that are generated through the data
3 collection and analysis.

4 Rapid Rural Appraisal was undertaken to understand the local context and to help build rapport with
5 communities. Seven different types of rural appraisal exercises were used in both sites with different
6 community members. The purpose of the activities was to gain an understanding of the socially-
7 differentiated nature of the communities, the impacts of the environmental perturbations as well as the
8 prevalence and nature of migration.

9 A survey was administered in the form of a face-to-face questionnaire to the self-identified household head
10 (or acting household head) or the spouse of the household head in the dwelling of the respondent. The
11 sample frame for the survey was the entire resident household population of each study site elicited
12 though the RRA exercises. There were 106 households in Wanzhuang of which 44 no longer held a *de facto*
13 residence in the village. 47 households were surveyed in Wanzhuang representing 38 per cent of the total
14 number of *de jure* households or 76 per cent of the *de facto* resident households. In Dongdian, there were
15 124 households of which 43 no longer held *de facto* residence. 44 households were surveyed, representing
16 40 per cent of the total number of *de jure* households or 62 per cent of the *de facto* households. The
17 questionnaire survey was split into three parts. The first part covered issues associated with environmental
18 change and the impact of the weather event under study; the second part focused on migration and the
19 third part sought information on the household and its members.

20 Within the questionnaire a distinction was made between longer-term and shorter-term migration. Longer-
21 term migration was defined as a move of three months or more, or an intention to stay away for three
22 months or more if the move was more recent. This cut-off period accords with the definition in the
23 Foresight Report and is often used for distinguishing migration from shorter-term moves (Foresight 2011:
24 34; Bell et al. 2014). Shorter-term moves were defined as a period of more than one week but less than
25 three months or an intention to stay away for less than three months if the move was recent. This period
26 was selected to capture the more cyclical nature of moves present in the villages and revealed through the
27 RRA activities.

28 Life history interviews were conducted in households' first language with migrants in Shanghai who
29 originated from the source communities and with a subset of questionnaire respondents in the source
30 communities to investigate emerging issues from the preliminary analysis. In total, six interviews with
31 migrants in Shanghai were undertaken in phase two of the research and 12 life history interviews with
32 households in the rural sites, capturing a sample of the different household mobility typologies. The
33 interview data were transcribed as spoken (in Anhui dialect) and translated into English before being coded

1 and thematically analysed (using Nvivo); pseudonyms are used throughout the text to protect identity of
2 the participants.

3 The life history approach was used to generate detailed insights into participants' lives, the choices they
4 make, the reasons for these choices and their perceived outcomes. In this context, the life histories provide
5 a means to "advance understanding about the complex interactions between individuals' lives and the
6 institutional and societal contexts in which they are lived" (Cole 2001: 126). Life history interviews are
7 skilful in revealing the individual experiences set within broader structures and the perceptions, values and
8 motivations that underpin behaviour (Bruner 1991; Murray 2002; Locke & Lloyd-Sherlock 2011).

9 The insights from the life history interviews are used to augment the more quantitative analysis and link
10 data about mobility outcomes with an understanding about the role of choice and the nature and form of
11 the institutional structures that mediate it. The life history interviews focus on significant events in the
12 productive lives (adulthood) of the respondents and not on the climatic perturbations and their use of
13 mobility. The underlying rationale was to understand from the perspective of the respondents the
14 significant points in their lives and the role that mobility played in these points. Crucially, however, all of
15 the respondents experienced the climatic perturbations within their adult life meaning that these events
16 were part of their lived experiences.

17 3.2. Resilience measures

18 We examined the resilience of households through the application of an innovative combination of self-
19 perceived and externally-derived measures (see Table 2 and Supplementary Information for the
20 methodology used in constructing each of the indices). Through the household survey we collected
21 information on the respondents' perceptions of change (incorporating the period of climatically-induced
22 environmental change) in yield, their financial situation, and wellbeing. These attributes constitute
23 elements that have all been shown to contribute to resilience (Plummer & Armitage 2007; Smith 2014; Afifi
24 et al. 2015). The measures draw on the five capitals that are undoubtedly important in influencing a
25 household's level of resilience. In addition, the measures also capture perceived change over time and
26 enable the incorporation of the subjective, lived experiences and circumstances of individual households,
27 thus generating a more holistic view of how resilient households perceive themselves to be (Cutter et al.
28 2008; Brown & Westaway 2011; Armitage et al. 2012; Biggs et al. 2013).

Variable	Self-perceived or externally derived	How measured	Measurement / variables	Descriptive statistics
Yield	Self-perceived	Questionnaire: comparing the current situation with five years ago	Increased, decreased, stayed the same	n=61; Range: 0 – 1; Mean: 0.83; S.D.: 0.10; Variance: 0.1

Financial situation	Self-perceived	Questionnaire: comparing the current situation with five years ago	Got better, got worse, stayed the same	n=61; Range: 0 – 1; Mean: 0.77; S.D.: 0.07; Variance: 0.01
Wellbeing	Self-perceived	Questionnaire: comparing the current situation with five years ago	Got better, got worse, stayed the same	n=61; Range: 0 – 1; Mean: 0.87; S.D.: 0.08; Variance: 0.01
Dependency on agriculture	Self-perceived	Questionnaire: describing reliance on agriculture for livelihood	Completely dependent, dependent, not that dependent, not dependent at all	n=61; Range: 0 – 1; Mean: 0.73; S.D.: 0.07; Variance: 0.01
Wellbeing ranking	Externally derived	RRA activity: Each household was discussed and ranked by a group of community members	Upper group, middle group, lower group	n=61; Range: 0 – 1; Mean: 0.60; S.D.: 0.08; Variance: 0.01
Asset index	Externally derived	Questionnaire: Derived from 8 variables representing household characteristics and socio-demographic conditions	Number of ceiling fans, refrigerators, washing machines, bicycles; size of farmland, number of adults in household and the dependency ratio	n=97; Range: 0 – 1; Mean: 0.50; S.D.: 0.07; Variance: 0.01

1 Table 2: Description, mean and variation in variables used to measure resilience.

2 Three other measures were also used to complement those described above. First, a self-perceived
3 measure of dependency on agriculture was included. The majority of households were reliant on rain-fed
4 agriculture, indicating that they were vulnerable to changes in the weather particularly in relation to
5 precipitation and drought conditions (Marshall et al. 2007; Zhou et al. 2010). Second, a community-derived
6 measure of wellbeing was generated through an RRA activity. This measure provided a counterpoint to the
7 self-perceived reported change over time in wellbeing, and gave an overall indication of how well
8 households were perceived to be doing by their peers. Thirdly, an asset index was developed to provide a
9 proxy measure of the households' socio-economic position to generate insights into their financial stock
10 (permanent income) rather than their financial flow (current income) (Balen et al. 2010).

11 Although all three measures were snapshots from the point the data were collected, they are indicative of
12 the long-run condition of the household. Agricultural dependency is strongly associated with the size of the
13 agricultural land holding each household possesses and these land holdings have remained relatively static
14 since the 1990s (when the last major land reallocation took place). The externally-derived measure of
15 wellbeing and the asset index were both generated to reflect the long-run status of the household; one
16 through a discussion-based exploration of each household, and the other through a focus on physical assets
17 that are unlikely to vary substantially on a monthly or yearly basis.

18 Resilience encompasses the ability to learn and exert agency and it reflects households' perceived ability to
19 shape the world around them. Cumulatively, the measures provide an insight into how well households see

1 themselves to be doing and an indication of their perceived level of resilience. The externally-derived
2 measures provide an interesting counterpoint to the self-perceived measures and show, for example, the
3 community perception of the wellbeing of individual households in relation to each other explored through
4 a snapshot measure of wellbeing, or the long-run socio-economic status of the household as expressed
5 through the asset index.

1 **4. Results**

2 4.1. Impact of the climatic perturbations on mobility patterns

3 The climatic perturbations (see Table 3 for summary of impacts) in both sites resulted in a variety of
 4 mobility responses. The survey recorded changes to households’ mobility patterns as a result of the
 5 climatic perturbations for the following classes of movement: frequency or duration of short-term mobility
 6 into or out of the village, changes to longer-term mobility (into or out of the villages), unplanned return
 7 mobility and temporary relocation. Overall, the most commonly deployed mobility response was the
 8 temporary relocation of the inhabitants of Wanzhuang in response to the flooding (85 per cent of survey
 9 respondents in Wanzhuang). For both sites, a minority of survey respondents (less than 20 per cent)
 10 reported changes (increases and decreases) to all classes of mobility out. For mobility into the villages,
 11 across all classes of movement a minority of households reported changes in Dongdian but not for
 12 Wanzhuang. The cases of no change were reported for a decrease in the number and frequency of people
 13 using mobility to return to the village (Table 3).

Variable	Wanzhuang (flood)	Dongdian (drought)
Agriculture	Significant and uniform impacts on soya and corn crop with losses also reported for harvested wheat	Range of impacts from very little to almost complete loss on major crops (wheat, soya, corn)
Physical assets	Impacts reported on a number of physical assets including homes (59%), items in the home (47%) and farming equipment (15%)	Majority of respondents (89%) reported no impact on physical assets
Food availability	80% of respondents reported that the availability of food decreased by either ‘a little’ or ‘a lot’	Just over half (53%) reported decreasing availability of food
Health	More than half (53%) of respondents reported an impact on health	Only 37% respondents reported impacts on health
Financial assets	Majority of households across both sites reported impact on finances but the length of time taken to recover ranged from less than 3 months to more than 2 years	
Impact across mobility types	Variety of mobility responses (frequency, duration and distance) employed by a minority of different households with no one type dominant. Majority of households report no change in mobility behaviours in response to the perturbation.	
Short duration, short distance mobility	More short duration, short distance coping mobility	Negligible short duration, short distance coping mobility
Longer duration mobility	Peak in longer duration mobility during and just after the flood event (but not statistically significant)	Peak in longer duration mobility during drought event (but not statistically significant)
Return migration	Some return migration, but not substantial	
Number of dependents	Comparably more households reducing number of dependants	Few households reducing number of dependants

14 Table 3: Summary of impacts of climatic perturbations on study sites (n=97; period of analysis=2007 to
 15 2012).

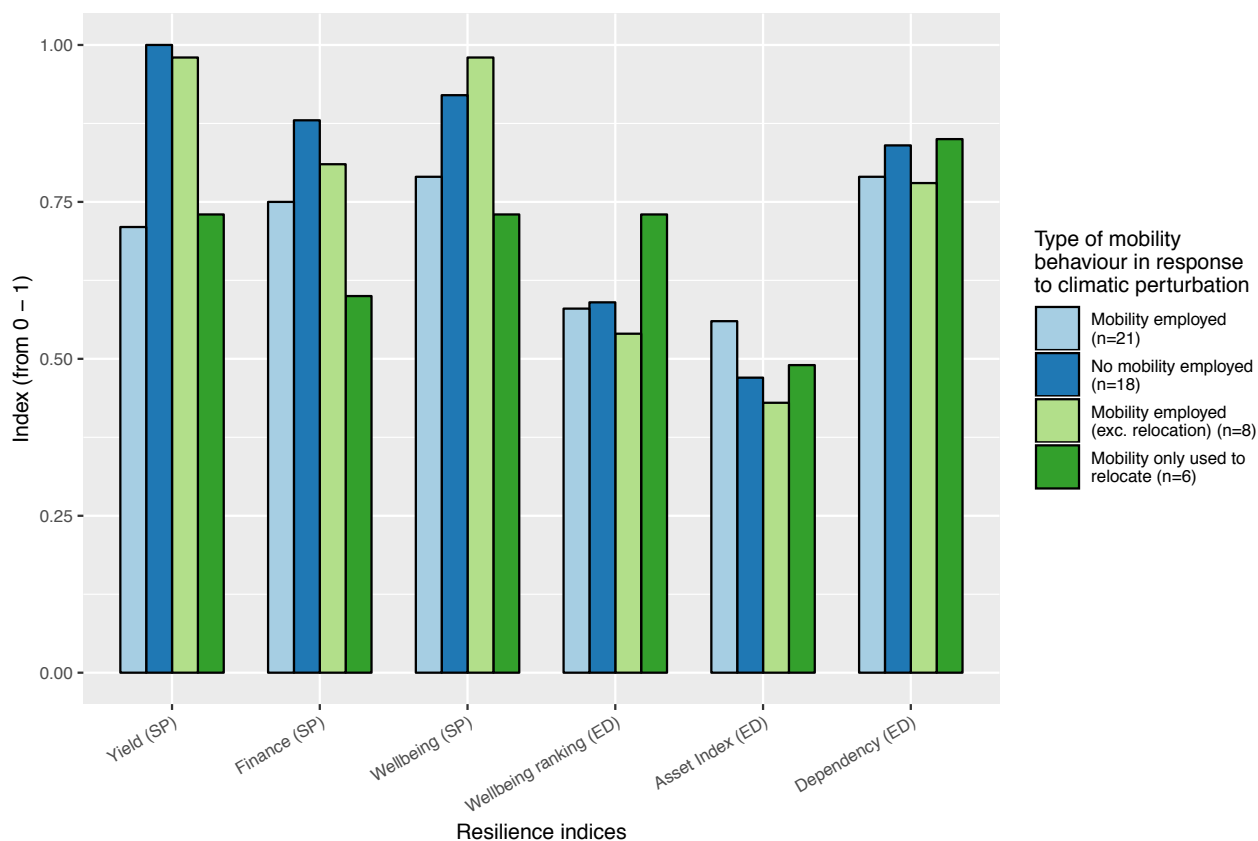
16
 17 Excluding the government-initiated evacuation of Wanzhuang, the evidence suggests that, for a majority of
 18 households the impact of the perturbation on mobility was negligible. However, for a minority of
 19 households the perturbation did contribute to a change in mobility behaviour in a variety of ways. In effect,
 20 the perturbation disrupted existing patterns of behaviour as households sought to cope with and adapt to

1 the new circumstances brought about by the climatic perturbation. This inconsistency between households
2 suggests that the impact of the perturbation on mobility behaviour was strongly socially differentiated,
3 with households drawing on a specific portfolio of responses depending on their existing resources,
4 mobility endowments and mobility entitlements.

5 4.2. Households practising short-term mobility appear more resilient to livelihood shocks in the context of
6 weather-related variability

7 The analysis of the household survey, rural appraisal activities and interviews shows that mobility has, in
8 some cases, enabled individuals and households to increase their resilience to climatic perturbations.
9 Figures 1 and 2 show groups of households exhibiting different types of mobility behaviour (in direct
10 response to the climatic perturbation and more generally) disaggregated by mobility type and their scores
11 on a range of self-perceived and externally-derived measures. These measures provide an indication of how
12 well a household perceives themselves and is perceived to be doing, through which we infer levels of
13 resilience.

14 Figure 1 shows household use of mobility in response to the impact of the climatic perturbation. Four types
15 of mobility are included in the plot: households that report using some form of mobility (including
16 relocation due to the flooding in Wanzhuang), households that report using no mobility whatsoever,
17 households that report using some form of mobility but not to relocate, and households that report using
18 mobility only for the purpose of relocating from Wanzhuang. Looking at the self-perceived measures, the
19 households that score themselves higher are those that did not use mobility to relocate but may have used
20 mobility in other forms. For the externally-derived measures, the differences between households
21 exhibiting different types of mobility behaviour are smaller but often reversed, with those households not
22 using mobility to relocate appearing to do worse.

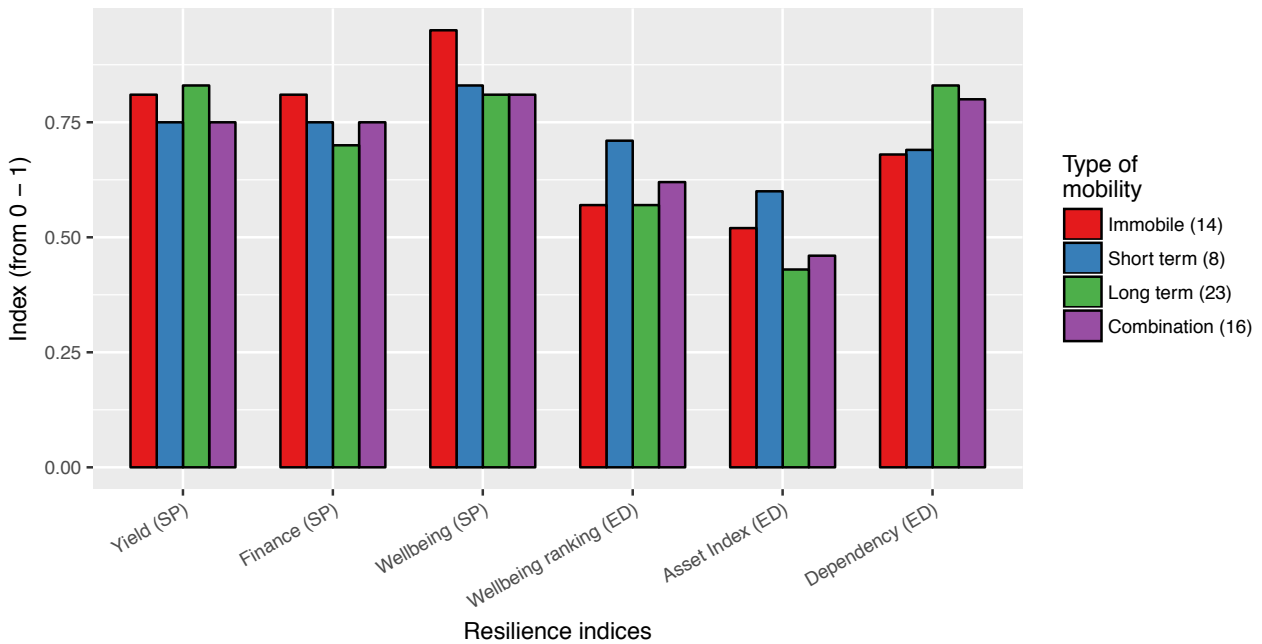


1

2 Figure 1: Indices of resilience for households exhibiting different types of mobility in response to the climatic
 3 perturbation (n=53; Wanzhuang=flood; Dongdian=drought; SP=self-perceived; ED=externally-derived).

4

5 Figure 2 shows households use of mobility over a longer time-period that includes the climatic perturbation
 6 but is not necessarily in response to it. Over the period that incorporated the climatic perturbations,
 7 households that practiced mobility but retained *de facto* residence within the village (through circular or
 8 seasonal mobility) reported larger improvements in yield and a lower dependency on agriculture compared
 9 to those households that only utilized longer-term migration or practiced a combination of different types
 10 of mobility. Furthermore, the households using only short-term migration scored highest in the wellbeing
 11 ranking (community-perceived measure) and the asset index (an externally-derived measure). For
 12 households with longer-term members absent through migration the picture is much more mixed, these
 13 households show greater dependency on agriculture, levels of wellbeing and lower scores on the asset
 14 index. The self-perceived measures of change for the immobile households tend to compare favourably in
 15 relation to the more mobile households whilst the reverse is true of the externally-derived measure.



1
2 Figure 2: Indicators of resilience for households exhibiting different types of mobility over the period of analysis
3 including the period of the climatic perturbations (n=61; period of analysis=2007 to 2012; SP=self-perceived;
4 ED=externally-derived).

5
6 Although the differences for individual measures between mobility types were not statistically significant,
7 the overall results suggest that the group of households employing short-term mobility were doing
8 moderately better in comparison to other groups on a range of self-perceived, community-perceived and
9 externally-derived measures especially when compared to the other groups that utilize mobility. These data
10 suggest that the group of households employing short-term mobility are more resilient to the sort of
11 livelihood shocks that are experienced during periods of climatically-induced environmental change.

12 One of the most notable features of Figures 1 and 2 is the difference between the self-perceived measures
13 and the externally-derived measures for households exhibiting certain types of mobility. In Figure 1, the
14 group that only used mobility to relocate scored themselves amongst the lowest on the self-perceived
15 measures and were the highest in two of the three externally derived measures. In Figures 1 and 2, the
16 immobile households scored themselves very positively for the self-perceived measures of change.
17 Whereas the externally-derived measures of wellbeing or the asset index is often one of the lowest. This
18 suggests that these households perceive themselves to be well, whilst the external measures imply this
19 may not be the case.

20 4.3. Choice is an essential element in mediating resilience under conditions of mobility

21 Interviews were undertaken with a subset of the surveyed households and those who had migrated to
22 explore the circumstances through which household members exercised mobility choices. The clearest
23 example of the role of choice as a mediator of resilience is for households that have retained a *de facto*
24 residence within the village. We present three examples to illustrate the importance of choice and how it
25 can have potentially significant implications on mobility and resilience.

1 **Example 1: an immobile household.**

2 Wang Hong-Li is 82 and lives with his wife, aged 81, in Wanzhuang, he has one daughter who lives in a
3 village nearby. Wang Hong-Li and his wife have two *mu* of land (a *mu* equals 666.66m²) that they farm for
4 themselves. During the interview Wang Hong-Li stated that he could not farm any more land owing to his
5 physical condition, he is reliant on help from his extended family (nephew) and some hired labour to do
6 some of the more strenuous activity for him. Despite some minimal state support, Wang Hong-Li is reliant
7 on agriculture for his subsistence.

8 If I don't farm, I have nothing to eat [and] [I]f we can get good harvest in crops, we have enough to eat,
9 while if not, we don't have enough to eat (20140203 Interview Wang Hong-Li).

10 In recovering from the flood, Wang Hong-Li was reliant on support from two main sources of support: the
11 state and his daughter. Yet Wang Hong-Li's ability to respond and cope with shocks and stresses is limited
12 in a number of ways. At a cognitive level, his ability to conceive of life beyond the immediate area appears
13 constrained. Such cognitive limits are perhaps related to a combination of life history and the impact of the
14 stricter controls in movement up until the mid to late 1980s. Other than one daughter (who remains close
15 but is considered part of her husband's family) and a nephew, Wang Hong-Li has no other surviving
16 immediate relatives. Wang Hong-Li's social network is very limited and strongly focused within the village.
17 Institutionally, the state structures at a local and national level are working as barriers to mobility. Finally,
18 he is poor (as demonstrated through his receipt of government support) with very limited assets, suffers
19 from ill health and is dependent on subsistence cropping.

20 Wang Hong-Li appears vulnerable to local (weather-related) shocks or stresses that reduce his yield and the
21 functioning of his social support network. For example, an event that negatively impacts on his ability to
22 farm whilst concurrently affecting his daughter's household (reducing her ability to provide remittances)
23 and disrupts his local support network would further increase the pressure on the minimum guarantees
24 provided by the state. In this instance, Wang Hong-Li has limited resources and low levels of mobility
25 endowments and mobility entitlements brought about by his reliance on the state. The low levels of wealth
26 and resources possessed by Wang Hong-Li are major impediments to his mobility choices and also
27 influence his resilience to shocks and stresses.

28 **Example 2: mobility enacted to return to the village**

29 Wang Zhou is 48 years old, married and has two children (aged in their mid-twenties). Whilst their children
30 were growing up, Wang Zhou and his wife worked and lived in Shanghai and his children remained in
31 Wanzhuang with Wang Zhou's parents. During this time Wang Zhou was able to remit money back to his
32 parents including during times of hardship as was the case with the flood in 2007. In 2013, Wang Zhou's
33 father became ill and Wang Zhou and his wife had to return to Wanzhuang to care for him, giving up their
34 jobs in the process. Wang Zhou has started farming again but the change in jobs has had an impact on the

1 household economy. Wang Zhou stated that his father used to farm and he used to work in Shanghai:
2 stretching the household between two locations, boosting the livelihood options available to the family and
3 increasing their earning potential.

4 Since Wang Zhou's father became ill, it has become more difficult for the household as they make less
5 money and have greater outgoings. For example, Wang Zhou reported that they had to borrow money to
6 fund the cost of an operation, as the state would only contribute a small amount to the medical costs.
7 Repaying this money was entirely dependent on the income generated through farming.

8 We are not sure [when we can repay]. In more than one year, if there is something wrong, we can only
9 go home for getting in the crops, and we can pay it off if we have money left. But if we don't have money
10 left, it will cost another year [through farming] (20140203 Interview Wang Zhou).

11 Wang Zhou's father's illness has curtailed his ability to work (reducing the amount of labour available to the
12 household) and increased the demands on the other adult members of the household who are obliged to
13 care for him. In addition to his father, Wang Zhou is also responsible for bringing up two grandchildren who
14 live with him in Wanzhuang. Wang Zhou's house was damaged in the flood in 2007 and a village level
15 moratorium on new building and renovations has meant that the house has yet to be repaired. The poor
16 state of repair the house is in has resulted in it being classed as 'dangerous to live' (category of building
17 condition). Wang Zhou stated that should another flood occur the family would be strongly affected and
18 the cost of rebuilding would have to be met through loans and borrowing as they have no money to fund
19 such measures.

20 The confluence of these factors on Wang Zhou's life make him much more vulnerable to future
21 environmental perturbations (such as a flood), a point that he himself articulated during the interview. The
22 account of Wang Zhou highlights the interaction of household institutions (its organisation), social norms
23 and laws and expectations (in the form of *bao* (reciprocity) and *xiao* (filial piety)) that place an obligation on
24 Wang Zhou to return to care for his father and the wider societal changes occurring in China. Cumulatively,
25 these personal circumstances, institutional factors and broader changes in China (increased mobility,
26 growing urban rural wage differences) obliged Wang Zhou to use his mobility endowments and deploy his
27 mobility entitlement to return to his village to care for his father. However, Wang Zhou and his family now
28 appear more immobile and are less resilient to future shocks and stresses.

29 **Example 3: household resides in village and the household head works away for portions of the year**

30 Wang Chung has lived in the village all his life earning a living through teaching and administration within
31 the local government. Wang Chung is 68 years old, is married and has two children. In addition to his
32 clerical work, Wang Chung maintains 14 *mu* of farmland, which is considerably larger than the average plot
33 size for Wanzhuang (8.35 *mu*), maintained by his wife when he works away. Wang Chung states that,

1 I had been doing the water works for many years before I left my village. I was confused at that time
2 thinking whether I should work outside. On the one hand, I was not sure about the income level of the
3 new job. On the other hand, I was still working on how to become an official [recognised by neighbours
4 and undertaking a specific role] worker in the village. But my sister-in-law told me that they lacked a
5 technologist and I happened to be free at home, I went to the building site and I get to know that they
6 would offered me a better salary. Therefore, I made the decision [to go] ... It was right. Now I get a much
7 better income (20140204 Interview Wang Chung).

8 The excerpt demonstrates the value in stretching livelihoods to exploit additional opportunities to boost
9 income. Wang Chung was able to convert the resources at his disposal: family connections to open up job
10 opportunities, the ability of his wife to manage the farmland, and the regular income from agricultural
11 activities enable him to pursue other livelihood activities by deploying his mobility endowments and
12 mobility entitlements. By using mobility to support the process of diversification Wang Chung has boosted
13 the household income and reduced his reliance on agriculture, therefore reducing the impact of variations
14 in yield due to weather-related shocks and stresses (such as those caused by floods and droughts) in his
15 home village. Furthermore, the networks and contacts he has developed will also help should he decide or
16 need to relocate to other areas. Finally, should his work outside of Wanzhuang end then he can fall back on
17 his farming and networks within the village and surrounding area.

18 As stated in section 3.1, the life history interviews were undertaken to generate data on significant events
19 within the respondents' lives and to understand if and how mobility featured. Interestingly, whilst the
20 climatic perturbations were discussed during the interviews they were not highlighted as a primary
21 motivator of mobility. Instead, the data present a more complex picture of mobility (and immobility)
22 decisions as multi-causal. The spectrum of mobility responses shows the role of the state, the importance
23 of family ties and social networks, individual ambition, and happenstance. Changing environmental
24 conditions are visible within the data but given form in indirect ways through, for example, decreasing
25 agricultural yields and the provision of remittances.

26 **5. Discussion**

27 5.1. Mobility as a means to diversify livelihood options and access locations unaffected by the climatic 28 perturbation

29 Literature on resilience of resource dependent communities frequently cites diversification as a key means
30 through which households can overcome shocks and stresses (Ellis 1998; Ellis 2000; Goulden et al. 2013;
31 Nguyen & James 2013; Bennett et al. 2014). In this study, households that have diversified through the use
32 of short-term mobility appear to be more resilient when compared to those households with members
33 practicing longer-term mobility as shown through self-perceived and externally-derived measures.
34 Although derived from small sample sizes, this finding contradicts assertions made in some previous studies

1 on links between farming and migration that infer a negative impact on productivity for shorter-term, more
2 circular migration (see, for example, Li & Tonts 2014). More broadly, the research suggests that the extent
3 to which longer-term mobility and diversification are assumed to result in positive outcomes for
4 households is less clear cut than sometimes portrayed (see, for example, Agrawal and Perrin 2009 and
5 Banerjee et al., 2017). As such, we recommend more research on these issues is warranted to understand
6 the extent to which these findings are replicated elsewhere.

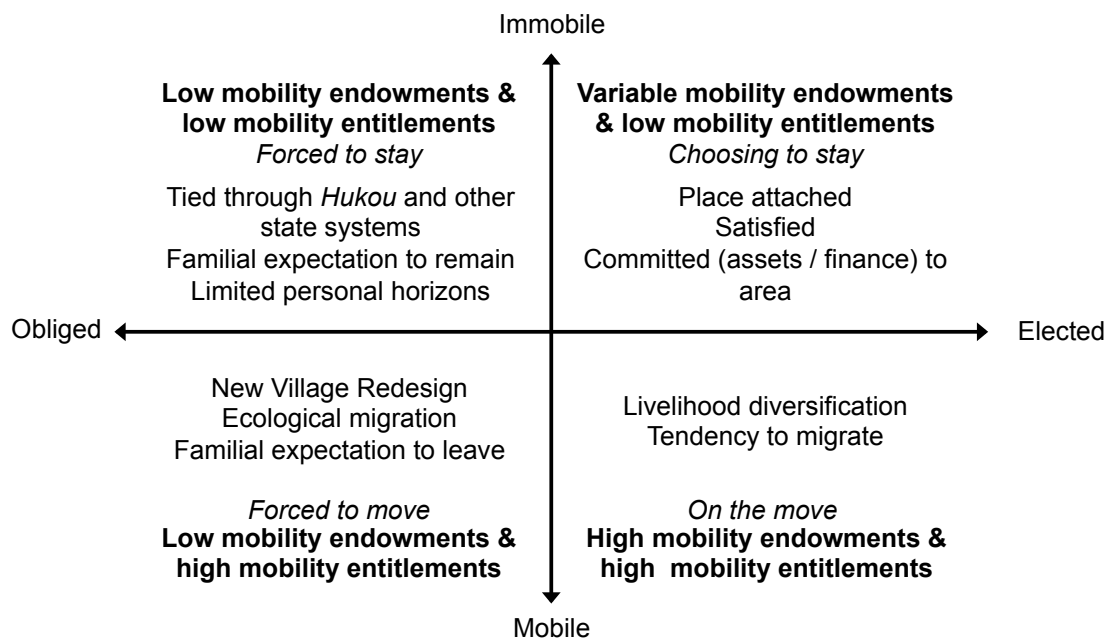
7 The difference between the households practicing short-term and long-term mobility in this case could
8 arise from the nature of the relations the household members retain with their rural home. A household
9 practicing more circular mobility appears well adapted to cope with livelihood shocks and stresses in the
10 village. The farm-related income provides an income base that serves to meet the subsistence needs of the
11 household. This income source is augmented by other non-farm activities that act as insurance when the
12 income from agriculture is disrupted. The resilience of that household is derived both from the diversity of
13 livelihoods practiced and an increase in the geographic area within which livelihoods are practiced.

14 Whereas, the impact of losing labour, in the form of longer-term out mobility, allied with the reluctance to
15 ask for substantial amounts of support reduces the ability of those households to sustain increases in yield,
16 as additional investment is reliant on remittances that may not be sufficient for the household's needs.

17 Households that are immobile, both in response to the climatic perturbation and more generally, also show
18 evidence of increased resilience when looking at self-perceived measures, although the picture is more
19 mixed when compared with the more mobile households when looking at the externally derived-measures.
20 These more immobile households appear to lack the means to invest in and improve their livelihoods owing
21 to the limited income that can be derived from a more exclusive reliance on agriculture. Béné et al. (2014),
22 in a review article examining poverty and resilience, refer to the notion of adaptive preferences whereby
23 people learn to live with poverty by suppressing wants and desires. In other words, the households reporting
24 greater increases in yields, finances and wellbeing, indicating greater resilience, may be expressing the
25 personal processes through which they have adjusted their expectations to cope with deteriorating
26 conditions and marginal improvements are considered much more positive than would be the case for
27 other households with greater levels of wellbeing.

28 5.2. Choice as a mediator of resilience

29 As shown through the example households, the way in which mobility is or is not used is strongly socially
30 differentiated. Households of similar levels of wealth and exposed to the same livelihood shock can and do
31 respond in very different ways which results in very different outcomes. Building on the work of Lister
32 (2004), Coulthard (2012) and Brown and Westaway (2011), we present in Figure 3 a taxonomy of mobility
33 showing differing levels of mobility endowments and entitlements. The figure is differentiated along two
34 axes: immobile to mobile and obliged to elected, reflecting movement and choice respectively.



1
2 Figure 3: Adapted taxonomy of mobility showing different levels of mobility endowments and mobility entitlements
3 with hypothetical examples based on the case study data.
4

5 *Low mobility endowments* relate to the rights to be mobile and include a small asset base limiting one's
6 ability to move, low levels of education hindering opportunities in other locations, issues associated with
7 state structures such as the *Hukou* and tied support, and the obligations placed on members of a family to
8 remain in the rural location to ensure an active claim on the land, whilst other members are more mobile.
9 Conversely, *high mobility endowments* are associated with those who have the financial means and good
10 levels of education to support mobility, a supportive family and social network, and the personal ambition
11 to move. Our understanding of *low mobility entitlements* relates strongly to the linked set of mobility
12 endowments. In cases where mobility endowments are low and one's right to move is constrained, then
13 one's ability to deploy mobility is minimal. Conversely, if one's mobility endowments are high then we can
14 infer that there is no wish to deploy their mobility entitlement and that person is more likely to be staying
15 put as they are place attached, satisfied or committed to the area in terms of investments, assets, or more
16 socially. As with low mobility entitlements, our understanding of *high mobility entitlements* is again
17 influenced by the linked set of mobility endowments. Cases where mobility endowments are low but
18 mobility entitlements high are likely to be associated with instances of forced mobility. In China this may be
19 due to instances of village reorganisation (the involuntary moving and grouping of 'old' villages into new
20 purpose-built villages in other locations) (Long et al. 2010) or ecological migration (Mao et al. 2012).
21 Alternatively, in instances where mobility endowments are high we can assume that the person is mobile
22 because they have a desire to be (for example to increase quality of life).

23 Referring to the examples provided previously, Wang Hong-Li is in the upper left quadrant with low
24 mobility endowments and low mobility entitlements. He is unable to be mobile even if it is desired and this
25 contributes to his low levels of resilience. Wang Zhou is located in the bottom left quadrant of the figure.

1 He was working in Shanghai until his father's illness obliged him to move back to Wanzhuang. To all intents
2 and purposes, this move was unwanted and was something that Wang Zhou felt obliged to do. Now that he
3 has relocated to his ancestral village he is reliant on farming and appears less resilient to climate-related
4 environmental perturbations. Lastly, Wang Chung is in the bottom right quadrant. His mobility appears to
5 be more elected and he has used it to diversify his livelihood with associated increases in levels of
6 resilience.

7 The typology is, inevitably, a simplified and static representation of people's lives and needs further
8 empirical evidence to test its applicability in other settings and contexts. Over time, households and
9 individuals will move between the different quadrants as is evidenced in the case of Wang Zhou. As a result
10 of his father's illness, he felt obliged to move back to his rural home (the bottom left quadrant), since
11 returning his ability to be mobile appears more constrained and he may now be located somewhere in the
12 upper left quadrant with low mobility endowments and low mobility entitlements. Further, whilst the data
13 presented have been primarily at the level of the household, considerable variation will exist within
14 households. For example, an increase in the mobility endowments and entitlements of some individuals
15 within a household cannot be assumed to be universally experienced by other individuals within the same
16 household (indeed, it may have the opposite effect).

17 We argue that those households at the elected end of the spectrum are more likely to be resilient (whether
18 by externally-derived or self-perceived measures) to livelihood shocks and stresses than those at the
19 obliged end of the spectrum and this applies regardless of a household's level of actual mobility. Despite
20 the more exploratory nature of the findings, they suggest the need to draw a theoretical distinction
21 between those who are able to be mobile but choose to remain immobile at one end of the spectrum and
22 those who are unable to be mobile (except *in extremis*) at the other end of the spectrum, highlighting the
23 need to look beyond simple outcomes (in this case mobility). Human actors are rarely just passive in the
24 face of change (or stability) and will seek to understand and prioritise certain behaviours based on their
25 understanding of the world around them (McLaughlin & Dietz 2008). In the case of immobile households,
26 the distinction between whether a household is trapped or voluntarily immobile is highly likely to influence
27 their level of resilience to shocks and stresses (Foresight 2011: 35).

28 Whilst there is a danger that the argument becomes circular in that households are trapped because they
29 are poor and they are poor because they are trapped, this is less likely within the Chinese context. The
30 influence of the state over one's ability to move, remains significant and is enacted through policy
31 instruments such as (but not exclusively) the *Hukou* system. The *Hukou* system links place of residence with
32 access to social welfare support, government employees' place of work is determined by the state, and the
33 state has the power to relocate whole villages if they are deemed unviable (in terms of the population).

34 Whilst the links between the *Hukou* system and welfare support will impact more so on those households

1 living in poverty, the other two examples can apply just as much to households that are considered wealthy
2 as those that are considered poor.

3 5.3. Methodological innovations and study limitations

4 China's politics and institutional architecture play a central role in the lives of its citizens. In relation to
5 migration, Deshingkar (2005) argues that the diversity of movement patterns is historically, socially and
6 culturally specific. In a similar vein, the influence of the *Hukou* system, as an institutional barrier to
7 mobility, is commonly acknowledged as profound in spite of the reforms over the last 30 or so years (Cai
8 2003; Chan 2011). More generally, the continued importance of other socialist era instruments of state
9 control is a point commonly acknowledged by scholars writing on China including Zhang (2008), Fan (2004)
10 and Chan (2010). These examples demonstrate the need for theoretical and methodological approaches
11 that are able to understand or explain the changes in modern China (Zhang 2008). Our findings bear this
12 out in relation to mobility, choice and resilience and demonstrate the need to design and implement
13 research that is sensitive to the prevailing social, political, cultural and economic context within which the
14 research is taking place.

15 The mixed methods approach used in this study reveals differences between self-perceived and externally-
16 derived measures of resilience and how they relate to mobility as well as generating insights concerning the
17 multi-casual nature and complexity of mobility decisions. Mixed methods approaches have rarely been
18 used to measure social resilience to date and, in this case, generate useful insights methodologically and
19 empirically. More generally, the mixed methods approach provides a rich understanding and appears
20 particularly suitable for exploring complex phenomenon such as those under study in this research
21 (Bryman, 2008: 629 - 652; Gray, 2014) and for examining a role for more subjective evaluations of resilience
22 based on self-reporting (Béné et al. 2016; Jones & Tanner 2017). One of the main limitations of the study
23 was the small sample sizes within the analysis of subsets of data of the household survey (especially when
24 the data were disaggregated at a sub-village level) that precluded the use of a range of statistical analysis
25 techniques. In these instances, we have been cautious not to over-generalize across populations in other
26 contexts.

27 **6. Conclusion**

28 In the study here mobility has increased the resilience of some individuals and households in general and in
29 regard to specific climatically-linked environmental changes. The results suggest that the use of mobility
30 constitutes an adaptive response to constrained livelihood opportunities in an economically and
31 ecologically marginal location. In this case, mobility has enabled individuals and households to diversify
32 their livelihoods and exploit opportunities for boosting income. In so doing, individuals and households
33 have increased the number of potential locations they can utilise to generate livelihood opportunities,
34 some of which may be outside the area physically affected by the weather driven shock or stress. These

1 findings show that households use multiple locations, often concurrently, as part of their portfolio of
2 livelihoods to manage and cope in times of stress. If these findings hold in other locations then, attempts to
3 understand place-specific risks have insufficiently engaged with the complex reality of this translocal
4 householding and what that means for how households utilise and derive benefits from different locations
5 (Harvey 1989; Deshingkar & Grimm 2005; Bakewell 2007; Collyer & King 2014).

6 This study shows that resilience and wellbeing are not always mutually reinforcing and suggests a need for
7 further research on their relationship. For example, individuals and households that were living in
8 conditions of poverty were potentially adapting down their preferences or limiting their expectations.
9 These actions suggest that in some cases individuals invest in resilience at the expense of wellbeing and
10 highlights the fallacy of assuming that greater resilience is beneficial to wellbeing. Hence our findings align
11 with Béné et al., (2012) and others who argue that increased resilience does not necessarily lead to a
12 reduction in poverty. Caution is needed therefore, when seeking to build resilience to ensure that
13 wellbeing is also enhanced rather than compromised.

14 In summary this study suggests that wellbeing is affected by more than mobility outcomes in the context of
15 environmental change. Mobility through choice appears more likely to result in positive outcomes than
16 mobility if it is obliged or forced. Similar findings apply to immobility with those remaining immobile
17 through choice more likely to realise positive outcomes compared to those who trapped in place. Whilst
18 the findings are generated in specific cultural and economics contexts, we argue that the motivations for
19 moving or staying and the ability to make that choice and how that choice is realised, are crucial
20 everywhere in determining the impact of the movement on lives and livelihoods. Hence this research
21 points to a new frontier of relating wellbeing to individual intentions and their lived realities in the context
22 of mobility decisions.

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