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Chapter 7

Seasonal livelihoods and adaptation strategies for an uncertain environmental future: Results from participatory research in Kratie Province, Cambodia

Savuti Henningsen, Natasha Pauli and Chanchhaya Chhom

Abstract

The effects of environmental change are becoming more noticeable in the Lower Mekong Basin, where there is growing pressure on the agriculture-based livelihoods of communities living along the mainstream of the Mekong River. This chapter presents an investigation of temporal seasonal variability in four communities of Kratie Province, Cambodia, including identification of locally developed strategies to adapt to temporal changes in weather patterns. A mixed methods approach was adopted, combining historical hydrometeorological data with participatory seasonal calendars and daily routine diaries. Seasonal calendars were compiled from nine workshops across four villages in Kratie Province, and daily diaries were collected from seven individuals across three villages. The results indicate that patterns in rainfall, flooding, and drought have become more variable due to the impacts of environmental change; a phenomenon that will likely continue into the future. Without effective, locally appropriate adaptation measures, changing weather patterns will likely continue to have adverse impacts on communities in the region due to their reliance on reliable seasonal rainfall and flooding events for crop cultivation. Households and communities in the study region have already developed a number of approaches to mitigate adverse impacts of environmental change. This research also reiterated the importance of incorporating both local knowledge and scientific data to gain the most accurate understanding of the impacts of environmental change in a given region.

Key words: Mekong River; Cambodia; seasonal variability; local knowledge; gender; climate change adaptation

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Introduction

Over the last decade, the impacts of environmental change[1] on livelihoods in developing countries have become more pronounced (Piya, Maharjan, & Joshi, 2019). In particular, the Lower Mekong Basin (LMB) region is expected to be significantly impacted by environmental change, with climate change models projecting increases in seasonality, severe flooding and drought events (Doch, Diepart, & Heng, 2015; Hoang et al., 2016; Kingston, Thompson, & Kite, 2011). While the aggregated effects of climate change have often been emphasised (such as an increase in annual average temperature, or declining in average annual rainfall), the impacts of environmental change on temporal variability in weather events are important, particularly in communities that have close relationships between seasonal patterns and livelihoods (Mainuddin, Kirby, & Hoanh, 2013; Poulton, Dalgliesh, Vang, & Roth, 2016). The research presented in this chapter seeks to understand these finer-scale variations in seasonal weather patterns, both within and between years, reflecting on 'typical' conditions as well as changes that may be outside the scope of 'normal' variability.

The ways in which communities have adapted historically, and continue to adjust to environmental change is of significant importance to current research, with a strong emphasis on acknowledging and prioritising local knowledge and experience (Mainuddin et al., 2013). In recent years, mixed method approaches incorporating both quantitative and qualitative means of gathering data have been employed to aid in understanding the dimensions of environmental change in areas that may be 'data-poor' but are also 'knowledge-rich' (Bernard, 2006). These methods often incorporate a gendered aspect to ensure that the data are representative of a wide range of experiences (Carr & Thompson, 2014). This investigation aims to explore the temporal variability in weather-related natural hazards and the subsequent adaptation strategies pursued by local communities in the LMB, with an emphasis on understanding strategies across a spectrum of village, livelihoods and individuals.

Environmental change and temporal variation

Variations in the weather resulting from climate change have become an increasingly important focal point globally. This variability can be partitioned into temporal and spatial variation from established 'average' or typical conditions. Temporal variation can be further divided into short and long-term variation, or in other words, seasonal and inter-annual variation (Chen, Hu, & Yu, 2005). The temporal aspects of environmental change will likely be just as important as the overall magnitude of change (Sowjanya, Reddy, & Shashi, 2018). Understanding both the seasonal and inter-annual variation resulting from environmental change is a crucial aspect in quantifying the current and future impacts of change and planning for its management (Nam, Hong, & Choi, 2015). For instance, a recent analysis of rainfall and drought records in Southeast Asia stretching back over 350 years indicated a high degree of variability and uncertainty in the effects of the El Niño Southern Oscillation, with the authors recommending that future planning for climate change adaptation must embrace this

[1] In this chapter, 'environmental change' refers to the combined effects of climate change and other anthropogenic drivers such as (but not limited to) land use change and alterations to river flow regimes through dam construction and reservoir operation. Hydropower dams are leading to significant biophysical change along the Mekong River (Piman, Lennaerts, & Southalack, 2013; Pokhrel et al., 2018).

uncertainty and complexity, and consider how societies have coped with, and persevered through, extreme conditions in the past (Räsänen, Lindgren, Guillaume, Buckley, & Kummu, 2016). Effective planning and management will likely result in the development of locally appropriate adaptation strategies, thus limiting the impacts felt by communities (Holzkämper, Calanca, & Fuhrer, 2011).

Adaptation and environmental change

Among many varied definitions, adaptation can be framedis defined as the adjustment of natural or human systems to a new or changing environment, and has come to the forefront of discussions surrounding environmental change in recent years (Evers & Pathirana, 2018). Human adaptation to climate change encompasses the ability to change and adapt behaviours to meet current conditions, while simultaneously developing strategies to mitigate the impacts of expected environmental change in the foreseeable future (Evers & Pathirana, 2018). The concept of adaptation has become a focal point in global conversations, particularly with respect to the predicted impacts of climate change in developing countries, particularly within the agricultural sector (Sovacool, Amp, Agostino, Meenawat, & Rawlani, 2012).

The process of adaptation to environmental change can occur on different scales ranging from individual, regional, sectoral, national, and global settings (Bryan, Deressa, Gbetibouo, & Ringler, 2009). Adaptive responses are also said to include autonomous responses and conscious adaptation (Dang, Li, Nuberg, & Bruwer, 2014). Autonomous responses can include irrigation, crop diversification or altering the agricultural calendar, while conscious adaptations are generally understood as government intervention strategies and public policies (Dang et al., 2014). Adaptive responses can also be categorised into short-term and long-term responses and have been shown to be impacted by socio-economic factors and resource availability (Below et al., 2012).

To understand and record the impacts of environmental change and subsequent adaptation strategies developed by individuals and communities, it has become increasingly important to include components of scientific and local knowledge (Mercer, 2010). There often areas of synergy and overlap between different forms of knowledge, as well as many ways in which different forms of knowledge may complement and support each other (Hiwasaki, Luna, Syamsidik, & Shaw 2014; Raymond et al. 2010). Research has indicated that when local communities are actively involved in research the information gathered leads to a deeper understanding of the situation, particularly with respect to community adaptation (Fazey et al., 2010). Community involvement also has the potential to be beneficial in terms of future management, as the two-way relationships built during the process pave the way for future endeavours (Raymond et al., 2010).

The Mekong River and Cambodia

The Mekong River forms the largest river basin in Southeast Asia and spans six countries (Lauri et al., 2012). The resources provided by the Mekong are less understood and developed in comparison to other large river basins around the world (Evers & Pathirana, 2018). The Lower Mekong Basin (LMB), which incorporates parts of Myanmar, Laos, Thailand, Cambodia, and Vietnam, is said to be the most productive and ecologically diverse

river basin in the world; supporting an estimated 60 million people (Mainuddin et al., 2013). By 2060, the total population in the LMB is predicted to reach 83 million (Evers & Pathirana, 2018).

The majority of the residents of the LMB are strongly dependent on the resources provided by the Mekong to sustain their livelihoods, as food security is closely tied to the river through agriculture, fisheries, and hydropower (Sok & Yu, 2015). Over time, residents have adapted their livelihoods, particularly their agricultural systems, to the ebb and flow of the Mekong's seasonal flood regime (Sok & Yu, 2015). The health of the LMB is under threat due to significant flow regime changes resulting from the combination of anthropogenic stressors and climate change (Dugan et al., 2010). These anthropogenic factors include but are not limited to the development of hydropower stations, deforestation, unsustainable fishing practices, and large-scale irrigation schemes (Eastham et al., 2008; Grumbine & Xu, 2011). These stressors are predicted to become more significant and result in more visible impacts on the Mekong over time.

The Mekong Basin is also predicted to be adversely impacted by climate change (Ziv, Baran, Nam, Rodríguez-Iturbe, & Levin, 2012). Modelling undertaken by Kingston et al. (2011) and Västilä, Kummu, Sangmanee, & Chinvanno (2010) projects that the discharge of the Mekong will decrease between 5.4 and 4.5 percent annually. An increase of 1°C in night temperatures could reduce rice grain yield by 10% (Peng et al., 2004), having a negative impact on the Mekong's residents who rely on rice-based agriculture (NCCC, 2013). The impacts of environmental change are influencing the LMB's weather and have resulted in significant flood regime shifts that are projected to continue into the future (Junk et al., 2006; Keskinen et al., 2010). Changes to the Mekong's flow regime are expected to have significant repercussions for the basin's major functions including: reductions in aquatic productivity, inhibition of riverine transport, reduced availability of freshwater, and lowered agricultural productivity (Eastham et al., 2008; Lauri et al., 2012; Mekong River Commission, 2010). Current projections for future environmental change highlight the vulnerability of rain-fed rice agriculture in the LMB, with increased seasonal variability set to continue (Jiang et al., 2019).

Cambodia is predicted to be particularly adversely impacted by environmental changes due to low levels of resilience and adaptive capacity related to high levels of poverty (Doch et al., 2015). Cambodia's vulnerability to environmental change is predominantly driven by the combination of environmental and socioeconomic factors. Exposure to natural hazards alongside poverty, inequality, and a high dependence on natural resources aggravate the impacts of climate change on Cambodian households (Arias, Holtgrieve, Ngor, Dang, & Piman, 2019). In recent years, attaining food security has become challenging in many rural communities due to an increase in seasonal variability in combination with an increase in severe floods and droughts (Arias et al., 2019). In response to these predicted threats, the Cambodian Government has developed a Climate Change Strategy Plan for 2014-2023, the aim of which is to: "…Create a national framework for engaging the public and private sector, civil society organizations and development partners in a participatory process for responding to climate change to support sustainable development" (NCCC, 2013). This plan also emphasises the importance of mainstreaming gender with respect to climate change planning, to ensure that women's experiences are taken into account in adaptation planning.

Gender roles and Cambodia

Over the last two decades, the importance of gender equity has gained momentum worldwide, particularly in the agricultural sector in developing countries where women comprise half, or more than half, of the workforce (Ogawa, 2004). Women comprise 51.8% of the 13.8 million residents in Cambodia, representing 51.6% of the economically active residents, and heading 25.7% of households (NIS, 2013). Moreover, Resurrección and Boyland (2017) found that Cambodian women own approximately 65% of all registered businesses in the country.

Within rural Cambodia, women farmers comprise 55% of the farming population and their importance in rural development has long been emphasised by the Government and in academic circles (Ogawa, 2004). The Cambodian Climate Change Strategic Plan (NCCC, 2013) denotes that the rural poor of Cambodia, the majority of whom are women, are most vulnerable to the impacts of environmental change due to their significant reliance on agriculture and natural resources. As women comprise more than 50% of the Cambodian population and in some circumstances may be disproportionately at risk to the impacts of environmental change, it is important to actively seek out and include women's experiences to inform future policies and plans to facilitate adaptation and gender mainstreaming.

Research aim and objectives

A number of studies have been undertaken in Cambodia, investigating the changes in the frequency and intensity of extreme climate events associated with environmental change (Jiang et al., 2019; Kingston et al., 2011; Lauri et al., 2012). However, the documentation and understanding of adaptation is still notably limited particularly on relatively small scales (Evers & Pathirana, 2018). It is for this reason that there is a need for research integrating both the scientific and local knowledge surrounding the adaptation strategies developed in response to continued environmental change in Cambodia. The overarching aim of this research is to investigate the impacts of temporal variation resulting from environmental change using the four villages in Kratie, Cambodia as a case study. This research incorporates three main objectives, as follows:

(1) To assess historical temporal variability in rainfall and weather-related natural hazards for the region

(2) To characterise seasonal and inter-annual variability in livelihood strategies and identify critical periods for decision; and

(3) To highlight strategies employed by community members and individuals to adapt to predicted changing environmental conditions.

Methods

Study site

This research focused on a region south of the town of Kratie in the province of Kratie, approximately 300 km north-east of the capital Phnom Penh. Kratie province is among the

most disaster-prone provinces in the country, and is frequently affected by damaging floods. Between 1996 and 2017, flooding in the province adversely affected over 500,000 people, damaging nearly 2,000 houses and destroying extensive areas of crops (Neef et al. 2020). In the most recent census, the population of the province was 344,195 people, with just over 70% living along the Mekong (NIS, 2013). The majority of residents obtain their livelihood from subsistence agriculture based predominantly on the cultivation of rice and corn, alongside raising livestock and fishing; all of which are highly impacted by changes in the flood regime (Mekong River Commission, 2010).

The communities in this region have adapted not only their agricultural practices but moreover, their entire livelihoods around the seasonal monsoon. Plate 7.1 shows a traditional homestead for the region built on stilts to cope with the anticipated seasonal flooding. Historically, the first rice crop of the year is rainfed and grown at higher elevations to avoid damage from floods, and the second crop is grown after the floodwaters recede, relying predominantly on moisture stored within the fine-grained clay-rich soils, and supplementary irrigation from nearby wetlands and the Mekong River itself.

The four villages included in the study (Thma Reab, Ou Lung, Dei Doh Kraom and Kbal Kaoh, as shown in Fig. 7.1), are within Prek Prasob district, which is one of the most severely flood-impacted districts within Kratie province. The district encompasses eight communes and 48 villages. The four study villages were located in close proximity to the Mekong, with Kbal Kaoh being situated on an island (Koh Tasuy) in the middle of the river. The villages were selected as a representative cross-section of villages within the most severely flood-affected part of Prek Prasob district, covering a range of socio-economic and physiographic characteristics.

Plate 7.1. Traditional-style homestead in Thma Reab. Source: Authors' own.

The living areas for this house are elevated to give the residents and their belongings a degree of protection if floodwaters enter the village. Not all residents are able to construct elevated houses, as shown by the house at right which is only slightly raised from the land surface.

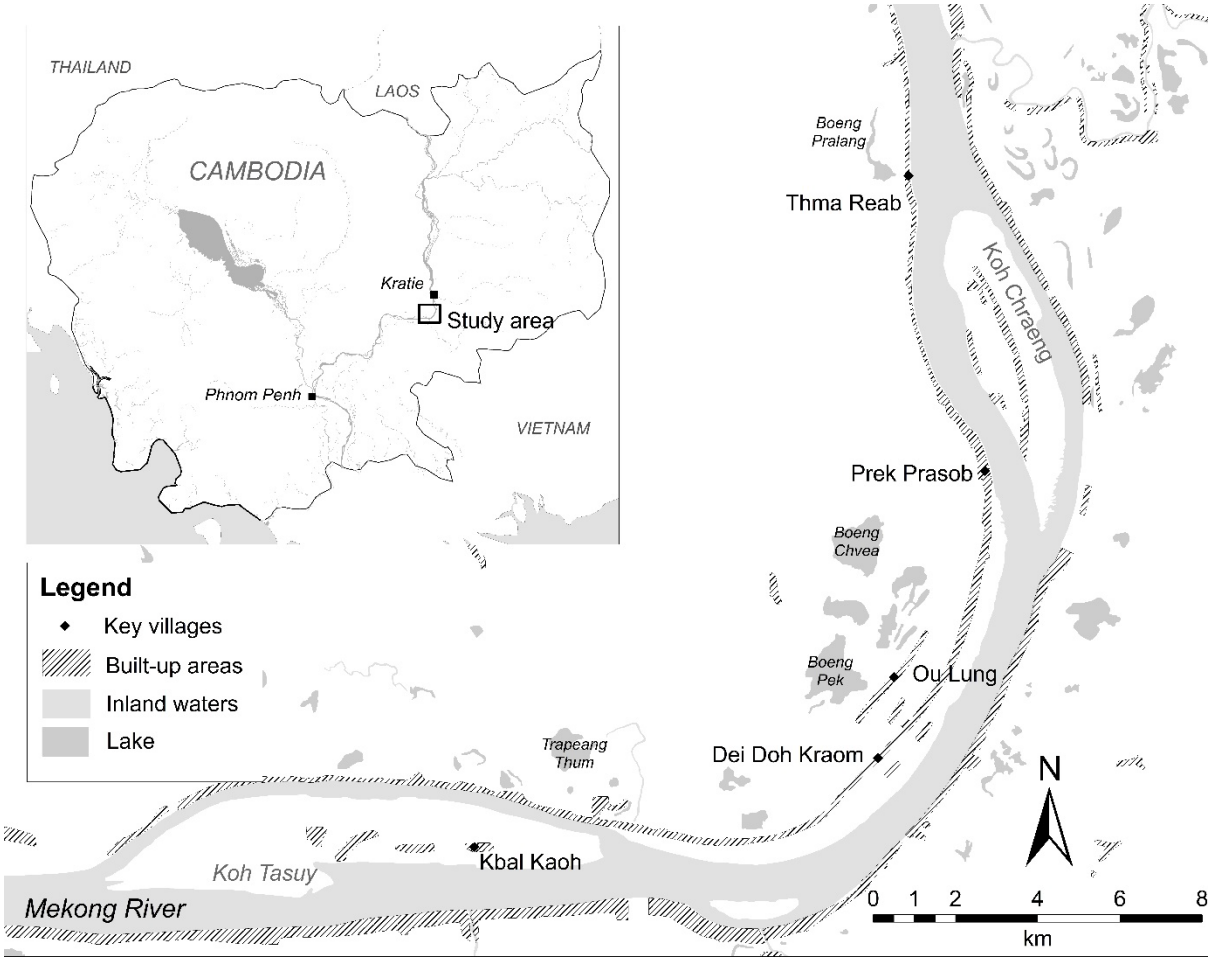

Fig. 7.1. Map of the study area showing village locations and built up areas. *Source:* Williams, Pauli, & Boruff (this volume)

Prek Prasob is the largest settlement in the district and location of the district government. Numerous other villages are located within the regions marked as built up areas.

As shown by the linear built up areas mapped in Fig. 7.1, there are no distinct physical boundaries between villages; village boundaries are administrative and encompass a defined number of households within each village. Villages as a unit are closely linked to administrative goals from colonial and post-colonial periods (Oveson, Tranke, & Öjendal, 1996), although kinship and patronage relationships and networks are still central to village life (Ledgerwood and Vighjen, 2002; Thon, Ou, Eng, & Ly, 2010). In Cambodia, there are strong tendencies to work towards the collective good of the group or village (Chan & Chheang, 2008). Ledgerwood and Vighjen (2002) detail six complex, interlocking domains of influence and power that work together to make Khmer villages function as a unit, encompassing administration, religion, knowledge, spiritual leadership, wealth, and development assistance, each of which have different patrons and power-brokers. With respect to administration, each village has a leader and deputy, appointed by the commune councillors. Commune council elections have been held since 2002 under the Cambodian programme of decentralisation (Thon et al. 2010). Village leaders play an important role as gatekeepers between the villagers (who are also voters) and the commune council, and hold influence in decisions concerning village and

commune activities (Kim, 2010). Commune councils make decisions around administration and development goals, and are responsible for Commune Development Plans (Chhoeun, Sok, & Byrne, 2008), which are developed through village-level consultation and often include components around infrastructure and climate change adaptation (BenYishay et al., 2019; Carter & Sok, 2013).

With regard to infrastructure, including electricity, access to clean water, and road access, Kbal Kaoh had the most developed infrastructure, and Ou Lung had the least developed, with the other two villages intermediate. In Kbal Kaoh all residents had functioning solar panels and access to clean fresh water supplied by a water treatment plant developed by the NGO Lien AID (Ye, 2017). Moreover, Kbal Kaoh had a relatively well-maintained main road and access to a ferry port on both the eastern and western sides of the island. Thma Reab and Dei Doh Kraom demonstrated similar levels of infrastructure with some members of the community having access to power, water and the main road (which was reasonably well maintained). Dei Doh Kraom was the largest community with diverse businesses, markets and schools. Finally, Ou Lung was observed as the least developed in terms of infrastructure, with almost no residents having access to electricity and only relatively wealthy residents having access to well water. Furthermore, Ou Lung was also located a significant distance off the main road, which runs south along the Mekong between Thma Reab and Dei Doh Kraom, thus making it less accessible.

These four villages are also notably variable with respect to topography, with Thma Reab and Dei Doh Kraom situated at comparatively high elevation for the region, on the natural levee of the Mekong. The village of Ou Long was closer to the backswamp and at a lower elevation away from the higher natural levee of the riverbank. Historically, Thma Reab and Dei Doh Kraom have not experienced flood inundation on an annual basis, however, Ou Lung floods almost every year. Finally, the village of Kbal Kaoh is also located on reasonably low-lying land on the island of Koh Tasuy in the middle of the Mekong, with the majority of this island submerged annually by floodwaters. The study villages consisted of approximately 100-200 households, with around 3-4 people per household, with the exception of Dei Doh Kraom which had around 350 households and an estimated 1000 residents.

Research Approach

The methodology developed for this investigation combined local and scientific knowledge in the context of understanding the temporal variability in weather-related natural hazards and adaptation strategies pursued by local communities in the four study villages (Fig. 7.2 provides a graphical representation of the approach). The data required for this investigation was obtained using a mixed methods approach, combining quantitative and qualitative approaches (Creswell & Plano Clark, 2017). This included a desktop analysis of relevant quantitative secondary biophysical data and a fieldwork component comprising qualitative seasonal calendar workshops and individual daily routine diaries. Interpretation of qualitative information was used to identify local adaptation strategies in line with Agrawal and Perrin's (2008) framework for understanding risks to rural livelihoods, following the example of Neef et al. (2018).

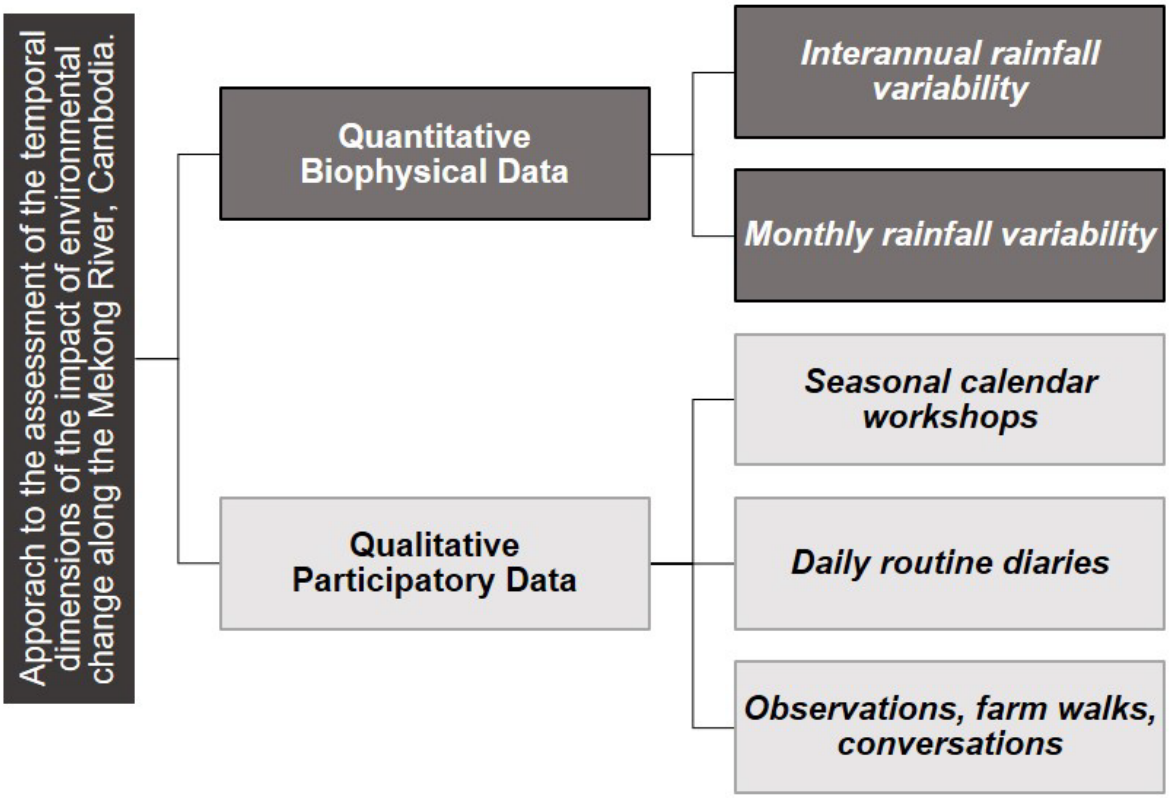

Fig. 7.2. An overview of the methodological approach adopted in the research presented in this chapter.

Quantitative biophysical data

All hydrometeorological data analysed in this report were drawn from the PERSIANN-CDR; a global gridded (0.25° × 0.25°) dataset of weather observations developed by NOAA (Sorooshian, Hsu, Braithwaite, & Ashouri, 2014). This data set provides daily, modelled weather observations for the latitude band 60°S–60°N. We chose a location for the gridded data output concordant with the village of Dei Doh Kraom, Cambodia. Prior to analysis, all data was cleaned, and all subsequent analysis and graphics were created using RStudio (Rstudio Team, 2015).

Qualitative data gathered through participatory processes

Seasonal calendar workshops: Workshops around the timing of key livelihood activities and hydrometeorological events were conducted in each of the four communities. Two workshops were conducted in Thma Reab, Ou Lung and Kbal Kaoh and three workshops were conducted in Dei Doh Kraom. All workshops were conducted in Khmer, facilitated by Cambodian research assistants from the Royal University of Phnom Penh under the guidance of the authors. The workshops were run as semi-structured focus groups centred around an A0 size seasonal calendar, as illustrated in Fig. 7.3 (Bernard, 2006). To assist in the translation and accuracy of the information gathered, small visual cards were used with an illustration or photo of a particular crop, animal or event, as well as both the English and Khmer words.

Each workshop had between eight and twenty participants and was usually conducted in or around the village leader or deputy leader's house. The majority of the workshops were held outside, either below the house, or in an open area, and were therefore accessible to anyone passing by. A small number of workshops were held inside homes and typically had fewer attendees. The workshops ran for approximately 60 to 90 minutes, and participants were invited to attend by the respective village leader. At each workshop there was a minimum of one researcher (the authors), and one Khmer-speaking research assistant. The researcher acted as a note taker and session facilitator, posing guiding questions to keep the group on task. The research assistant/s acted as translators and filled in the seasonal calendars in Khmer based on instructions from the members of the focus group. Originally, the workshops were intended to be split along gender lines, with at least one workshop per village focusing on men, and one on women. However, upon arriving in the villages there was a clear sense from participants that women and men worked together in many endeavours, and the researchers did not wish to exclude community members who wanted to participate in the workshops. In practice, this meant that some workshops where the invitation by the village leader was for a 'women's workshop' or 'men's workshop' ended up also including members of the opposite gender, with a bias in participant numbers towards either men or women (as advertised), while a small number of workshops ran with a more even split along gender lines. The seasonal calendars that were generated within sessions in each village were very similar, with no substantive differences noted among outputs from different sessions.

Fig. 7.3. Seasonal calendar workshop format and example output. Source: Authors' own.

The images within the composite area: (A) discussing the calendar during a focus group predominantly attended by women in Thma Reab; (B) a mixed gender focus group in Kbal Kaoh and (C) an example seasonal calendar developed during a workshop in the village of Dei Doh Kraom.

The semi-structured focus group technique was implemented with the aim of allowing the participants to steer the conversation in the direction they felt was most important for their own livelihood, while still allowing the researchers to redirect the group when necessary (Gero, Méheux, & Dominey-Howes, 2011). Each workshop commenced with a discussion surrounding the general rainfall and flood regime that participants expected and whether 2018 was notably different. The discussion was then focused on important livelihood activities particularly with respect to agriculture, and when these activities were undertaken. Discussions around adaptation measures, coping strategies and noted changes in weather and climate were often raised during the focus group sessions. The responses from the focus group were reviewed for recurrent patterns and themes. A seasonal calendar was created for each village, by collating information from all workshops within a particular village.

Daily routine diaries: The fieldwork component of this research also included the creation of opportunistic daily routine diaries with women in three villages. This method was pursued as a means of gathering more detailed livelihood data, as the seasonal calendar sessions were not capturing as much gender-specific information as anticipated. Williams (2016) found that women in this region generally spoke more often about adaptation activities than men, prompting an interest to understand on a more individual level how women are affected by temporal environmental change. Moreover, these diaries were conducted with women due to the fact that most previous research in this area engaged in one-on-one conversations primarily with the village leaders and deputy leaders, of whom most, but not all, were men. The daily diaries were often undertaken directly after a seasonal calendar workshop if any participant was willing to stay behind for a further discussion. These were typically conducted on an individual basis and lasted under 30 minutes. In total, seven daily routine diaries were collected, two in Ou Lung, and three in Dei Doh Kraom and Kbal Kaoh respectively. The participants ranged from 28 to 60 years old, all having at least one child and having been married. The purpose of gathering the diaries was to gain a deeper understanding of the types of activities the residents participated in and how they were impacted by seasonal flooding and drought.

Observations, farm walks and structured conversations: Alongside the more formal qualitative methods used for gathering data, the authors also took part in farm walks and traverses with local community members, made observations during time spent in the villages (data were collected over a two-week period where the researchers stayed in, or in close proximity, to the study villages), and engaged in structured conversations with local leaders. Structured conversations took place at an opportune moment for the village elder, leader, or deputy leader, and often included an overview of the village history, the impacts of recent floods or droughts, and views of what the future might hold.

Findings I: A region of inherent variability in rainfall patterns

Temporal analysis of average inter-annual rainfall

Over the last 34 years, the total annual rainfall (average: 2167 mm) in Dei Doh Kraom, Cambodia fluctuated from year to year, as expected for this region. Over time, the residents have shaped their livelihoods, particularly their agricultural systems, to take into account fluctuations in rainfall volume, developing various methods to aid in decision making based on that year's conditions (Sok & Yu, 2015). However, from 2012 onwards, these fluctuations have become more prominent and have more regularly exceeded one standard deviation (380 mm) from the mean (Fig. 7.4). This is a notable amount of variation, particularly if one takes into account the relative frequency in which the average rainfall has exceeded one standard deviation in recent years. In particular, 2017 showed a substantive reduction in rainfall almost two and a half standard deviations from the mean, equating to a loss of over 40 percent of the region's annual rainfall (Fig. 7.4).

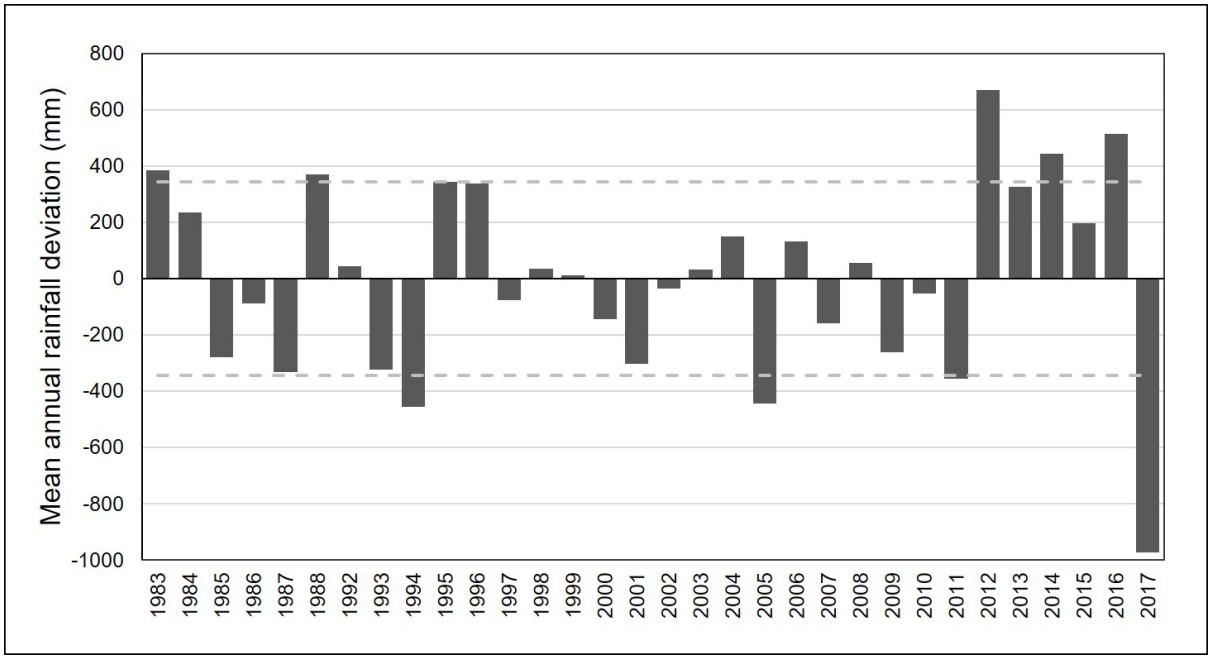

Fig. 7.4. Annual average rainfall deviation from the mean (2167 mm) for the study area near Kratie, Cambodia from 1983 to 2017.

Dashed grey lines depict one standard deviation from the mean. Data for 1989-1991 were excluded due to anomalies in the data. Data source: Sorooshian et al. (2014)

Analysis of temporal monthly rainfall variation

Whilst the wet monsoon falls between the beginning of May and late October, it is also important to note that this region experiences rainfall in most months of the year. Monthly rainfall is highly variable within each year, as well from year to year. Fig. 7.5 illustrates variability in monthly rainfall for the study area. The average rainfall patterns follow a roughly unimodal distribution peaking in August and September. A more detailed examination of monthly rainfall for one of the driest years recorded (2017) indicated that there were still high levels of rainfall in May, August, and September. However, there was a clear lack of rain in June and July contrary to the expected rainfall pattern for the region, changing the distribution to a bimodal one. The rainfall pattern for 2017 was highly variable and inconsistent with the expected rainfall flow for the region. In comparison, in the wettest year (2012) recorded between 1983 and 2017, there was a notable increase in rainfall in January and February due to a prolonged rainy season in 2011. There is was also considerably more rain recorded for August and October relative to average conditions.

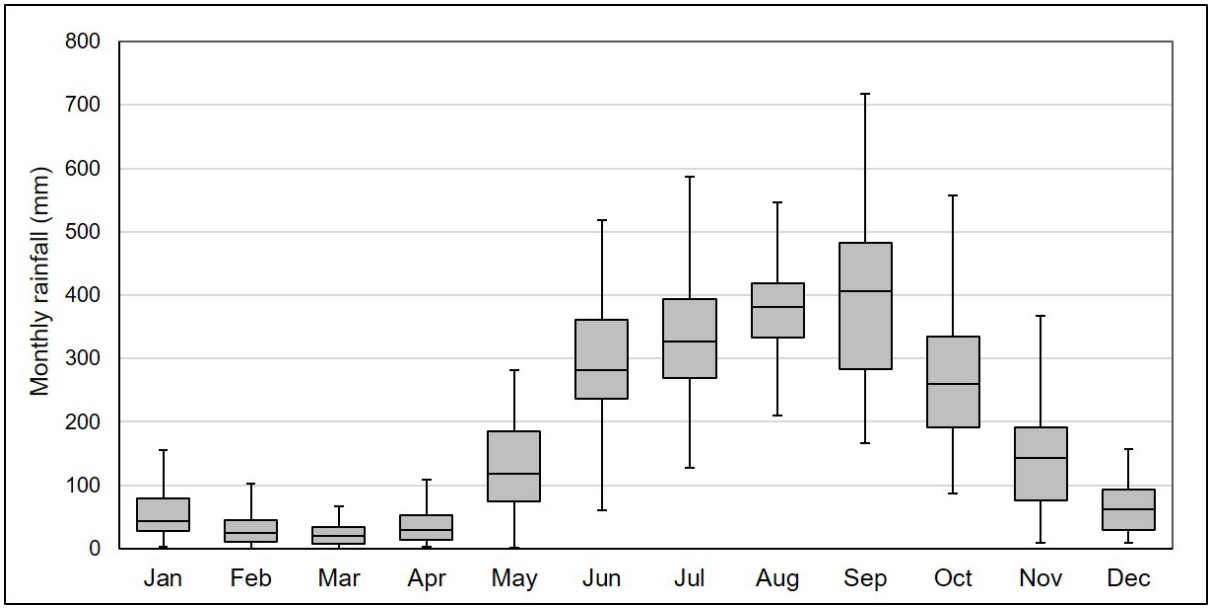

Fig. 7.5. Representation of average monthly rainfall variability in the study area near Kratie, Cambodia between 1983 and 2017.

The boxes represent the 25-75 percentile range of monthly precipitation values, with the solid bar depicting the median value. 'Whisker' bars represent the range; outliers have been removed. Data source: Sorooshian et al. (2014).

Significance and interpretation

The quantitative data outlined above supports the predictions of environmental changes for the region, in that rainfall, flooding, and drought-like conditions have increased in variability and are likely to increase in variability and intensity in the future (Dang et al., 2014; Dugan et al., 2010; Eastham et al., 2008; Evers & Pathirana, 2018). The increased variability in rainfall, timing of the wet season rains, and reduction of rains outside this period were also noted by members in all four of the communities during field research. Many of the residents noted that changes in seasonal variability of the floods have already begun to impact their livelihoods. In 2018, the floods commenced early (mid-June) and rose rapidly in under two weeks due to a dam failure upstream in Laos. Subsequently, members of the communities in Thma Reab, Ou Lung, Dei Doh Kraom and Kbal Kaoh stated that they had lost large proportions of their wet season crops, leading to a significant and detrimental loss of income on both an individual and community scale. During the workshops in all four villages, residents also highlighted that the flood waters receded faster than expected and indicated that they were currently (in November 2018) experiencing the impacts of drought-like conditions, predicting that their dry season crop would also show a decrease in yield. Previous research has also shown that continued changes in the seasonality of major hydrometeorological events in the region will likely have negative impacts on the number and variety of crops that can be cultivated in the region (Chung, Takeuchi, Fujihara, & Oeurng, 2019). Overall, this desktop analysis alongside supporting scholarly literature and community perceptions lends support to the notion that the long-standing flood patterns on which residents of this region rely, have increased in variability both on a seasonal and inter-annual scale.

Findings II: Rural livelihoods adapt to seasonal variability and environmental change

Seasonal calendars and key decision-making periods

The seasonal calendars developed during focus group workshops were focussed around a *typical* year for each location. Participants were invited to discuss major hydrometeorological events, as well as different agricultural and fishing activities undertaken during the year. In this section, we present the detailed calendars compiled for each of the four villages, together with an explanation of key points. This level of detail, provided by the research participants, may be valuable to others working in the field, as well as a helpful reference for planning purposes. There are some similarities across the four villages, particularly those villages on the mainland that incorporate rice cultivation as a mainstay of agricultural production.

Thma Reab. The major hydrometeorological events depicted by the residents of Thma Reab closely follow the average rainfall patterns in the previous section (Fig. 7.5), similarly to residents in the other villages studied. Around 80% of the households in Thma Reab are involved in agriculture, which is focussed on the cultivation of rice, maize and cassava, with an expanding area of tree crops (particularly cashew and mango) in upland areas providing opportunities for income through sharecropping, as hired labour, or by owning trees. Special techniques are used to allow for two crops of mangoes during the year; mangoes command a higher price in the 'off-season' of November-December and can be sold to international buyers; the ordinary fruiting period is in March-April.

The seasonal calendar (Table 7.1) illustrates the timing of various agricultural activities in Thma Reab in a 'typical' year. In ideal conditions, two crops of rice and two crops of maize are grown per year. 'Wet rice' is planted with the onset of monsoon rains at higher elevations that are unlikely to flood, and is rainfed, with a similar pattern for 'wet maize'. The variety of rice that is planted depends on when the rains start; if the rains start early with planting possible from May, then a long-maturing rice can be grown, which fetches a higher price at market than short-maturing varieties which could be planted in July. If there are heavy rains from the beginning of the wet season, people may decide not to plant much rice. The second crop of 'dry rice' and 'dry maize' is sown at lower elevations, after floodwaters have receded, and is harvested towards the end of the dry season. The 'dry' crops rely on retained soil moisture and on pumping of water into cultivated fields.

This fine balance in terms of the effects of rainfall on crops extended beyond rice and maize; for example, if rainfall is too heavy then mango flowers will be destroyed, which affects yield, but with more rain, the fruits grow larger. Cassava takes a long time to mature compared with other crops, however, it can survive for one month without rain after planting. The risk inherent in reliance on seasonal weather patterns was brutally demonstrated in 2018, when farmers from Thma Reab lost much of their wet season crop due to rapid, early flooding in June, with many having to pick up off-farm labouring work to compensate for the loss.

Table 7.1. *Seasonal calendar for a 'typical year' in the village of Thma Reab, Cambodia.*

Not illustrated are crops grown only for household consumption, such as coconut, jackfruit and bananas, nor short-duration crops that are grown sporadically and opportunistically such as cucumber.

Thma Reab	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
HYDROMETEOROLOGICAL EVENTS												
Rains			*Little Rains*			*Heavy Rain*						
Floods							*Flood*					
Drought	*Drought*										*Drought*	
LIVELIHOOD ACTIVITIES												
Wet Rice					Preparation, sowing			Caring	Harvest		Drying	
Wet Maize					Prep., sowing		Harvest					
Dry Rice	Caring	Harvest			Drying					Preparation, sowing		
Dry Maize	Caring	Harvest								Preparation, sowing		
Cassava	Drying			Preparation, planting			Caring				Harvest	
Soy	Caring	Harvest									Prep., sowing	
Cashew		Fruit							Flowering			
Mango			Fruit						Flowering			
Off-season Mango									Flowering		Fruit	
Pig						Vulnerable to illness						
Buffalo/Cattle					Sold							
Bamboo Shoots	Harvest				Best	Harvest						
Fish	Regular Fishing									Best Fishing		

Ou Lung. The timing of monsoon rains and floods given by residents of Ou Lung are similar to timings mentioned in Thma Reab (Table 7.2). Ou Lung is heavily reliant on rice cultivation, with at least six varieties of rice grown in the fields around the village covering some 140 ha. Transplanting of seedlings and direct seeding are both used for rice crops. The first crop of rice is sown with the wet monsoon, with villagers waiting until the rain starts and then choosing a rainy day to start planting. If the rains are delayed, then a short-maturing variety may be used.

During the flood of 2018, around 10% of the total rice crop was destroyed; wet season rice is normally planted at higher elevations so that it is not affected by floods. The rapid arrival of the flood at an earlier date than normal gave villagers little time to prepare; the village was inundated to a depth of around one metre for two months. The drought was of greater concern than flooding at the time of the research in November 2018; little rain had fallen since September of that year and there was concern for the second crop of rice, typically planted at the end of the wet season. Some irrigation channels have been dug near the village, however farmers must pay the cost of the water hose and fuel for the pump in order to receive water for their fields. The concern over drought is demonstrated in the seasonal calendar, which highlights that drought can start even before the flood season is typically finished.

There were fewer alternative crops in Ou Long compared with the other villages in the research. Cassava, soy and maize were not cultivated, as the village's land was low-lying and

not suited to these crops. Fruit trees, sugarcane and other crops grow in and around the village; some young trees were badly damaged by flooding and other crops have suffered from successive droughts and floods.

***Table 7.2**. Seasonal calendar for 'typical' year for the village of Ou Lung, Cambodia.*

Not illustrated are crops grown primarily for home consumption (home garden vegetables, herbs and fruits such as banana and coconut) nor sugar palm products

Ou Lung	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
	HYDROMETEOROLOGICAL EVENTS											
Rains			*Little Rains*			*Heavy Rains*						
Floods						*Flood*						
Drought									*Drought*			
LIVELIHOOD ACTIVITIES												
Wet rice					Prep., sowing	Caring					Harvest	
Dry rice	Harvest								Prep., sowing		Caring	
Sesame			Preparation, sowing						Caring		Harvest	
Bamboo shoots	Harvest			Best	Harvest							
Lotus	Harvest				Flowering	Harvest						
Cashew		Harvest							Flower			
Mango		Harvest								Flower		
Off-season mango									Flower		Harvest	
Fishing	Regular fishing									Best fishing		

Dei Doh Kraom. The village of Dei Doh Kraom is the largest of the four villages, and has the most diverse array of crops grown (Table 7.3). Preparation for the wet season rice tends to begin later here than in other villages. The floods of 2018 badly affected the wet rice crop around the village, with perhaps 80% of the crop destroyed. The dry rice crop was already suffering from the effects of drought in November 2018, with fears of a poor yield for that season. Other important crops include maize (with the potential for two crops per year), cassava, sesame, cashew, mango and rubber. Table 7.3 shows that many of the vegetable crops are planted or sown at the end of the rainy season, with harvests occurring from early to middle dry season. Some vegetable crops (e.g. cucumber, long bean) are grown intensively and opportunistically throughout the year owing to their short time to maturity and can be sold for income. Similarly, many of the fruit trees flower at the end of the rainy season, with fruits maturing through the dry season. Sugar palm and rubber trees can be harvested almost all year for their sap.

Dei Doh Kraom was the only village to identify a period of the year where fishing does not occur – during the breeding season of June and July. The 'best' fishing occurs at the end of the wet season, around September and October.

Table 7.3. *Seasonal calendar for the village of Dei Doh Kraom, Cambodia.*

Dei Doh Kraom	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
HYDROMETEOROLOGICAL EVENTS												
Rains			*Little rains*			*Heavy rains*						
Floods							*Flood*					
Drought											*Drought*	
LIVELIHOOD ACTIVITIES												
Wet rice						Prep	Caring			Harvest		
Dry rice	Harvest									Prep.	Caring	
Wet maize				Prep.	Caring		Harvest					
Dry maize	Harvest									Prep.	Caring	
Cassava	Caring	Harvest			Preparation		Caring					
Sesame					Prep.	Caring		Harvest				
Sweet potato					Prep.	Caring					Harvest	
Cucumber*					Prep.		Harvest			Prep.	Harvest	
Pumpkin										Prep.	Harvest	
Eggplant	Caring				Harvest						Prep.	Caring
Green bean									Prep	Harvest		
Tomato	Harvest									Prep.	Caring	
Cabbage	Harvest									Prep.	Caring	
Sugarcane**				Harvest								
Watermelon				Prep.	Harvest						Prep.	Harvest
Peanut										Prep.	Caring	Harvest
Long bean*									Prep	Harvest		
Gourds	Harvest									Prep.	Caring	
Morning glory	Harvest					Best		Harvest				
Bamboo shoots	Harvest									Best		
Ginger	Best	Harvest										
Sugar palm	Palm water (sap)			Fruits		Palm water (sap)					Best	
Rubber	Harvest				Harvest						Best	
Mango		Fruit								Flowering		
Off-season mango									Flower		Fruit	
Cashew		Harvest										
Grapefruit										Flower		Fruit
Jackfruit				Fruit						Flower		
Sapodilla	Fruit										Flower	
Custard apple				Flower				Fruit				
Guava											Flower	Fruit
Longan					Flower		Fruit					
Tamarind			Fruit									Flower
Fishing	Regular fishing					(Breeding)		Fishing	Best fishing		Fishing	

*Notes: * Cucumber takes 40 days from planting to harvest and can be grown at different times of the year. Long bean can be harvested every 30 days including at other times of the year from that shown. Okra (not shown) can be harvested every 2 months ** Sugarcane takes around 12 months to grow before harvesting. Other: banana fruits throughout the year and is not depicted here.*

Kbal Kaoh. The island of Koh Tasuy floods in most years, with residents expecting some degree of inundation between July and October. In 2018, flooding of the island was severe and rapid, with a large proportion of crops destroyed. Although only a short distance from the mainland, livelihood activities on the island are quite distinct. Rice has not been grown on the island for more than 30 years. In the 1970s, tobacco was introduced as a cash crop, but this has gradually been replaced with maize as the major crop. The island produces around five tonnes of maize per year, which is sold as a cash crop. The periods for wet and dry maize cultivation are similar to those on the mainland, with the first crop sown at the start of the wet season around May, and the second crop sown at lower elevations after floods have receded around October (Table 7.4). Participants in one focus group commented that due to uncertainty around the impact of floods and droughts, some farmers are experimenting with intercropping corn and tobacco as a form of insurance in case one crop fails.

Some of the villagers from Kbal Kaoh have invested in land on the mainland, where cashew and mango are grown. Other crops include sesame, morning glory (also known as water spinach, *Ipomoea aquatica*) which can be harvested throughout the year and also grows wild, various other vegetables and bamboo. The latter has been planted to reduce erosion on the northern side of the island, and mature bamboo poles are also cut and sold.

Table 7.4. *Seasonal calendar for a 'typical' year for the village of Kbal Kaoh, Cambodia.*

Kbal Kaoh	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
	HYDROMETEOROLOGICAL EVENTS											
Rains			*Little Rains*			*Heavy Rains*						
Floods							*Flood*					
Drought											*Drought*	
LIVELIHOOD ACTIVITIES												
Tobacco	Caring		Harvest							Preparation		Caring
Wet Maize					Prep.	Harvest						
Dry Maize	Caring			Harvest							Prep., sowing	
Sesame				Prep., sowing		Harvest						
Eggplant			Preparation		Harvest							
Cucumber										Prep	Caring	Harvest
Watermelon										Prep	Caring	Harvest
Pumpkin	Caring		Harvest							Preparation		Caring
Tomato	Harvest											Prep
Lettuce									Prep	Harvest		
Morning glory	Harvest							Best		Harvest		
Bamboo shoots	Harvest							Best			Harvest	
Mango			Fruit							Flowering		
Cashew		Fruit										
Papaya							Flowering			Fruit		
Banana				Fruit						Flower		
Wood apple*			Flower							Fruit		
Fishing	Fishing							Best Fishing			Fishing	

*Note: * Wood apple refers to* Limonia acidissima *(Rutaceae), a tree related to the citrus species.*

Key decision-making periods. Although the four villages reported slightly different timing of various livelihood activities, it is clear that significant agricultural decisions around when to plant crops, and which varieties of crops to plant, are made at the beginning of the wet monsoon, and at the end of monsoon as floodwaters recede and rainfall declines. Projections indicate reduced rainfall at the beginning of the wet season under future scenarios of environmental change, which will negatively affect agriculture reliant on early wet season rain, such as long-maturing varieties of rain-fed rice (Hoang et al., 2016; Yamamauchi, 2014). The importance of early season rainfall is perhaps emphasised by comparing the seasonal calendars (Tables 8.1-8.4) with monthly rainfall records (Fig. 7.5). Rainfall for March and April is relatively low according to gridded data (Fig. 7.5), but focus group participants consistently said that 'little rains' fell in these months. By contrast, average rainfall in October and November is typically over 100 mm (higher in October), but these rains were not recorded on the seasonal calendars produced in focus groups. One explanation is that the calendars were more reflective of the most recent years' hydrometeorological events; another interpretation is that early wet season rainfall is a key indicator for agricultural decision-making, and is closely monitored.

Rainfall, temperature, soil moisture, flood duration and a variety of other environmental factors all hold influence over the quality and quantity of many crops produced in the four villages. Farmers with access to irrigation are able to negate some of the risks of drought conditions for dry season crops, and even late wet season crops if rainfall is insufficient. The decision to plant rice in an area that may be flooded is risky. For instance, in Dei Doh Kraom, farmers who took a risk by planting rain-fed rice in relatively low-lying areas were rewarded by a high price at market when the predicted floods of 2016 did not eventuate. In other years, the same decision could lead to major crop loss. There was a recurring theme in focus groups of disbelief around flood projections and flood warnings, as many people no longer heed official warnings, and believe that flooding is now less predictable than in prior years.

Daily routine diaries: experiences of individual women

During workshop discussions, women and men emphasised that they helped each other with the vast majority of livelihood activities conducted throughout the year. Daily activity diaries were collected only from women, in order to ensure that their experiences were documented; this is not to negate or downplay the experiences of those who were not interviewed. At least one of the women interviewed stated that we should also note down her husband's daily activities, as he also worked very hard throughout the day and year.

The daily activities drawn from seven women across three villages are depicted in Fig. 7.6. Although there was variation in the income-producing activities undertaken by the women interviewed (including selling produce, running small businesses, working in their own fields, and working as hired labour), most were also responsible for household food preparation (for daily consumption, and for longer-term preservation), cleaning, childcare (respondents with adult children were still involved in childcare for family members), tending to home gardens (vegetables may require daily watering especially in the dry season), providing feed and water for livestock, and collecting firewood.

In the villages of Ou Lung and Kbal Kaoh, where seasonal flooding significantly and regularly affects homes and fields, the daily activities carried out by women can differ greatly

between seasons. During floods, women tend to stay at the primary residence, prepare food for themselves and their husbands (and any children staying in the house), collect and transport fodder for livestock (which are also kept on higher ground, tended to by the men, who stay with the livestock), and take fish to market, commonly travelling by boat. The days are very long and challenging; in addition, the women we spoke with could not swim, putting them in danger if the boat capsizes during storms and resultant choppy wave conditions that tend to occur from the middle to late afternoon in the wet season. With more frequent extreme flooding events predicted under climate change, there may be an increase in the length of time that families are physically separated and women remain in flooded villages, doing arduous work in difficult conditions and exposed to significant risks. Pumping water to irrigate fields during the dry season was another burdensome seasonal task undertaken by some of the women interviewed.

<table>
<tr><th></th><th colspan="2">Ou Lung
Seasonal daily routines, two women</th><th colspan="3">Dei Doh Kraom
Daily routines reported by three women throughout the year</th><th colspan="2">Kbal Kaoh
Daily routine, one woman</th><th colspan="2">Kbal Kaoh
Seasonal daily routine, two women</th></tr>
<tr><th>Hour ↓</th><th>Dry</th><th>Wet (floods)</th><th colspan="3">All year</th><th>All year</th><th>Dry</th><th>Wet (floods)</th></tr>
<tr><td>4:00</td><td rowspan="2">Prepare food, eat</td><td>Prepare food</td><td rowspan="2">Cultivate land</td><td>Sleep</td><td rowspan="2">Prepare food, clean, feed pigs</td><td rowspan="2">Prepare food, sell breakfast</td><td>Sleep</td><td>Prepare food</td></tr>
<tr><td>5:00</td><td rowspan="5">Travel by boat to gather forage, take feed to live-stock (tended by hus-band), then take fish caught by husband to market</td><td rowspan="3">Prepare food, clean, feed pigs</td><td>Clean</td><td rowspan="5">Travel by boat to tend to livestock, fetch feed for livestock and driftwood</td></tr>
<tr><td>6:00</td><td rowspan="3">Tend to livestock</td><td rowspan="2">Prepare food, clean</td><td rowspan="3">Work in the fields</td></tr>
<tr><td>7:00</td><td rowspan="4">Sell food all day at the local school</td></tr>
<tr><td>8:00</td><td rowspan="3">Tend to children</td><td rowspan="3">Work in the fields</td></tr>
<tr><td>9:00</td><td>Clean</td><td rowspan="3">Prepare food, eat</td></tr>
<tr><td>10:00</td><td>Rest</td><td>Go to market</td></tr>
<tr><td>11:00</td><td rowspan="3">Work in the fields</td><td>Prepare food</td><td>Prepare food</td><td rowspan="2">Rest in fields, eat</td><td rowspan="2">Prepare food, rest</td></tr>
<tr><td>12:00</td><td rowspan="4">Tend to house garden</td><td rowspan="6">Tend to children</td></tr>
<tr><td>13:00</td><td rowspan="4">Work in the fields</td><td rowspan="4">Tend to crops, pump water</td><td rowspan="4">Tend to livestock</td></tr>
<tr><td>14:00</td><td>Prepare food, eat</td></tr>
<tr><td>15:00</td><td rowspan="3">Work in the fields</td><td rowspan="4">Return home and rest due to storms and waves</td></tr>
<tr><td>16:00</td><td rowspan="2">Dinner</td></tr>
<tr><td>17:00</td><td rowspan="3">Prepare food, eat clean, rest</td><td rowspan="2">Rest</td></tr>
<tr><td>18:00</td><td rowspan="3">Prepare food, eat, rest</td><td>Clean</td><td rowspan="3">Prepare food, eat, clean, rest</td><td rowspan="3">Prepare food, eat, clean, rest</td></tr>
<tr><td>19:00</td><td rowspan="2">Prepare food, eat</td><td rowspan="3">Tend to children, rest</td><td rowspan="3">Prepare food, eat, rest</td><td rowspan="3">Prepare food, eat, clean, rest</td></tr>
<tr><td>20:00</td><td rowspan="3">Prepare food, eat, clean, rest</td></tr>
<tr><td>21:00</td><td rowspan="3">Sleep</td><td rowspan="3">Sleep</td></tr>
<tr><td>22:00</td><td rowspan="2">Sleep</td><td rowspan="2">Sleep</td><td rowspan="2">Sleep</td><td rowspan="2">Sleep</td><td rowspan="2">Sleep</td></tr>
<tr><td>23:00</td><td>Sleep</td></tr>
</table>

Fig. 7.6. *Representation of daily activities conducted by seven women across three villages*

In the village of Dei Doh Kraom, the women's daily livelihood activities did not differ substantively between seasons. The village floods irregularly, having been flooded only three times since 2000 (2001, 2013 and 2018). The women interviewed in Dei Doh Kraom stated that during severe flood years their daily lives were adversely impacted as they did not have mechanisms in place to cope with these conditions.

Adaptive responses to temporal variability and environmental uncertainty

During fieldwork in the four communities, research participants and community members mentioned a number of strategies that could be described as ways of adapting to recent environmental change and uncertainty. The strategies were mentioned as an aside to, or in response to, discussions around the central research themes of temporal variability, and respondents were not specifically asked about all strategies used to cope with or adapt to environmental change. It is important to note that the extent and duration of flooding, along with the volume and seasonal distribution of rainfall, have varied from year to year within these communities over long periods of time, so that villagers are accustomed to variability. Many villagers perceive that the predictability of seasonal change has recently declined, so that new strategies are required to assist in overcoming these new challenges.

In this section, we reflect on how some of the strategies used by communities in response to increased environmental uncertainty fit within Agrawal and Perrin's (2008) framework on adaptation practices that may alleviate risks to rural livelihoods posed by climate change. The framework highlights five classes of adaptation practice: mobility; diversification; storage; communal pooling; and market exchange. We follow Neef et al.'s (2018) example by elaborating on community-led adaptation practices that fit within social norms and cultural values at a particular place, as well as the environmental setting. Here, we do not seek to construct an exhaustive list of all adaptation practices used by the studied communities in the face of environmental change, but rather offer this interpretation as a way of bringing together different threads of practice and theory as a potential example for categorising and understanding adaptive responses to temporal change and environmental uncertainty.

Mobility as a strategy to alleviate risks to rural livelihoods across space was mentioned in a variety of contexts. At a very fine spatial and temporal scale, members of all four villages discussed the use of boats in times of flooding in order to move between homes, upland areas and markets, and highlighted boats as an important financial investment for families. Particularly in Kbal Kaoh, the most physically isolated of the four communities, almost all households reportedly owned or had access to a boat. In Thma Reab, mobility at a micro-scale was discussed, with children in the village now being taught how to swim after the drowning death of a child during the floods of 2013. Commonly, villagers (particularly the elderly and vulnerable, some children, and men looking after livestock) may leave their homes if villages are inundated, and go to other towns, homes on higher ground, or to the nearest temple (see also Williams, Pauli, & Boruff, this volume). One family encountered in the fields inland of Thma Reab explained that they had bought 10 ha of land above the floodplain about ten years prior, and planted cashew trees. They no longer farm rice and stated that floods and droughts cannot affect their trees due to their elevated location.

The village of Thma Reab is the most well-connected with the town of Kratie on the opposite bank of the Mekong, with a regular ferry service. Following the devastating floods of 2018, which destroyed much of the wet season rice crop in the village, there was an increase in residents from Thma Reab taking jobs as labourers and drivers outside of the village; Phnom Penh was a common destination but some international mobility also occurred with reports of work in Thailand and South Korea. In 2017, nearly 100,000 Cambodians went to work overseas (Mom, 2018). At the time of this research, a number of residents from across multiple villages stated that they believed that working in South Korea would lead to the best livelihood outcomes.

Diversification as a class of adaptation practice was mentioned frequently during focus group discussions, particularly with regard to agricultural activities. As highlighted by the seasonal calendars, there has been widespread growth in tree crops such as mango, cashew and rubber, as well as increased investment in high-value, intensively grown vegetables such as cucumber and tomato (several greenhouses planted to high-value vegetables were observed in the study area, along with areas of intensive seedling production). Examination of the seasonal calendars reveals that there are crops to be harvested (whether annual, perennial, or wild-harvested) and fish caught in most months of the year, allowing for multiple income streams. During several focus groups there was explicit mention of intercropping and consideration of different crop varieties to reduce risks and decrease the livelihood impact of failure in one particular crop. In Ou Lung, the village with the least access to infrastructure and the greatest reliance on agricultural activities, the village headman explained that he would like to see more government investment in irrigation in the province, so that farmers can have more opportunities to grow high-value crops that are reliant on regular water supplies just as in other provinces of the country.

Storage as an adaptation practice that reduces risks across time also arose in workshops and observations, with households storing large quantities of grains, livestock fodder and preserved fish (*prahok*) to last throughout the year (these are long-standing strategies that are related to the inherent seasonal variability that comes with living in the floodplain of the Mekong River). Storage locations for fodder and foodstuffs were often elevated on stilts to reduce the risk of damage by floodwaters, with many households with the economic means to do so opting to build higher stilts beneath houses due to the increased uncertainty around flood severity.

Members of all four villages also highlighted the importance of pooling of communal resources to help maintain their livelihoods. Residents from Ou Lung and Dei Doh Kraom highlighted the shared use and maintenance of water wells and irrigation ditches on a community level, while residents from Kbal Kaoh noted the shared use of water pumps and agricultural machinery. Communal investment was also seen in Kbal Kaoh, where residents planted bamboo to stabilise river banks and worked together to build up portions of elevated land to shelter livestock in times of flood. Temples have long been used as a place to house children and those without alternative accommodation during flood periods.

Adaptation practices related to ‘market exchange’ (such as crop insurance, new products for market, and access to markets) were not explicitly mentioned during focus group workshops. However, many of the crops grown in the four villages were targeted strongly towards sale at market (including maize, tobacco, cashew, mango, rubber, sesame, vegetables,

fruits, and more), and participants were quick to highlight times of the year or situations that would lead to the highest or lowest price at market. Off-season mango was frequently mentioned as gaining a higher price at market as it could be sold via Cambodian middlemen to Chinese buyers. Other locally produced or caught commodities (such as rice, poultry, fish and pigs) would be split between household consumption and sale at market, allowing for flexibility based on the situation in any particular year.

Household and community-level adaptation strategies have and will continue to play a significant role in rural livelihoods in the study region. However, an important level of structural support to aid in continued adaptation to environmental change depends on access to reliable infrastructure, particularly access to roads, electricity, and clean water. Participants in all four villages explicitly stated that they were looking to the government to provide support to aid in their adaptation to environmental change, in terms of knowledge and guidance, hard infrastructure, and economic funding.

Conclusion

This investigation explored the temporal aspects of environmental change, seasonality and adaptation strategies pursued by residents of four villages that have been severely impacted by seasonal flooding in the Lower Mekong Basin. Our findings highlight that local communities use a variety of methods to manage the effects of seasonal and interannual variability, including growing a variety of crops at different times throughout the year, choosing appropriate varieties based on environmental conditions, and investigating the potential of new methods to lessen the impact of reduced or more variable rainfall, such as irrigation. Local perceptions (see also Williams, Pauli, & Boruff, this volume) and rainfall records highlight that patterns in rainfall, flooding, and dry spells have become less predictable in the study area. The increased climatic variability noted in the case study area is indicative of the projected direction of future environmental change across the Lower Mekong subregion (Jiang et al., 2019). As such, the adaptive responses by residents in the study area are likely to reflect the measures that other communities in this region will need to enact to sustain rural livelihoods into the future.

Beyond the four villages encompassed in this research, a substantial proportion of the rural population of the lower Mekong subregion draw livelihoods from agriculture and fisheries tailored to seasonal rainfall and the flood-pulse of the Mekong (FAO, 2011). The detailed seasonal calendars produced as part of this research highlighted two main decision-making periods, coinciding with the start (May-June), and the end (September-October), of the wet monsoon season; there are likely analogues in other villages of the region. These two periods of the year are also among the most likely to be affected by projected changes in precipitation patterns under climate change (Hoang et al., 2016; Yamamauchi 2014). The predicted temporal impacts of climate change combined with alterations in flow from the development of hydropower dams upstream will likely hold adverse impacts (if unmitigated) for many communities in the Lower Mekong subregion, due to their strong reliance on seasonality for their agriculture-based livelihoods.

The residents of the Lower Mekong have long been accustomed to environmental variability, with a variety of strategies available to adjust to years that are dryer or wetter than

usual. The experiences and knowledge of community members documented in this research suggests that there has been an acceleration or intensification in variability over recent years, so that an increasing repertoire and extent of coping and adaptation strategies are needed. Our findings highlight the importance of ensuring an accurate representation of experiences when researching environmental change. This investigation also clearly illustrated that drawing on communities' experiences and knowledge through participatory processes can add substantial value to scientific research; resulting in a more accurate understanding of the temporal effects of environmental change.

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